EXPLORING STUDENTS' PERSPECTIVES ON THE BENEFITS AND CHALLENGES ON THE ADOPTION OF THE INTERNET OF THINGS: A CASE STUDY IN AN INDONESIAN UNIVERSITY

Thesis

Submitted to meet the Graduation Requirements of

Master's Degree MA in Education

Author

Cut Manda Sari

Student ID: 04242110014

UNIVERSITAS ISLAM INTERNASIONAL INDONESIA

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ABSTRACT

The 21st century is a century characterized by a vision and mission that emphasizes technology applications in organizing human activities. Currently, many Indonesian universities have begun to integrate, incorporate and adopt the IoT applications and devices into their academic programs. However, there are limited scientific discussions and research on IoT implementation in education within Indonesian University pose an opportunity for further exploration and advancement in this area. This study aims to address this gap by investigating students' perspectives on the benefits and challenges of IoT implementation in higher education, specifically, the research focuses on a university that have integrated and utilized IoT to support students in their academic processes. This research utilized a qualitative case study design to conduct a comprehensive analysis of students' perspectives on IoT applications. The survey findings indicate that students express a significant level of satisfaction with IoT services in terms of benefits such as quicker access to resources and improved research and learning experiences. The adoption of smart boards in classrooms enhances learning effectiveness and creates a dynamic environment. Students recognize the importance of technological fluency and a digital mindset and appreciate user-friendly interfaces. owever, challenges include the lack of clear guidelines, unstable internet connectivity, and system errors. Furthermore, students also recognize the importance of technological fluency and the development of strong technical skills to adapt to the advancements in technology. Students also highlight the positive impact of IoT on classroom management, collaborative learning, and skill development. IoT devices contribute to an easy and efficient learning process, sparking curiosity and motivation. IoT tools improve academic tasks, access to information, and overall achievements. While some challenges exist, personal exploration, peer assistance, and attending workshops help overcome them. Expectations revolve around comprehensive education, improved system quality, and expanded IoT integration. In conclusions, it is recommend adopt a technology system that facilitates the assessment of these perceptions. By using a technology system, organizations can collect data and insights from staff IT members through surveys, interviews, or other feedback mechanisms.

Keywords: internet of things (IoT), students' perspectives, higher education, benefits, challenges

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ABBREVIATION PAGE

The Internet of Things (IoT) is a concept that revolves around the interconnection of various smart devices and objects, allowing them to communicate and interact and collaborate without direct human intervention (Pandey, 2016; Escobar, 2022)

University' Students is a person who has registered and been accepted into a college, institute, or recognized educational institution in order to pursue a particular course or program.

Benefits are the numerous advantages of higher education have a profound positive impact on students, such as their personal academic lives.

Challenges are these various difficulties financial obstacles students face in higher education.

Higher Education is the level of education beyond secondary school, typically provided by universities, colleges, and other institutions of higher education.

Perspective is the understanding of the relationship between perspectives and cognition is essential for comprehending how individuals perceive and interpret the world around them (Camp, 2013).

CHAPTER I

INTRODUCTION

1.1. Study background

The 21st century is a century characterized by a vision and mission that emphasizes technology applications in organizing human activities. One of the most popular technological applications of this century is the Internet of Things that has reached an outstanding user number of about 5.16 billion or equivalent to 64.4% worldwide in 2023 (Kemp, 2023). The Director of Digital Economy Protection of the National Cyber and Crypto Agency (BSSN) (2020) confirmed there are 31 billion IoT devices connected to the internet in 2020 (Telkomsel.iot.com, 2021; qbee.io, 2020). It is also indicated that the United States has invested expenditure of around 194 billion U.S dollars in the Internet of Things (IoT) (Vailshey, 2022). Many nations like China, Japan, Germany, South Korea, France, and the United Kingdom also has been utilizing the Internet of Things in various industries with the aim to accelerate the efficiency of city management, transportation, public safety, medical equipment, infrastructure, and logistics (Chuck Hasenauer, 2017; Vailshey, 2022). In 2020, the data depicted the growth number from 12.2% from 8% or equivalent to 12.3 billion devices that already has an active connection (Hasan, 2022) and approximately 2.85 billion people residing in Southern, Eastern Asia, and Africa are still registered as “unconnected” from Internet of Things (Kemp, 2023).

IoT is a technological concept established in 1999 by Professors from Massachusetts Institute of Technology's Radio Frequency Identification Development (RFID) group (Mkrttchian, et al., 2021). According to Chen, IoT is an intelligent network which is connected in machines that can exchange information through devices like smart technologies, smart system applications, smartphones, computers, and laptops. IoT is also considered as a paradigm to communicate from human to human and machines to machines that are able to provide services to meet users needs through internet connectivity in daily basis.

The aim of IoT is to present the environment “digital things” with low cost, low size anywhere and everywhere, for example IoT capable to control patient health issues through the technology monitor, locking doors automatically, optimize the energy consumption, reducing waste, improve the accessibility for special needs people and enhance communication in real time with reduce costs and long distance effectively (Chen, 2014; Patel, 2016; l-Qozani & Aleryani, 2018).

In Indonesia, The IoT has been implementing about 65% in technical support and operational efficiency such as in sharing data, communicating and working together (Telkomsel, 2021). Indonesian also has been designating in growing the internet users number significantly from 90 million to 215 million users within the period of five years from 2016 to 2021 (Telkomsel, 2021). The data also depicted that 65% of Indonesians already utilize IoT to change and simplify the working, business ways and operational efficiency. Telkomsel (2023) also confirmed that the Internet of Things (IoT) in Indonesia has transformed in various sectors such as in education that help students to complete the assignments, upload subject cOurse materials, and correspond virtually. According to the Ministry of Communication and Information of Indonesia (2019), IoT is a good opportunity to build a connection between one profession and another profession (Aji Cakti, 2019). The governments are also trying to build digital technologies for solutions and create new innovation in education and health sectors. It is also estimate that the IoT device number in Indonesia will reach from 400 million to 678 million devices by 2025 (Prasetya, 2021). These numbers are also similar to internet users increasing about 73.3% from the population or equivalent to 202.7 million of Indonesians. The government also has a desire to expand IoT development in several tourism national cities like Danau Toba, Raja Ampat, and Labuan Bajo (Novianty, 2021)

Currently, many Indonesian universities have begun to integrate, incorporate and adopt the IoT applications and devices into their academic programs. Several Indonesian university located in Java has utilized a smart education system that includes IoT-devices such as smart boards, interactive

projectors, and smart lighting. Those devices enable to maximize the educational activities to become more active, collaborative and enhance students' understanding effectively (Satria, 2021; Riyadi, 2022; Insgreeb, 2022). Another university also already integrate IoT-based smart campus systems like smart lightning, smart environmental monitoring, and smart parking that enable to sensor and optimize the university consumption overall. It is also already incorporate into IoT system for campus building security, laboratory monitoring, students' academic records to optimize the educational accessibilities and improve the convenience for students in university (Santosa, 2021; Communication, 2022; Febrianto, 2022; Zahra, 2021).

The implementation of IoT also plays a big role in educational institutions' activities. One of the most popular implementation of IoT that could assist students and lecturers in completing teaching and learning processes interactively is smart board, smart board is a digital board that support digital learning experiences for students by facilitate interactive learning, time-saving, productivity, and collaborative engagement (Raja & Nagasubramani, 2018; Vidhyashram International School, 2022). The Smart board also enable students to connect to "internet" and "devices (e.g., laptop, tablet or handphone)" and have an adaptive learning systems in cooperating multimedia content, virtual reality looks, and interactive displays such as videos, animations, and quizzes (Wahab, Rose, & Osman, 2012). Similarly like Smart board, another implementation of IoT is a tracking system to monitor campus safety, security, university conditions, including temperature, humidity, energy waste, building performance and prevent from incidents like fire, theft, and crime on campus (Appsiera, 2021; Elsaadany & Soliman, 2017). In addition, Virtual Reality (VR) is another example of IoT implementation. Virtual Reality (VR) is a new innovation that combines digital technology and the real elements that is designed to build interaction virtually. VR is the newest product that has been using at several universities to facilitate learning environments with more visual, interactive, and imaginary dynamics (Christou, 2015).

However, despite the growth of IoT technology in academic institutions, many researcher still contend that IoT presents both benefits and challenges to students. One of the most significant benefits of IoT in academic institutions is its ability to enhance learning. IoT can provide an immersive learning environment that improves students' understanding of complex topics, facilitates personalized learning, improves problem-solving skills, teamwork abilities, and collaborative learning. IoT also enables to develop customized learning plans based on students' learning style preferences for educators. However, there is a significant challenge of utilizing IoT in academics namely the ethical issues that arise from the collection and use of personal data. It is essential to establish clear ethical guidelines and policies to regulate IoT devices' use and data collection to protect personal data from invasion and misuse. Compatibility is another challenge that academic institutions face when implementing IoT technology. Some IoT devices use different protocols that may not be compatible with existing systems and infrastructure in academic institutions, leading to system failures and data loss. In addition, internet and system errors pose significant challenges when utilizing IoT in academic institutions. IoT devices rely heavily on stable and robust internet connectivity to function correctly. In case of internet connection failure, IoT devices may fail to perform as expected, resulting in delays in data collection and communication. System errors can also affect the functioning of IoT devices, leading to data loss and delays in data collection.

Interestingly, some scholars are having different opinions on this kind of Internet of Things topic. A scholar named White (2020) measured Adaptive Learning Technology (ALT) relationship with students' learning outcomes using quantitative methodology. The findings show that there are no relationships between ALT usage in improving students' academic performance or outcomes. Nevertheless, students express positive perspectives of using the ALT Smart Book and give many benefits in delivering knowledge, and contents for students. Another research also found that blended learning using internet applications system is showing a positive significant effect for students learning outcomes (White, 2020). That is because the usage of technology could enhance

students’ knowledge as well as exchange information in between. Not only that, the findings also shown that students can improve their self-instruction strategies and self-confidence which the use of Internet of Things (Mohamed, 2021; Tartory, 2020). On the another hand, Carstens et al., (2021) mentioned that modern technology could enhance students’ basic psychomotor and cognitive skills as well as engage students in the learning process, particularly in using a smart board that could improve students learning interest, for example the smart board able to demonstrate complex scientific phenomena through captivating videos and real-time experiments. As a result, students became more enthusiastic about the subject, and many even started conducting their research to explore the concepts further.

The study acknowledges that there are certain challenges associated with the use of modern technologies, including the Internet of Things (IoT), in higher education. These challenges include the need for students and teachers to receive proper guidance in utilizing these technologies, as well as the lack of technological skills and familiarity with IoT features among both students and teachers (Carstens & Mallon, 2021). Despite the increasing adoption of IoT technology across various sectors, however there is still a lack of comprehensive scientific discussions regarding its implementation in education, particularly in measuring students' perspectives as the primary focus. Indeed, there are several studies have been conducted in ASEAN countries and Europe to measure the benefits and challenges of IoT adoption from students' perspectives in education. However, there are limited scientific discussions and research on IoT implementation in education within in an Indonesian University pose an opportunity for further exploration and advancement in this area. As the adoption of IoT technology continues to grow globally, it becomes crucial for Indonesia, as a developing nation, to actively participate in the discourse surrounding its implementation in higher education. By conducting this scientific discussions and research on IoT implementation in education, this research can focus on measuring students' perspectives as the primary objective related to IoT in educational settings. This study aims to address this gap by investigating students' perspectives on the benefits and challenges of IoT implementation in higher education, specifically, the research focuses on a

university that have integrated and utilized IoT to support students within university educational process. By examining students' perspectives, this study seeks to investigating the potential advantages and drawbacks of IoT implementation in educational settings. The insights gained from this research will support the enhancement of accommodations for IoT utilization and contribute to the ongoing conversation surrounding the integration of IoT in higher education. Therefore, conducting research within the specific context of Indonesia, would allow for a more targeted exploration of the benefits and challenges of IoT adoption relevant to Indonesian higher education institutions.

1.2. Research Questions

This study aims to investigate the use of the Internet of Things (IoT) in higher education based on student perspectives. To be more specific, the researcher investigated students' perspectives of the benefits and challenges of IoT usage at their university. Therefore, this will be summarized in the following research questions that will lead to specific questions as listed below:

1. What are students' perspectives on the benefits of implementing Internet of Things (IoT) at university?
2. What are students' perspectives on the challenges of implementing Internet of Things (IoT) at university?
3. What are students' perspectives on what what specific improvements in the implementation of IoT to support students learning at the university?

1.3. Research Objectives

With the existing research questions, the researcher also formulated research objectives as follows:

1. To investigate students' perspectives on the benefits of implementing Internet of Things (IoT) at university

2. To explore students' perspectives on the challenges of implementing Internet of Things (IoT) at university
3. To examine students' perspectives on what specific improvements in the implementation of IoT to support students learning at the university

1.4. Significant of Study

This study aims to seek and gain a clear understanding of students' perspectives of benefits and challenges on IoT implementation in higher education. By focusing on the primary beneficiaries of IoT technologies, the research aims to ensure that the implementation of IoT in higher education aligns with students' needs and expectations, leading to improveeducational experiences. By incorporating students' insights, this study aims to provide valuable guidance for designing and implementing IoT technologies that can enhance and optimize the educational experiences for students. It is worth noting that there is a lack of comprehensive research on the usage of IoT in educational institutions, particularly in the Indonesian higher education.

Therefore, this study aims to shed light on the benefits and challenges in the implementation of IoT in higher education, based on students' perspectives. The insights gained from this research will contribute to the existing knowledge base, inform future strategies and policies related to IoT adoption in educational settings, and serve as a valuable feedback, input and resource for universities, educational stakeholders, technologists, academicians, and policymakers who involved in the implementation of IoT in higher education.

CHAPTER II

THEORITICAL FOUNDATION

2.1. Literature Reviews

This section presented a literature review of the topic of Internet of Things. A literature review involved comprehensively summarizing previous research on a specific topic. First, the researcher defined the background of the topic, focusing on the definition and scope of IoT. This followed by a discussion of the various applications of IoT. Next, the researcher described the different devices and applications of IoT for educational purposes, as well as the benefits and challenges associated with them. Then, the researcher enriched the topic by including studies on IoT in the context of education from different parts of the world. Finally, since the topic revolved around the Internet of Things at the university level, several additional theories were briefly summarized.

2.1.1 **Internet of Things (IoT) in University**

The term "Internet of Things" (IoT) refers to a network of digital objects that are interconnected and operate autonomously without human intervention (Birlog & Borcan, 2020; Giwerc & Rogers, 2020). Accoridng to Chu (2020) IoT is a primary objective to enhance people's lives by providing various devices and applications that enable seamless data transfer anytime and anywhere. IoT also define as a combination of smart devices and internet connectivity that collect, process, and exchange data automatically and as a transformative revolution that has a profound impact on various aspects of society (Rad & Ahmada, 2017; Efendi, 2018; Bussooa & Mungur, 2019). IoT also conceptualized as a Machine-to-Machine Communication (M2M) paradigm that enables interaction and data exchange without human intervention (Rad et al., 2017, p.90). Hence, the Internet of Things (IoT) can be described as a device that facilitates communication through internet connectivity or as a system development concept that leverages data from devices to optimize human daily activities (Giwrec et al., 2020).

In the context of universities, IoT pertains to the implementation of IoT devices and applications to maximize benefits and address challenges within the educational community (Aldowah & Rehman, 2017; Kassab, DeFranco, & Laplante, 2019; Zulfadli, 2022). According to Sunil (2019) the growing utilization of IoT applications in universities and colleges, could integrate students' learning experiences with digital resources and enhance information accessibilityKassab et al. (2018) also assert that IoT in education refers to the incorporation of IoT technologies into academic institutions to enhance educational activities, pedagogical processes, learning process and influence teaching methodologies for faculty, students, and staff.For instance, it provides user-friendly interfaces, enables to remote interaction between faculty and stakeholders, and optimizes the learning process (Madni & Ali, 2022).

2.1.2 **Benefits and Challenges of IoT in Higher Education**

When it comes to educational technology for students, the implementation of IoT offers a range of benefits that positively impact different aspects of their educational processes. One such benefit is evident in assignments. With IoT, students can leverage advanced technologies to enhance their assignment completion process. For instance, they can utilize connected devices and sensors to gather data, conduct research, and access relevant information more efficiently, resulting in higher-quality assignments (Brou, 2015). In the context of teaching and classrooms, IoT enables the development of personalized content, the enrichment of adaptive learning materials, real-time communication among classmates for project sharing, remote student monitoring, and displaying warning messages on LCD screens. At the university level, IoT has proven effective in recording class attendance, tracking campus activity, and enhancing access control in classroom environments (Kassab et al., 2018).

However, despite the widespread adoption of IoT technology has brought about numerous benefits, but it is also considered brought numerous challenges (Sunil, 2019; Tomás & Teixeira, 2020). There are six challenges in implementing

IoT in higher education. Firstly, cloud computing, while serving as a virtual data storage solution, requires constant internet connectivity for accessibility. Additionally, the frequency of downtime due to high user usage, potential security threats, and difficulties in data transfer to personal computers pose challenges in cloud computing. Secondly, limitations in instructional technologies hinder the development of student-friendly applications for accessing content. Thirdly, mobility applications require ongoing upgrades and improvements to ensure uninterrupted utilization. Fourth, security and privacy concerns necessitate universities to prioritize the protection and confidentiality of student and faculty data. Fifth, ensuring the quality and ethical behavior of students, including the prevention of cheating on assignments, presents a significant challenge. Finally, the financing of IoT infrastructure and services requires continuous significant investment (Sunil, 2019; Thomas, 2020).

2.2 **Theoretical Framework**

A Theoretical Framework is an essential component of a research study, providing a conceptual structure that guides the investigation and helps researcher understand research questions and hypotheses in a systematic and coherent manner (Grant & Osanloo, 2014). In the current study, the theoretical framework is based on several key concepts that contribute to the understanding of IoT integration in the educational context. These concepts include:

2.2.1 Internet of Things (IoT)

2.2.1.1 Definition of IoT and its scope

The concept of "Internet of Things" is frequently used among technologists. Beyond this term, there are actually two meanings that correlate to each other (Patel, 2016; Vermesan & Friess, 2014; Gattu, 2020). In the book Internet of Things-From Research and Innovation to Market Deployment, the authors pointed out IoT refers to a concept and a paradigm that exists in devices/things over networks schemes to create new services and interact with each other (Vermesan et al., 2014). The term

"Internet" means a mechanism that enables broadcasting to spread information and interact with individuals without regard to geographical location (Leiner, 2009; Khodadadi & Dastjerdi, 2017). While the term “Things” refers to objects/things that connecting into wireless or internet connectivity. Then, the 'Internet of Things' stands for the integration devices that function to connect people through networks and without human intervention (Khodadadi et al., 2017).

The IoT was born in the early 1980s when a group of Cargenie Mellon University's Graduate Students including Mike Kazar, an American Engineer and Technology Executive who specialized in Computer Science, experimented a joke mission to connect Cola-Cola machines’ information to the internet (Teicher, February 7, 2018; Ackerman, November 2020). However, According to Ali & Ali (2015), The IoT concept was first introduced by Kevin Ashton, MIT’s Executive Director of Auto-ID Labs, during a Procter & Gamble presentation in 1999.At first, the principle of IoT was primarily only concern in recognizing identities by computer systems like barcodes, QR codes, and Radio Frequency Identification (RFID) (Abdul-Qawy, 2015; Ali & Ali, 2015; Paranagama, 2022). However, along the way, IoT has been evolving and becoming more advanced in recognizing human commands, identities, and movement without human intervention. Examples of such advancements include smart lighting systems that can automatically switch lights on and off, as well as smart door parking systems that can monitor drivers' identities in public areas like malls. These advancements aim to simplify human work, alleviate daily tasks, and reduce waste and costs through the use of IoT devices and internet connectivity (Ali, 2015; Paranagama, 2022).

Professor Sanjay Sarma, a Professor of Mechanical Engineering and Co-Founder, Auto-ID Lab, of Massachusetts Institute of Technology (MIT) defines IoT as the ability to accumulate data and formulate responses through smart devices and systems (Merritt & Sarma, 2019). The IoT satisfies human data by employing sensors and it is growing significantly over time from machine to machine at homes, businesses, and governments (Merrit et al., 2019). The World Economic Forum's Head of Internet of Things, Robotics, and Smart Cities, Jeff Merritt (2019) illustrating the rise and potential expansion of IoT devices over the past few decades

is growing significantly. By 2021, it is predict that the IoT will install about 1 million devices hourly. Additionally, IoT has connectivity as the core element component, and computing and sensors as the supporting elements to operate data optimally. In practice, the current IoT mobilization elements are capable to execute data through the advanced smart phone which incorporates the three components mentioned above, thus the smartphones become like a magic wand and become the revolution for IoT. At this present, IoT devices are cooperating closely with smartphones to offer users' convenience and emergency control, for example, tracking features by popular ride-online applications like Uber, Blue Bird and Gojek in searching cars information seamlessly (Merritt & Sarma, 2019).

According to the Sreenivasa Institute of Technology and Management Studies (SITAMS) in India, IoT refers to the concept of Machine-to-Machine(M2M), which utilizes smart devices to facilitate human activities in homes, offices, and universities (Pandey, 2016; Sitams.org, 2022; Escobar, 2022). The M2M functionality aims to capture data track physical and virtual objects to exchange data and control the information to be accessible such as temperature, traffic congestion, building location, book availability, or everything relate on the data (Ali M. F., 2019). Especially, as a global network, IoT has abilities to capturing and recording data by the objects' communication (Nurzaman, 29 Jul 2019). In the book "Business @ the Speed of Thought in 1999", Bill Gates predicted that everything shape the future through mobile devices to Facebook, and IoT devices (Burns, July 2017). Therefore, Kevin Ashton predicted that IoT has the potentials to change the world through the innovative of smart environments significantly (Gabbai, January 2015). Moreover, IoT is playing a big role in various fields, for example smart smoke detection protect against cigarette smoke, automated lighting, smart education systems to maximize learning instructions become more comfortable and convenient, logistics tracking and room temperature control. These examples demonstrate how IoT leverages internet connectivity, tracking data to transmit information to devices automatically without human intervention. The overarching goal of IoT is to provide useful information to users and expand the exchange of information through connected devices (Dwiyaniti, 2018; Efendi,

2018; Lucent, 2020). Based on the above interpretation, it can be concluded that IoT is a concept has abilities to transfer data from smart devices through network. IoT also aims to provides users useful information and expand the information over connected devices.

2.2.1.2 IoT devices/application for educational purposes

IoT has significantly have been impacted various sectors, including education, where it has brought about positive changes in the teaching and learning process (Larsson & Muchate, 2022). Educational institutions, including schools and universities, have embraced and implemented IoT technologies to revolutionize classroom methods, enhance learning techniques, and foster collaborative learning environments. Here is a more detailed list of IoT examples in education:

Smart Board

In an academic context, the Smart Board is considered an innovative learning tool that enhances the educational system by facilitating more effective and interactive classroom materials (Akar, 2019; Hrithik Lall, 2020). It represents a transition from traditional blackboards to digital boards, providing convenience and advantages for digitalized, dynamic, and customized learning methods (Mohite & Raverkar, 2021). In the past, educators would write and scribble all over the blackboard to explain the material. However, with the introduction of smart board technology, educators can adopt a more effective approach by delivering flexible and engaging materials in smart classrooms (Hrithik Lall, 2020). These materials can be displayed not only on the smart board itself but also on other devices such as smartphones, laptops, and computers (Akar, 2019)

By utilizing the Smart Board, teachers can create an interactive learning environment that enhances student engagement and participation. Akar (2019) the board's digital capabilities allow educators to incorporate multimedia elements, such as videos, images, and interactive exercises, into

their lessons.This multimedia-rich content captures students' attention and facilitates a deeper understanding of the subject matter. Moreover, the Smart Board enables teachers to customize and adapt the learning experience to meet the needs of individual students or groups (Mohite, 2021). They can easily modify and update the displayed content in real-time, tailoring it to specific learning objectives or student preferences and this flexibility promotes personalized learning and accommodates different learning styles and paces (Ladislaw, 2012).

The Smart Board technology fosters collaborative learning. Multiple students can simultaneously interact with the board, either physically touching or using by digital pens. This fosters group discussions, problem solving, and collaborative projects, promoting teamwork and enhancing critical thinking and communication skills (Akar, 2019). Furthermore, the Smart Board serves as a versatile platform for formative assessment, feedback, quizzes, surveys, and interactive assessments, allowing them to gather real-time data on student progress and comprehension (Tsayang & Batane, 2020). This data can inform instructional decisions, identify areas of improvement, and provide timely feedback to students, promoting a more efficient and effective learning process (Ladislaw, 2012; Tsayang et al., 2020).

Smart Classroom

A Smart Classroom is an innovative solution that promotes active learning by enabling users to display a wide range of multimedia content, which enhances students' visualization and engagement during the learning process (Hrithik Lall, 2020). By incorporating technology and interactive tools, Smart Classrooms create an environment that encourages students-teachers and students-students interaction, fostering cooperation, critical thinking, and the development of essential learning skills (Venkatraman, 2022). These classrooms provide opportunities for students to participate in

discussions, collaborate on projects, and explore educational resources through digital teaching platforms (Jena, 2013).

One of the key advantages of smart classrooms is the immediate access to technology and digital resources, which allows teachers to deliver lessons more efficiently and effectively, ultimately saving time (Jena, 2013, p. 1). Faculty members can utilize pre-prepared resources, such as educational videos, interactive presentations, and online learning materials, reducing the time required for lesson preparation and enabling more focused instructional time (Hrhitik Lall, 2020). Moreover, Smart Classrooms provide students with readily available content and resources, eliminating the need for extensive time spent searching for information (Jena, 2013). According to Hrhitik Lall (2020) With a variety of digital tools at their disposal, students can access educational materials, research articles, online textbooks, and interactive learning platforms, enhancing their engagement and making the learning experience more interesting and engaging.These classrooms also allows for easy customization and adaptation of content to meet individual student needs and learning styles, personalize instruction, deliver differentiated lessons, and provide tailored support based on students' abilities and preferences (Hrhitik Lall, 2020; Venkatraman, 2022).

2.2.1.3 IoT Services Characteristics; Principles and its Scope

According to Patel (2019), IoT possesses specific characteristics that define its identity and functionality, which observed in its principles, values, functions, or habits, and these characteristics include connectivity, intelligence, scalability, and sensors.Connectivity in IoT is essential as it establishes a communication network that connects devices to each other, facilitating interaction, communication, and information exchange between devices and the internet, enabling humans to easily interact and exchange information, with examples routers, gateways, and sensors, and without reliable connectivity, IoT cannot operate efficiently without relies on internet connectivity (Patel, 2016; Ruziyev & Sultanov, 2022).

Intelligence, often associated with Artificial Intelligence (AI), plays a vital role in the Internet of Things (IoT) as it utilizes pattern recognition and machine learning techniques to solve complex problems in the specialized field of computer science (Patel, 2016). By leveraging these techniques, AI is capable of recognizing and interpreting various forms of data, including sounds, visuals, pictures, words/languages, and big data (Ruziyev & Sultanov, 2022). This ability to process and analyze big data through algorithms enables AI to provide rapid information and make autonomous decisions without the need for human intervention. In the realm of education, AI finds application in personalized learning platforms such as Duolingo, Ruang Guru, and Khan Academy. By utilizing this innovative AI technology, these platforms deliver customized educational content to students, thereby eliminating the need for continuous teacher presence, and enabling students to access personalized learning experiences and receive targeted support aligned with their individual needs and preferences (Dualingo, 2023; Khan Academy, 2023).

In an academic context, scalability refers to a system's capacity to effectively process and handle a large volume of data while maintaining stable performance, improving service quality, and remaining responsive to user requests, without compromising the generation and delivery of data (Patel, 2016). This concept ensures smooth operation even with substantial data volumes, such as in a student attendance system that must efficiently handle a significant amount of data collected from student taps without compromising scanning speed and identity quality (Ghosh, 2018). Not only scalability, sensors and actuators are also integral components of IoT systems. sensors are utilized to collect data by measuring and detecting environmental conditions like temperature, rainfall, light, shadows, objects, and movements, while actuators are employed to control hardware or devices, including machinery or engines (Ghosh, 2018). This data, collected through internet-connected sensors, transmitted to a server and processed using communication system protocols, and subsequently analyzed using techniques such as big data analytics, machine learning, or artificial intelligence, for example, if the

collected data indicates warm weather, the smart AC system can automatically adjust the temperature to 18°C (Ruziyev & Sultanov, 2022).

2.2.1.4 Benefits IoT in Educational Institutions

The implementation of Internet of Things (IoT) in education offers a multitude of advantages that impact students in a positive manner (Ali M. F., 2019). Benefits can be understood as the advantageous outcomes derived from engaging in specific activities, resulting in improvements in productivity, efficiency, quality, quantity, or cost reduction. In the context of educational technology for students, benefits pertain to the positive effects on students' educational processes, assignments, security, safety, convenience, access to online resources, and assignment completion (Brou, 2015; Ali M. F., 2019). Universities strive to harness IoT not only to enhance students' educational abilities but also to introduce a more interactive and enjoyable utilization of technology. By maximizing collaborative and productive learning experiences with peers and teachers in the classroom, students can further develop critical thinking and creativity (Bogdanović & Simić, 2014; Explorance, May 2020).

Moreover, in this era of technological revolution where technology permeates various spheres of life, universities aim to educate students in adapting to, comprehending, and employing technology skills contextually and critically (American University, June 2020; Lin, 2021). Through the integration of IoT in education, several benefits can be realized. Firstly, IoT facilitates personalized and adaptive learning experiences, allowing students to learn at their own pace and fulfill the individual needs and preferences which leads to promote the engagement and effectiveness in the learning process, for example able to engage students in active learning experiences to enhances their understanding and knowledge, such as discussions, group activities, hands-on projects, and experiments(Ali M. F., 2019). Secondly, IoT enables seamless access to online resources, empowering students to retrieve information, conduct research, and access educational materials

more efficiently. This enhances the availability and accessibility of educational content (Brou, 2015).

Furthermore, IoT enhances the security and safety of students within the university environment. By implementing IoT-enabled security systems and surveillance mechanisms, potential risks and threats can be identified and addressed promptly, thereby ensuring the well-being of students (Brou, 2015). Additionally, IoT technology can optimize administrative processes within the university, leading to improved efficiency in areas such as registration, course management, and resource allocation. This streamlines administrative tasks reduces paperwork, and frees up valuable time for both students and staff (Ali M. F., 2019).

2.2.1.5 Challenges IoT in Education for students

In accordance with Park (2021), smart devices are designed to enhance the daily lives of individuals. However, despite their benefits, these devices also present various challenges. Uslu (2020) identifies a key challenge in education, particularly in universities that have implemented the Internet of Things (IoT) on their campuses: the limitation of technological skills. Despite technological advancements, students still face confusion, necessitating teachers to possess adequate technological knowledge. Understanding how to use technology is crucial for students to expand their knowledge and effectively utilize new technologies, particularly IoT devices. Furthermore, students encounter challenges related to security and privacy. The use of technology compromises the privacy of user data due to the substantial volume of information generated. Issues such as data leakage, loss, and theft arise, posing threats to user security and privacy (Safdar, 2019; Scheau, 2018). Additionally, IoT implementation incurs costs. Users may need to repurchase internet connectivity or universities may impose maintenance and improvement fees, which can be relatively expensive. In some cases, universities rent applications to students, requiring additional fees for easy platform access (Gul, 2017). Moreover, the sophistication of IoT systems presents difficulties for students. Not all students are familiar with IoT technology, leading to complexities

and challenges during system integration, resulting in unexpected delays (Scheau, 2018).

Another challenge for students is the rapid pace of change in IoT. Continuous upgrades offer users new features and services, necessitating students to keep their knowledge up-to-date with the evolving technology (Scheau, 2018). Furthermore, compatibility limitations pose challenges. IoT devices may be incompatible or struggle to integrate with various devices or systems, hampering their seamless use across different platforms (Scheau, 2018). Lastly, students may develop a dependence or addiction to technology. While IoT usage in universities facilitates efficient assignment completion, students unknowingly become reliant on technology, hindering their ability to work on tasks independently and think critically and creatively without the aid of technology or internet connectivity, for example students reliant on IoT devices may struggle to independently approach problems and assignments, opting for quick online answers rather than developing original thinking and creative problem-solving skills(Uslu, 2022).

2.2.2 Perspectives

The word "perspective," as a noun, can have various definitions depending on the context in which it is used (Hughes, 2005; Camp, 2013). Its origin stems from the Latin term "perspectivus," which means the "science of optics." In psychology, for example, perspective refers to an individual's unique point of view or interpretation of a situation, influenced by their experiences, beliefs, and attitudes. In literature, perspective refers to the narrative point of view through which a story is told, shaping the reader's understanding and interpretation of events (Hughes, 2005). Perspectives are more likely to appear sensible and understandable to students who possess knowledge about the lives of the individuals who have shaped those perspectives (Keith, 2014). A perspective serves as a representational lens for interpreting and explaining truth-conditional contents, but it does not entail a commitment to any specific content or belief (Camp, 2013). Perspectives are

intertwined with cognition, generating cognitive structures and playing a crucial role in motivating certain explanations and higher-order interpretations. They shape individuals' cognitive processes, influence their attention and memory, and guide their reasoning and sense-making abilities (Hasib, 2017). Understanding the relationship between perspectives and cognition is essential for comprehending how individuals perceive and interpret the world around them (Camp, 2013).

In term of education, students' perceptions refer to the point of view or subjective experiences of students regarding something that happened during the learning process in class (Sidhu, 2013). When it comes to learning, students can adopt either deep or surface learning concepts tend to take a more active role in their own learning process, they actively engage with the material, seeking to understand the underlying concepts and meaning (Keith, 2014). They employ a variety of methods and strategies, such as critical thinking, analysis, and application of knowledge and they go beyond mere repetition and aim for a comprehensive understanding of the subject (Hughes, 2005). When students express their perceptions, they often provide suggestions or arguments to improve the learning process for themselves, their classmates, or their teachers. These suggestions can range from specific recommendations for instructional methods, classroom activities, or assessments to broader ideas about the learning environment, communication, or engagement (Hasib, 2017).

In summary, perspectives and students' perceptions have a profound impact on cognition and education. Perspectives serve as lenses through which individuals interpret and understand information, while students' perceptions provide valuable insights into their individual learning experiences. When students adopt deep approaches to learning, actively engaging with the material and seeking comprehensive understanding, they enhance their educational journey. It is crucial to acknowledge and value students' perspectives, as this fosters a supportive and inclusive learning environment and promotes continuous improvement in education. By recognizing the significance of perspectives and students'

perceptions, educators can create more effective and meaningful learning experiences for their students.

2.3 **Technology Acceptance Model (TAM) Theory**

The Technology Acceptance Model (TAM) is a widely utilized framework in the domains of technology adoption and customer satisfaction (Andy, 2021; Hassler & Macdonald, 2021; Abdullah & Ward, n.d). Its primary objective is to comprehensively comprehend and measure user behavior and satisfaction concerning technology applications. Many companies employ the TAM methodology as a means to assess user satisfaction with their technologies and pinpoint areas for improvement (Ma & Gam, 2017). TAM incorporates diverse tools and features, such as questionnaires, comment fields, and live chat buttons, to collect user feedback and evaluate their responses to the application (Mugo & Njagi, 2017). The original TAM model, as delineated by Andy (2021), encompasses five fundamental constructs as follows:

2.3.1 Perceived Ease of Use (PEOU)

Perceived ease of use is a concept that assesses an individual's perception of how easy it is to understand and use a particular technology. It is an important factor in determining technology acceptance and usage. When a technology is perceived as easy to use, individuals are more likely to adopt and utilize it in their daily lives (Ma & Gam, 2017). The perceived ease of use is influenced by various factors, including the clarity of the technology's interface, the intuitiveness of its functionalities, the simplicity of its operation, and the availability of user-friendly features. Individuals tend to perceive a technology as easy to use when it requires minimal effort, cognitive load, and technical skills to operate effectively (Abdullah & Ward, n.d). A positive perception of ease of use can lead to increased user satisfaction, improved user experience, and higher levels of technology adoption. It reduces the learning curve and the need for extensive training, making it more

accessible to a wider range of users. Additionally, perceived ease of use can contribute to increased efficiency and productivity, as users can quickly and effectively accomplish tasks without encountering significant obstacles or frustrations (Ma & Gam, 2017).

2.3.2 Perceived Usefulness (PU)

Perceived Usefulness (PU) is a concept that relates to how individuals perceive the benefits and advantages of using technology. When users believe that a particular technology can provide them with valuable benefits or help them achieve their goals, they are more likely to consider it useful. Perceived usefulness is subjective and varies from person to person based on their individual needs, preferences, and goals (Mugo & Njagi, 2017).

2.3.3 Attitude Toward Using (ATU)

The Attitude Towards Using (ATU) model offers a framework for analyzing users' attitudes towards the adoption or rejection of a work-related system (Kusumadewi & Lubis, 2021). By considering cognitive, emotional, and behavioral components, along with various contributing factors, organizations can effectively promote technology adoption and facilitate a positive user experience (Alharbi & Drew, 2014). The cognitive component of ATU pertains to individuals' beliefs, perspectives, and thoughts about technology, encompassing factors such as perceived utility, perceived ease of use, and understanding of the system's benefits and functionalities. Positive cognitive factors, such as perceiving the technology as beneficial and advantageous, can contribute to a favorable attitude towards system utilization (Abdullah & Ward, n.d).

2.3.4 Behavioral Intention to Use (ITU)

Behavioral Intention to Use (ITU) involves an individual's inclination to continue using a specific technology, including factors such as upgrading hardware, maintaining continuous usage, and influencing others to adopt the technology (Prieto & Migueláñez, 2015). Recognizing and addressing these variables can enhance long-term technology adoption and engagement (Kusumadewi & Lubis,

2021). A crucial component of ITU is the desire to update technology-related devices or applications, which reflects the individual's commitment to investing in resources to improve their experience and ensure continued usage, demonstrating users dedication to keeping up with technological advancements (Faisal & Handayanna, 2021)

2.3.5 Actual System Usage (ASU)

ASU, or Acceptance and Satisfaction of Users, is a measure that gauges users' practical application and overall experience with a system. It is influenced by user satisfaction, system usability, and the system's capacity to enhance productivity (Faisal & Handayanna, 2021). Organizations should focus on developing user-friendly systems that effectively meet user requirements and contribute to increased productivity in order to achieve a positive ASU (Andy, 2021). User satisfaction with a system is an indication that it meets their expectations and fulfills their needs, which can be influenced by factors such as system usability, functionality, performance, and the support it provides for users' professional or personal activities (Hassler & Macdonald, 2021).

2.4 IoT in Education Context: Studies from different parts of the world

Numerous international researchers have extensively investigated the application of Internet of Things (IoT) in the field of education, finding compelling evidence of its efficacy in enhancing learning processes, promoting interactive learning, and fostering participatory learning (Ackerman, November 2020). Various countries, including the United States, Malaysia, United Kingdom, China, Serbia, and Saudi Arabia, have been subject to comprehensive scrutiny regarding the benefits and challenges associated with leveraging IoT for educational purposes (Chuck Hasenauer, 2017). IoT has emerged as a preeminent technological advancement with global prominence across diverse sectors (Kumar A. , 2022). Aligned with principles of sustainable growth, technological systems, and practical outcomes,

this concept epitomizes the ongoing digital transformation in education (A.R.Moghrabi & Bhat, 2022).

Leading nations such as the United States, Japan, and the United Kingdom have assimilated IoT technologies into their educational landscapes and contribute to their educational process (Kinney, 2018). Notably, the number of connected IoT devices worldwide surpassed 8.4 billion in 2017, excluding laptops, computers, tablets, and smartphones, and is projected to further surge to 20.4 billion, underscoring the anticipated continued growth in 2020 (Meulen, 2017). This means, IoT has rapidly expansion within information processing, cloud computing, and artificial intelligence domains, with far-reaching beneficial implications worldwide (Wang, 2022).

Within the educational context, an influential Serbian research study titled "A Platform for Learning Internet of Things" conducted by Bogdanović & Simić (2014) unveiled IoT's recognized utility in augmenting students' learning processes. Moreover, Kassab and Drefanco's study (2019) corroborates IoT's facilitation of data exchange, collaborative course material creation, real-time academic performance monitoring, personalized learning experiences, and engagement through multimedia presentations, interactive games, and digital content. These advanced technologies substantially contribute to students' acquisition of digital technology skills, problem-solving acumen, teamwork competencies, and leadership aptitude (Bogdanović & Simić, 2014; Shi & Hou, 2022).

Recent research conducted by Shi et al. (2022) provides compelling evidence supporting IoT's efficacy in enhancing students' efficiency and productivity in accessing digital modules and resources. Additionally, Amy and Guan's study (2021) validates IoT's pivotal role in cultivating students' digital mindset, encompassing their adeptness in navigating the digital realm, harnessing its potential, critically analyzing digital information, and adapting to novel digital environments. Furthermore, "The Conundrum of Internet of Things Adoption in Higher Educational Institutions" journal publication presents empirical evidence show casing students' adeptness in comprehending digital culture and developing

their digital mindset proficiencies (Amy et al., 2021). Notably, IoT devices and applications facilitate adaptive learning, collaborative learning processes, and critical digital analysis skills. They also significantly aid students in assignment completion, affirming IoT's suitability and relevance in the educational realm (Bogdanović et al., 2014).

Teachers also benefit from IoT, as it assists them in content creation, monitoring students' learning environments, and affording access to a multitude of resources, rendering it an effective technology for educational purposes, for example teachers can integrate multimedia resources like educational videos, documentaries, and interactive simulations into their lessons. This variety of multimedia content enriches the learning experience and caters to different learning styles. (Shi & Hou, 2022).To conclude, the comprehensive analysis presented herein underscores the pivotal role of IoT in enhancing the learning process, with its myriad benefits and advantages for students and educators alike.

CHAPTER III
METHODOLOGY

In this section, an overview of the research methodology employed in the study will be presented. The chosen approach for this study is qualitative, aiming to investigate the perspectives of lecturers and students regarding the implementation of Internet of Things (IoT) in university settings. The methodology encompasses several key components, including research design techniques, data collection techniques, data analysis techniques, and participant characteristics deemed suitable for this study. A comprehensive description of the methodology will be provided at the end of this chapter, highlighting the specific techniques employed for gathering pertinent information related to the research questions. Additionally, data verification techniques utilized to ensure the accuracy and validity of the collected data. Finally, the data analysis process involved establishing linkages among the collected data in alignment with the research objectives. A more detailed explanation of these aspects will be provided as follows:

3.1. **Research Approach and Research Design**

The research method employed in this study is a qualitative approach, which involves an in-depth exploration and understanding of the research topic. According to Creswell and Creswell (2018), qualitative methodology focuses on presenting data through discussions, interpretations, and validations using words and narratives. It aims to capture the richness and complexity of human experiences and social phenomena (Cropley, 2023). In this study, the qualitative approach chosen to examine the perspectives of students regarding the application of IoT in university. Qualitative research characterized by its emphasis on detailed analysis, contextual understanding, and the exploration of multiple perspectives (Creswell & Creswell, 2018). It allows researchers to delve into the intricacies of a particular phenomenon and gain a comprehensive understanding of the research questions at

hand (Mack & Woodsong, 2005). The use of qualitative methodology enables researcher to gather in-depth insights into the benefits and challenges associated with IoT applications in the university context.

To conduct this study, a case study design was employed. A case study is a qualitative research method that focuses on a specific instance or situation to gain a deep understanding of the phenomenon under investigation (Mack & Woodsong, 2005). In this case, the focus on students' perspectives of the benefits and challenges of using IoT applications in their university. The case study design was employed to thoroughly examine students' experiences, opinions, and behaviors concerning IoT, thereby generating comprehensive and detailed data. This design choice was driven by the extensive usage of IoT applications in Indonesian universities. By focusing on the specific context of these universities, the study aimed to uncover valuable insights into the practical implications, benefits, and challenges associated with implementing IoT in the educational setting. The Indonesian Government's Minister of Education and Culture (KOMINFO RI) has recognized the potential of IoT to enhance students' digital technology understanding and support their learning needs, thereby positioning the integration of IoT in higher education as a means to enrich students' knowledge, skills, and overall educational experience (KOMINFO, 2018).

This research utilized a qualitative case study design to conduct a comprehensive analysis of students' perspectives on IoT applications. Multiple data collection techniques, including survey open-ended questionnaire, group discussions, and observations, employed to gather rich and detailed information. The collected data analyzed to effectively address the research questions and contribute to the existing knowledge on the advantages and challenges of implementing IoT in the university setting. The findings of this study aim to provide valuable insights that can inform future educational practices and policies related to IoT. The forthcoming research endeavors to present a detailed explanation of these tables:

Table 1.1 Research Design

No	Design	Description
1	Types of research	Qualitative – A Case Study
2	Research focus	Students perspective on IoT integration in higher education, specifically benefits and challenges
3	Research informants	Purposive Sampling Technique
4	Data collection technique	This study uses collection techniques by survey open-ended questions, focus group discussions (FGDs) and observation
5	Data analysis technique	The data analysis technique used is based on thematic coding analysis

3.2.**Time and Site/Research Context**

The research project conducted from March 2023 to May 2023 with the primary objective of investigating the implementation of IoT in Indonesian universities, focusing specifically on those that have already adopted IoT technologies. The study aimed to explore students' perspectives on the advantages and challenges associated with using IoT to enhance accessibility and the overall educational process within the university setting. The research cite took place at University X - Electro Engineering Department in West Java, Indonesia, which known for its extensive implementation of IoT solutions in various sectors, including education. Several IoT applications and devices deployed within the university, such as digital online libraries, smart attendance systems, smart e-books, and smart classrooms. By selecting University X as the research site, the study aimed to gain detailed insights into the experiences and perspectives of students who exposed to and engaged with IoT technologies in their educational journey.

3.3.Participants

In this study, the participants selected from University X, specifically from the electro engineering department. The participants were individuals who voluntarily

chose to take part in the research project due to their interest in achieving the study's objectives. The selection process considered their level of understanding and firsthand experiences in utilizing IoT technologies to improve accessibility and facilitate learning activities on campus. Purposive sampling used as the sampling method, which involved intentionally selecting participants who possessed specific characteristics or experiences relevant to the research topic (Mack & Woodsong, 2005). By using this approach, the researcher aimed to include participants who actively and extensively engaged with IoT technologies to enhance their educational progress and enrich their learning experiences.

A total of 15 university students were purposefully selected as participants for this study based on their demonstrated depth of understanding and rich experiences in utilizing IoT technologies. By including this specific number of participants, the researcher aimed to gather a wealth of valuable information that could provide profound insights into the personal experiences of university students regarding the use of IoT technologies. The study focused on exploring and examining the benefits and challenges associated with the implementation of IoT within the university setting. Through the active involvement of these selected students, the researcher sought to gain a comprehensive understanding of how IoT technologies were employed and their impact on enhancing accessibility and facilitating learning activities. The valuable insights and experiences shared by the participants significantly contributed to the overall findings of the research and provided crucial information for comprehending the benefits and challenges associated with the usage of IoT technologies in the specific context of University X. The research endeavor provided a comprehensive depiction of the participants in the following tables:

Table 2.2 Participants Categorization Selection

Faculty	Survey Participants' Indications (n=15)	Gender	Focus Group Discussions (n=6)

Electrical Engineering	Biomedical Engineering	S1	Male	Session One S6 S7 S8
		S2	Male	
		S3	Male	
		S4	Male	
		S5	Male	
		S6	Male	
		S7	Male	
		S8	Male	
		S9	Female	Session Two S9 S10 S11
		S10	Female	
		S11	Female	
		S12	Female	
		S13	Female	
		S14	Female	
		S15	Female	

For participant selection, the researcher specifically targeted students from the Electrical Engineering department, focusing on those enrolled in the Biomedical Engineering program. Biomedical engineering is a specialized discipline that falls within the broader umbrella of electrical engineering. It encompasses the application of engineering principles and techniques to the field of medicine and healthcare, with a focus on developing innovative solutions to improve patient care, diagnostics, and medical technologies. Biomedical engineering programs often integrate IoT concepts into their curriculum, allowing students to understand and work with the latest advancements in connected medical devices, remote patient monitoring, and healthcare data analytics in their educational process.

A total of 15 students were selected as participants for the study, consisting of 8 male students and 7 female students from the Biomedical Engineering major. In addition to the main group of participants, a subgroup of 6 students was chosen for further engagement through separate Focus Group Discussions (FGDs). This smaller group allowed for more in-depth discussions and insights into students' perspectives on IoT adoption in their university. By combining surveys

administered to the larger group and FGDs conducted with the selected subgroup, the researcher were able to gain a comprehensive understanding of the students' viewpoints and experiences related to the implementation of IoT technologies in their academic environment.

3.4.**Data Collection**

In a scientific study, data collection is one of the most important processes to conduct. Data collection involves systematically gathering information and collecting relevant data for analysis and discussion in a research study. Various techniques and methods employed to gather data that are pertinent to the research objectives and research questions. The purpose of data collection is to fulfill the information needs of the research and provide evidence to support the study's findings and hypotheses. In this qualitative study, the researcher employed a technique called triangulation to collect data. Triangulation involves gathering information from multiple angles on the same issue. This technique used to enhance the trustworthiness and authenticity of the results by comparing and correlating data from several explanation. The specific data collection techniques used in this study included questionnaires, interviews, and observations. These techniques chosen to gather comprehensive and diverse data that contribute to a thorough analysis and understanding of the research topic. The specific data collection techniques that will be use in this study include:

3.4.1.**Survey**

A survey is a standardized research method used to collect data through oral or written questioning (Glasgow, 2005). It is characterized as a data collection method that measures participants' views on specific information (Ponto, 2015). Surveys are also use to gather representative perspectives of individuals (Creswell & Creswell, 2018). According to Glasgow (2005), surveys can be conduct through various formats, including written surveys, verbal surveys, and mixed-mode surveys. Each format has its own advantages and considerations, for example

written surveys involve providing participants with a set of questions in written form, which they can respond to independently. Verbal surveys, on the other hand, involve conducting interviews or discussions with participants where the questions are aske orally. Mixed-mode surveys combine both written and verbal elements, allowing participants to respond using a combination of written and spoken responses (pg.2-8).

The purpose of conducting a survey in research is to facilitate a comprehensive understanding and interpretation of data by utilizing various styles of survey questions (Ponto, 2015). Different question styles provide researcher with flexibility in gathering detailed information from participants. Evaluative continua, for instance, offer respondents multiple-choice options to indicate their preferences or opinions on a given topic. Agreement continua allow participants to express their level of agreement or disagreement with specific statements, providing insight into their attitudes or beliefs. Rating scales enable respondents to rank or rate items on a scale, helping researcher assess the intensity or magnitude of certain characteristics or variables (Glasgow, 2005, pg.2-8).

In this research study, the researcher initially utilized an online survey in the form of an open-ended questionnaire consisting of five core questions to investigate the integration of IoT among university students (see Appendix A). However, due to the inherent limitations and constraints associated with conducting an online survey, the researcher made a deliberate decision to employ a paper-based survey questionnaire as an alternative data collection method. This approach involved the researcher personally visiting the field and directly engaging with the respondents to gather their opinions and experiences related to IoT usage at the university.

In the paper-based survey, students asked to provide essay-style answers to the questions posed. Although the paper-based survey added complexity to the research process, the researcher deemed it necessary to collect data directly from the participants rather than relying solely on an internet-based survey. This method believed to enable capturing a more nuanced understanding of the participants' perspectives and experiences regarding IoT integration. It is important to note that unlike an online survey where responses are immediately collected, the researcher

faced a time lag in retrieving the completed paper questionnaires, such as researcher had to wait for a period of 2-3 days to obtain the results of the respondents' answers.

3.4.2.**Focus Group Discussion**

Focus Group Discussion (FGD) is a collaborative process in which a group of individuals come together to share their thoughts, viewpoints, and experiences on a specific research topic or issue (Mishra, 2016). FGDs are recognize as valuable data collection tools in qualitative research. According to Nyumba (2018) and Intrac (2017), FGDs facilitate the exchange of ideas and insights among participants who possess knowledge and expertise related to the research subject. The book "Qualitative Inquiry and Research Design; Choosing among Five Traditions" by Creswell et al. (1998) acknowledges FGDs as a data collection method in qualitative research. FGDs serve the purpose of sharing experiences, exploring diverse perspectives, and generating new ideas and insights. By utilizing FGDs, the researcher can contribute to a deeper understanding of the research subject and provide valuable information that enhances the quality of the research. The International NGO Training and Research Center (INTRAC) highlight the significance of FGDs in confirming research results and providing insights into the practical implications of the research. Furthermore, FGDs have the potential to validate study findings and offer practical relevance to the research. An FGD typically involves a group of 6 to 12 individuals and includes a set of carefully crafted questions that promote in-depth discussion and exploration of the research topic (Intrac, 2017).

The primary purpose of conducting a Focus Group Discussion (FGD) is to identify research problems, gain a deeper understanding of the topic under investigation, and promote insightful comprehension of the phenomenon studied. FGDs can also serve as a platform for gathering feedback, reviews, or evaluations of ongoing implementations (Krueger, 2002; Basnet, 2018). FGDs are particularly effective in collecting qualitative data through the open-ended questions (Mishra, 2016). FGDs are commonly employe to access participants' views, opinions, and

interests on particular topics (Eliot & Associates, 2005; Mishra, 2016). For example, an FGD group could be formed to explore the social processes of students' attitudes toward certain aspects (Basnet, 2018).

In the subsequent phase of the study, the researcher employed Focus Group Discussions (FGDs) to enrich the students' understanding of IoT integration at the university (see Appendix B). These FGDs specifically targeted students who had previously participated in the online survey and paper-based questionnaire. A total of six students, consisting of three for session one and three students for session two from the Biomedical Engineering department, were selected to ensure a representation of perspectives from both genders. However, due to considerations and time constraints, separate FGDs conducted for each gender group. The FGDs with session one participants conducted in a face-to-face setting, where the participants gathered physically in a designated location for the discussion. On the other hand, the FGDs with session two participants conducted remotely using the WhatsApp calling platform. The decision to conduct separate FGDs driven by practical factors such as varying schedules and different-specific assignments' deadlines among students. Therefore, due to the constraints and complicated circumstances, the researcher had to adapt and conduct separate FGDs for the session one and two.

3.4.3.**Observation**

Observation is a research method that involves systematically observing and documenting behaviors, events, and phenomena in their natural settings (Mack & Woodsong, 2005, p. 23). In the context of scientific study, observation is use to gather more complete and detailed data, as well as to test hypotheses and gain a deeper understanding of the research topic (Baker, 2006). By directly observing and documenting behaviors and events, researcher can gather nuanced details and subtle cues that may not be easily captured through surveys or interviews (Intrac, Observation, 2017). Through systematic observation, the researcher can gather rich

and detailed data that contributes to a more comprehensive understanding of the research topic.

The purpose of utilizing observation as a research method is to enhance the validity and reliability of research findings by reducing reliance on participants' self-reports or subjective interpretations (Creswell & Creswell, 2018). By directly observing and documenting behaviors, events, and phenomena, a researcher can gather data in a more objective and unbiased manner (Kumar A. , 2022). This approach allows for a deeper understanding of the research subject by capturing real-time actions, interactions, and contextual factors that may not be accurately conveyed through self-reports (Baker, 2006). Observation also aims to strengthen the credibility and trustworthiness of the data collection process, as it provides an independent and firsthand account of the observed phenomena, leading to more robust and reliable research findings (Baker, 2006; Mack & Woodsong, 2005).

In this study, the researcher conducted observations after obtaining permission from the university's Rectorate. The primary focus of this study was the Z building, a recently constructed facility that serves as a symbol of the university's dedication to integrating technology. Specifically, the observations took place in the electrical engineering department, known for its expertise in implementing cutting-edge technologies. During the observation process, the researcher had the opportunity to observe the hybrid learning process in the biomedical department. This involved observing the use of technology in classrooms and laboratories, as well as interactions between students and instructors (see Appendix C). Additionally, the researcher explored the wider university campus, visiting different locations such as classrooms, laboratories, and common areas to witness firsthand the technological infrastructure in place. The researcher observed a range of technologies across the university, including smart classrooms equipped with interactive displays, computer labs with state-of-the-art equipment, and campus-wide Wi-Fi connectivity. By observing these technologies in action and experiencing the overall technological environment, the researcher could gain a comprehensive understanding of the technological landscape and its impact on students at the university.

3.5.**Data analysis**

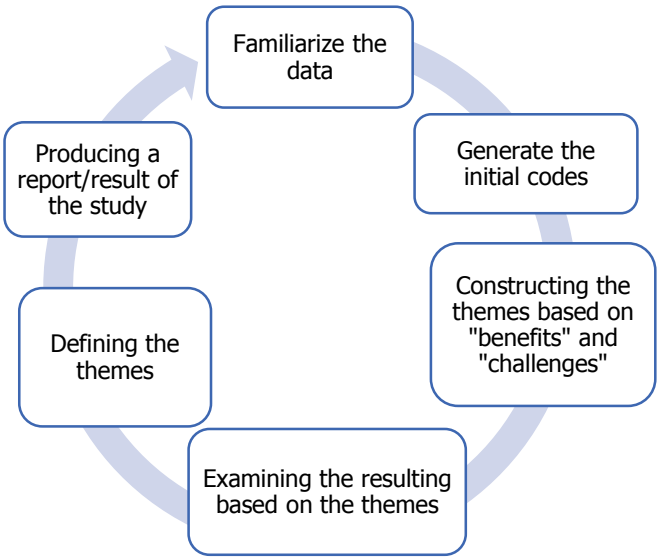
In qualitative research, data analysis is a critical step that involves examining and modeling the collected data to uncover meaningful information and draw conclusions (Mack & Woodsong, 2005). It is the process of systematically analyzing the data to identify patterns, themes, and insights that contribute to the research objectives. There are many techniques for analyzing data such as Coding, Thematic Analysis, and Interrater Reliability (Belotto, 2018). The thematic analysis allows researcher to explore the data in-depth, uncovering common themes, patterns, ideas, and meanings that represent the underlying patterns in the data (Creswell & Creswell, 2018, p. 200). While coding is an integral part of thematic analysis, as it aids in organizing and structuring the identification of connections and relationships within the dataset. Thus, when thematic analysis and coding work together that going to provide a comprehensive and structured approach to data analysis in qualitative research.

The purpose of data analysis such as thematic analysis and coding is to effectively organize, categorize, and interpret the collected data to derive meaningful insights and conclusions. These techniques assist researcher in uncovering valuable insights, supporting or challenging existing theories, and generating new knowledge (Belotto, 2018). By employing these techniques, researcher can identify key themes, patterns, and relationships within the data, allowing for a deeper understanding of the research topic. Through thematic analysis, researcher can uncover valuable insights, generate new knowledge, and contribute to the existing body of literature (Creswell & Creswell, 2018).

In this study, the researcher employed thematic analysis to analyze the collected data, which included online survey responses, focus group discussions, and observational notes. Researcher organized the data by coding and identified three main themes: benefits, challenges, and expectations for improvements. In addition, the sub-themes were also identified within each main theme. The researcher interpreted the findings and reported them comprehensively, providing

valuable insights into the students' perspectives on IoT implementation at the university. By employing a systematic approach, including thematic analysis and coding, the researcher ensured a rigorous analysis of the data, which ultimately enhanced the credibility of the research findings. To simplify the data analysis process, the researcher employed thematic analysis, which involves six key steps as following processes:

Figure 1.1 Six Phases in Analyzing Data (Kristanto, 2022)



The process of thematic analysis involves several steps. First, the researcher familiarized with the data by reviewing the survey responses, focus group discussion transcripts, and observational notes. Next, the researcher generated initial codes, which are labels or tags assigned to segments of the data that represent a specific idea or concept. These codes applied to relevant portions of the data to create a coding system. After coding the data, the researcher identified overarching themes by examining the codes and grouping them based on similarities and patterns. Themes represent the broader concepts or topics that emerge from the data. The researcher reviewed and refined the themes, ensuring they accurately reflect the data and capture the students' perspectives on the benefits and challenges of IoT usage.

Once the themes are finalized, the researcher further analyze the data within each theme to explore the variations, nuances, and connections between different codes and sub-themes. This analysis involved examining the relationships, frequencies, and significance of the codes within each theme. Through thematic analysis, the researcher gained a deeper understanding of the students' perspectives on the benefits and challenges of IoT implementation in the university. The analysis results provided insights into the various ways in which IoT enhances accessibility, facilitates learning activities, and improves the educational experience. It also sheded light on the obstacles, limitations, and concerns associated with IoT usage in the university context.

3.6. **Research Ethic / Ethical issue**

In a scientific study, it is important to have a research ethic. Research ethics is a set of rules approved by both sides of the relationship between the researcher and all people who involved in the research process or normally called as research participant. The purpose of research ethics is to provide an orientation to researcher in fully utilizing the participants' response. Despite the right to use the information provided by participants, the researcher must also respect participant privacy, autonomy, identity by ensuring there is no potential harm or hazard to participants after sharing responses or personal information. Here are some research ethics that employed in this research:

3.6.1 Informed Consent

Informed consent is a letter of agreement between the researcher and the participant in taking any steps towards participants. In the informed consent letter, the researcher must state and explain several things related to the research idea such as thesis title, research background, research objectives, and the reason why researcher choose the participant to become and involve in the research (Sanderson, 2010). The purpose of Informed Consent is to inform clearly, detail and specific information, for example, the participant interview for 40-60 minutes consisting of

15 questions related to the benefits and challenges of IoT usage based on personal experience.

3.6.2 Confidentiality and anonymity

It is important for a researcher to provide participants with the assurance of confidentiality and anonymity of the investigation. Confidentiality and anonymity are a subset of participant information that not publicize. Confidentiality and anonymity must provide before processing the collecting data. The researcher must protect the participant's identity whether the action before or after is completed. As a rule of law, the researcher should not necessarily reveal the identity of the participants as a form of protection, security, and privacy against unintended consequences (Charles, 2008). In order to respect participants' privacy, researcher would not reveal or state any citations, participant identification, participants' university affiliation, personal identifications, and biographical information in my study. This aim is to respect my participants' privacy and to express my gratitude for their contribution to my research as well as to protect my participants' University X's convenience and pleasantness.

CHAPTER IV
RESEARCH RESULTS AND DISCUSSION

This section focuses on analyzing and interpreting the collected data of students' perspectives regarding the implementation of the Internet of Things (IoT) at university that become sample of the study. The aims of this section are to present the findings and discussions about the benefits and challenges of IoT implementation from students' perspectives. Additionally, it will discuss and deliver students' expectations and desires for improvements in IoT within their university as follows:

4.1. Research Results

This section will present the research results; exploring students' perspectives on the adoption of the Internet of Things (IoT) in higher education, specifically at University X in West Java, Indonesia. The section highlights three main results obtained from the data collection.

4.1.1 Research Question One: Students' Perspectives on IoT Benefits

In this research question one, participants were specifically question about their perspectives regarding how the Internet of Things (IoT) contributes to and supports their diverse learning experiences, promoting enhanced accessibility, and positively influencing various crucial aspects of the educational process within their specific degree program. These discussions aimed to capture comprehensive understanding of how students perceive the implementation of IoT able to enrich and optimize the overall students' educational journey, opening up new avenues for immersive and personalized learning experiences, ensuring inclusivity and accessibility for all learners, addressing various facets of the educational process, enriching engagement in the classroom, fostering a dynamic and many more. The detailed explanation will elaborate as the following bellows:

4.1.1.1 Students Perceive Satisfaction and Fulfillment

Based on the Technology Acceptance Model (TAM), user satisfaction is recognized as a crucial element in evaluating an individual's level of contentment with using specific technologies, including the Internet of Things (IoT). TAM serves as a well-established theoretical framework for predicting users' acceptance and adoption of technology. In the students' context, the utilization of IoT often leads to a sense of satisfaction and fulfillment in their educational experiences as follows:

4.1.1.1.1. Integration of IoT Convenience and Access

The integration of IoT (Internet of Things) in higher education is undoubtedly bringing about numerous conveniences and improved access for students. The implementation of IoT features such as tap records for parking and integrated card systems for easy login and access to campus facilities have proven to be highly beneficial. One of the notable advantages of IoT implementation in higher education is the use of access card-based entry doors, where student ID cards serve as access keys. This not only simplifies the process of entering and exiting campus buildings but also enhances campus security. By utilizing IoT technology, campuses can ensure that only authorized individuals with valid ID cards can access specific areas, thus reducing the risk of unauthorized entry, as stated by S3:

> "Very helpful, such as logging tap records when parking or integrating cards with the integrated system for easy login and access to campus facilities." stated by S13

> "One of the benefits I've experienced in using IoT on campus is the use of access card-based entry doors, where the student ID card serves as the access key. This IoT implementation enhances the security of campus entrances and exits." by S11

> "The implementation of IoT in everyday life, especially on campus, brings significant benefits such as using student ID cards for organized smart door systems and as a means of access for motorized vehicles within the campus environment." stated by S10

The integration of IoT with student ID cards in educational institutions holds significant potential for improving the overall student experience on campus. By leveraging IoT capabilities, such as connectivity and data processing, these smart ID cards can bring about various benefits and streamline several aspects of campus life. Moreover, IoT-enabled ID cards can enhance security on campus. With traditional ID cards, it is relatively easy for someone to use a lost or stolen card for unauthorized access. By incorporating IoT features like biometric authentication or location-based tracking, the smart ID cards can offer enhanced security measures. This ensures that only the rightful owner of the card can access the campus facilities, reducing the risk of unauthorized entry and enhancing overall campus safety.

4.1.1.1.2. IoT in Personalized Learning Activities and Presentations

The integration of IoT in learning activities undoubtedly brings numerous benefits to students in higher education. One prominent example is the ability to connect devices to smart projectors, interactive whiteboards, and other presentation devices online. This enables students to enhance their presentations and engage with multimedia content, fostering a more interactive and immersive learning experience, as stated by respondents

> "Yes, of course, IoT can also help its users in learning activities. For example, when doing presentations, IoT allows users to connect their devices to smart projectors, interactive whiteboards, or other presentation devices online."

In addition to presentation capabilities, IoT devices such as smart boards offer various other advantages in the classroom. Students can utilize them for recreational purposes, such as listening to music or watching movies while waiting for the professor to arrive. This helps create a more relaxed and enjoyable atmosphere, allowing students to unwind before classes begin. IoT devices also extend their

benefits beyond the classroom. For instance, in campus libraries, providing tablets for students to freely use allows for personal refreshment and exploration.

> "With notifications through the smart board, students can obtain important information when entering the Z building. The large screen, similar to a smart board, inside the building provides various campus-related information, fundraising initiatives, scholarship information, and other updates. Through clear and easily accessible displays, students can quickly get updates on campus events, funding opportunities, scholarships, and relevant news." FGDs' Recorded

Furthermore, the availability of IoT in educational institutions is not limited to physical devices alone. Learning Management Systems (LMS) and mobile applications like Moodle offer additional benefits, for instance, allowing them to access course materials, receive assignment reminders, store their presentations conveniently, and access shuttle schedules and locations, enabling them to plan their travel efficiently. This creates a conducive environment for research, online collaboration, and accessing digital resources, as stated by S8:

> "Initially, I was unaware of the Internet of Things (IoT), but in my opinion, the smart board is very helpful in classroom learning. While waiting for the professor to arrive, we can use the smart board to listen to music, watch movies, or relax before class starts. In the campus library, they provide tablets for all students to freely use for playing, refreshing, and there are also computers and mini studios for recording and performing activities like singing. The LMS (Learning Management System) and university's applications also provide benefits, used to remind us of assignments, store presentations, and all the materials provided by the professors. Additionally, the campus mobile app is very useful. In the app, we can see the schedule of campus shuttles and their locations, so we can quickly depart for the campus." stated by S8

4.1.1.1.3. Overall Satisfaction and Availability of IoT

The implementation of a large screen inside the Z building, which serves as a platform for notifications and campus-related information, is a valuable application of IoT in higher education. This smart display not only enhances communication but also facilitates the dissemination of important updates and opportunities to students in a convenient and efficient manner. This large screen, similar to a smart board, serves as a centralized hub for delivering relevant information to students as they enter the building. The use of clear and easily accessible displays ensures that students can quickly and effortlessly access important updates on various aspects of campus life. This includes information about campus events, fundraising initiatives, scholarship opportunities, and other relevant news, as stated by S7 – for session two:

> "With notifications through the large screen, students can obtain important information when entering the Z building. This large screen, similar to a smart board, inside the building provides various campus-related information, fundraising initiatives, scholarship information, and other updates. Through clear and easily accessible displays, students can quickly get updates on campus events, funding opportunities, scholarships, and relevant news." stated by S7

The integration of IoT capabilities with large screens in educational institutions has the potential to revolutionize the way information is communicated to students. By leveraging real-time updates, these screens can ensure that students have access to the most up-to-date information, which is particularly valuable in a fast-paced educational environment where timely communication is essential for informed decision-making, active participation in campus activities, personalized messages, reminders, and even targeted advertisements based on specific student profiles.

4.1.1.2 Students Perceive IoT Easy to Navigate (User-Friendly)

The majority of students commonly recognize and acknowledge that IoT applications are user-friendly and easy to navigate. This perception of ease of use contributes to their positive attitude and willingness to engage with IoT technologies in their educational activities. Respondents also highlighted the advantages of enhancing the quality of academic and administrative services through the implementation of IoT. One notable example is the utilization of IoT in online-connected library systems, which enables quicker and more efficient access to collections and resources. This streamlined approach enhances the research and learning experience for students, providing them with seamless access to a wealth of information and materials using a smart board. As stated by participants in FGDs for session two:

> "It helps in doing home works with friends, presenting using smart board. I could imagine if there is no smart board, would display the images unclearly; making easier for presentations."

The IoT devices greatly facilitates efficiency, as lecturers can utilize PowerPoint presentations, share screens, and make annotations using smart boards. This enables them to teach more effectively and engage students in a dynamic learning environment. By leveraging IoT technologies, users can connect their devices to various presentation tools such as projectors and interactive whiteboards, offering a user-friendly and seamless experience. Smart Boards are also able to provide services like interactive displays and are integrate to create an interactive and engaging learning experience, as indicated in FGDs for session two:

> "Yes, that's correct. The ease of synchronization and assignment management makes it more effective and efficient. With the presence of IoT, it certainly facilitates the learning process itself, allowing for smoother learning activities. This, in turn, can enhance the understanding of individuals who are engaged in the learning process."

The presence of IoT in higher education facilitates the learning process, making it more effective and efficient. The convenience of synchronization and assignment management contributes to smoother learning activities and ultimately enhances individuals' understanding and engagement in the learning process.

4.1.1.3 Students' Technological Knowledge is Improving

It is evident that students recognize the importance of acquiring digital knowledge and skills to navigate various digital tools and platforms effectively in this present era, where advanced technology plays a central role and continues to evolve rapidly. This statement also highlighted by respondents that IoT enriches their personal experience with technology skills, which have enabled them to avoid technological challenges and bridge the gap of being technologically challenged (referred to Indonesian as "gaptek"). They recognize the value of acquiring various valuable skills through IoT, specifically emphasizing technology proficiency and analytical skills. These skills are particularly relevant and important in their chosen field of study. As per FGDs result:

> "It is true that technology skills have become increasingly important, especially in today's era where everything is driven by advanced technology and keeps up with the pace of development. In the past, during high school, IoT wasn't available, but once I entered college, I became familiar with technology skills through telecommunication. It helped me avoid being technologically challenged (gaptek). Undoubtedly, I have gained numerous valuable skills through IoT, such as technology proficiency and analytical skills, which are particularly important in my own field of study."

This statement highlighted that students aware of the importance of developing technology proficiency skills in preparation for the workforce, particularly in today's rapidly evolving technological landscape, being proficient in technology is crucial for success in various industries. As emphasized by the students's

experience, technology skills are highly sought-after and will continue to be in demand in the future, as indicated from FGDs recording:

> "Yes, it is indeed crucial because these skills will be needed when entering the workforce, and from my experience, one of the essential skills is technology proficiency. Technology skills are highly sought-after in both the present and future. Along with technology skills, communication and problem-solving skills are also important. By utilizing IoT technology in various campus facilities, it can expedite work processes and eliminate tasks that are deemed less significant."

However, it's important to note that technology proficiency alone is not sufficient. Alongside technical skills, communication and problem-solving skills are also essential for navigating the complexities of the modern workplace. A well-rounded skill set that combines technical expertise with effective communication and problem-solving abilities is also crucial for individuals to adapt, collaborate, and excel in today's rapidly evolving professional landscape.

4.1.1.4 Students Perceive the Enthusiasm in Learning Motivation

The results of an offline survey indicated that participants acknowledged the positive impact of IoT implementations on boosting learning motivation. One of the respondents also emphasized on how the positive experience of studying in the mini campus studio with the aid of IoT technology highlights the potential benefits and advantages can bring to the learning curiosity. It demonstrates how technology can be harnessed to create an engaging and dynamic learning environment, making the study sessions more enjoyable and effective. For instance, participant S6 expressed that IoT deepens their curiosity for information, making the process of seeking knowledge more engaging, as documented in a survey conducted by S6's statement:

> “I should be very confident, but sometimes I'm not. The reason is that when creating a PowerPoint presentation, I need to be as creative as possible with the design, and there is a sense of enthusiasm when presenting it to my peers using smart board.”

However, it is also important to note that the impact of technology on learning motivation can vary based on individual personalities and preferences. As expressed by S9 and S13- for session one:

> “It depends on each individual's understanding […] IoT is simply a tool to facilitate tasks.” stated by S9
>
> “Not really, because there are some classes without smart boards, but we can still learn. It's more relative.” stated by S13

This perspective indicated that the effectiveness of IoT in facilitating tasks and enhancing understanding depends on each individual's grasp of the underlying concepts and their ability to effectively integrate and utilize the technology. IoT serves as a valuable tool that can streamline processes and support learning, but it should also be seen as a complement to foundational knowledge rather than a standalone solution.

4.1.1.5 Students Perceive Hybrid Learning Experiences

In the Technology Acceptance Model (TAM) theory does not explicitly address the concept of perceiving hybrid learning experiences, research has shown that students recognized the benefits of interactive and personalized learning. Based on empirical observations, the researcher discovered that students have the option to engage in hybrid learning, which offers significant benefits to those unable to attend classes due to illness or other obstacles. The availability of platforms like Google Meet and Zoom Meeting for both offline and online learning reflects to providing flexible and accessible educational opportunities for students to participate and interact with their instructors and peers, as indicated by respondent in the FGDs session one:

> “Because the university allows students to participate in both offline and online learning through platforms such as Google Meet and Zoom Meeting. In addition, the campus also provides touch screen displays equipped with cameras. This feature enables students to engage in the learning process in a similar way to being physically present in the classroom.”

Additionally, the respondents also expressed the flexibility provided by the smart cameras, as they replicate the dynamics of an offline classroom environment, per recording by Participants at the Focus Group Discussions (FGDs) for session one. By utilizing these smart board and camera, students can actively engage in the learning process, similar to being physically present in the classroom. The hybrid learning experiences enable to deliver real-time video communication, allow students to ask questions, participate in discussions, and receive immediate feedback from their instructors like in physical class:

> “Yes, particularly with the presence of a smart camera that focuses on the lecture which enhances a real of engagement and provides a sense of participation as if we are in the physical class.”

However, it is contrary to observation, the researcher observed that the smart cameras were stationary and positioned at the center of the classroom and the camera's focus on specific objects or the lecturer is organized or situated by students or “not an automatic camera that analyzing object”. Since the camera could not automate tracking or motion capabilities, it requires a manual adjustment process, additional efforts, and active involvement from the students to situate the camera. Students must ensure that the camera’ object is properly connected and recognized by their laptops before they can actively participate in the online class. This dependency on students' laptop assistance and connectivity implies hindering or delaying students' engagement in the classroom, for example students may struggle to perform certain tasks without their devices, hindering their ability to function effectively in traditional learning settings or situations where technology is unavailable.

4.1.2 **Research Question Two: Students' Perspectives on IoT Challenges**

The utilization of Internet of Things (IoT) technology in university settings entails not only advantages and benefits but also presents several challenges and disadvantages. The researcher also undertook an investigation to examine the specific challenges associated with the implementation of IoT among students at the university. This section aims to explicate the particular challenges encountered in the application of IoT within the university context based on students' perspectives as bellows:

4.1.1.1.4. Psychological Issues

4.1.1.1.5. Students Encounter Confusion at The Beginning

Based on the comprehensive survey conducted, a substantial majority of 10 out of 14 students openly acknowledged experiencing a state of confusion during their initial interaction with IoT devices or applications. This confusion stemmed from the lack of formal training provided by the campus, leaving students unfamiliar with the intricacies of this advanced technology. S6 highlighted the diverse obstacles that contribute to this confusion, including difficulties in understanding device features and navigating interface elements on existing IoT devices, as indicated by S6 in survey:

> "When first using the smart board, I faced some challenges: 1) Confusion in determining which features to use. When initially operating the smart board, there is often confusion in selecting the available features and starting them correctly. 2) Uncertainty in choosing the appropriate buttons. There are many buttons and controls on the smart board, which may cause new users to feel confused in selecting the right buttons to initiate or operate specific functions."

This lack of familiarity can lead to complications and difficulties during the integration of IoT systems, leading to unforeseen delays, for example a sudden internet outage or connectivity issue affects several students, preventing them from accessing online resources essential for the activity. However, with time and

practice, users can overcome these difficulties and become proficient in operating the smart board effectively. It's important to note that these initial challenges are temporary and should not discourage users from embracing the benefits of using a smart board. Students also can overcome these hurdles and harness the full potential of the technology by asking peers and watching youtube channel The statement implies that students may face obstacles or difficulties when using smart classrooms initially.

However, it also suggests that these challenges can be overcome with time and effort. Students may encounter difficulties, but they have the potential to find solutions and adapt to the smart classroom environment successfully. The key is to remain persistent, seek support when needed, and gradually become more comfortable with the technology. Over time, the students can develop the skills and knowledge required to fully utilize the benefits of the smart classroom.

4.1.1.2. Technical Issues

4.1.1.2.1. The Unstable Connectivity of IoT Devices/Applications

Apart from the lack of guidance, another common problem that arises from students are when using IoT there is unstable internet connectivity. When the internet connection disruped, it renders the devices and applications unable to operate as intended. This issue raised by a male respondent S3, who highlighted the obstacle of dealing with an unstable network that hinders the smooth usage of IoT, as noted in the survey by S3

> "The common obstacle experienced is when the network is unstable, which disrupts the use of IoT."

Similarly, a student majoring in biomedical engineering also mentioned that when the connection goes down, the devices' performance compromised, as indicated in the survey where it noted that a loss of connection leads to reduced effectiveness. Additionally, another participant S10 mentioned that certain campus applications become less optimal when the internet connection is slow. Particularly, recent applications such as the campus learning management system can only be access through the campus connection. As a result, if the campus connection is down or

not functioning optimally, it becomes challenging for students to collect assignments, present material, and access applications. Respondent S10 expressed the difficulty faced by off-campus students, stating that "Application X" still requires the campus internet network, ultimately making it problematic for students who are not physically present on campus, as stated by respondent S10:

> "There are certainly challenges. Some examples include the suboptimal quality of IoT services, such as university website being inaccessible at times, or university application requiring access through the campus internet network, which can pose difficulties for students who are not on campus."

The performance disparities between Chrome and Firefox, with Chrome being faster and Firefox being slower, can often be attributed to the underlying network infrastructure. The quality and speed of the internet connection play a critical role in the accessibility and responsiveness of software applications. If the network experiences issues such as slow or unstable connections, it can lead to slower loading times, delayed responses, and overall reduced performance. Network congestion or limitations in bandwidth can also affect the speed at which data is transmitted, impacting the user experience on different software platforms. Therefore, when facing challenges with software performance, considering the network as a potential cause is essential in troubleshooting and identifying ways to optimize the user's experience.

> "There were some issues with different software. Chrome was faster to access, while Firefox was slower, so it was a bit challenging due to the network being one of the causes." FGDs' Recorded

Additionally, during the hybrid learning observation, the researcher also seeing directly that the smart board notify a warning when the internet connection is weak or unstable; where a stable internet connection is one of the crucial for facilitating students, therefore, any sudden weakening or loss of connection can disrupt Zoom meetings. Despite from this context, the focus group discussions (FGDs) for session two, it was resulted that their feedback did not specifically mention internet connectivity as a challenge they encountered while using IoT (Internet of Things)

technologies. This finding is worth noting as it suggests that internet connectivity might not have been a significant issue for this particular group of students for session two in relation to their experiences with IoT. The absence of mentions regarding internet connectivity challenges could indicate that the students for session two participating in the FGDs had access to stable and reliable internet connections, which allowed them to effectively utilize IoT technologies without disruptions or slowdowns.

4.1.2.2 The Frequent Occurrence of Technical Issues, and Server Down

Furthermore, the FGDs conducted with participants for session one highlighted additional challenges related to the utilization of IoT. Specifically, they identified configuration issues and technical difficulties, such as frequent server downtime of the application system. This can attribute to the system's insufficient capacity to handle a high volume of user requests, leading to an inability to meet the students' needs and causing the application to become inaccessible. During the FGD discussions, it revealed that all assignments, course materials, and student correspondence administration consolidating within a single application system. This system served as a vital platform for students to fulfill their academic requirements. A participant, identified as B, emphasized the impact of the application system's downtime on the delay in obtaining administrative documents:

> "The LMS application downtime caused considerable disruptions, leading to extensive delays in submitting assignments and obtaining internship certificates." participant B

> "In the beginning, yes, because it was still in the trial phase, so during online sessions, there were some challenges. The university was still experimenting, but now it has been largely resolved. There were instances of server downtime." participant C

The statement suggests that during the initial stages of implementing online sessions in the university, there were certain challenges due to the trial phase and

ongoing experimentation. This is a common occurrence when introducing new technologies or methods of instruction. The trial phase typically involves testing and fine-tuning various aspects of the online sessions, including the technology infrastructure, software platforms, and instructional methodologies. It is during this period that universities and institutions often encounter unexpected difficulties and obstacles. These challenges can arise from factors such as technical glitches, compatibility issues, insufficient training, or limited familiarity with the new systems. As a result of these challenges, students may have experienced difficulties during online sessions. It could include issues with connectivity, slow loading times, software crashes, or difficulty navigating the online platforms. These initial hurdles might have caused confusion and frustration among students as they were adapting to a new learning environment, for instance, unfamiliar interface, technical challenges, and lack of familiarity with features.

However, the statement also highlighted that the university has made significant progress in addressing and resolving these challenges. As the experimentation phase progressed, adjustments and improvements were likely made to the technology infrastructure, software platforms, and support systems. These efforts would have been aimed at enhancing the stability and functionality of the online sessions, thereby providing a smoother learning experience for students.

4.1.2.3 The Malfunctioning Over IoT Applications

The participants in the FGDs for session one also have highlighted the difficulties and complexities that arise due to the large number of assignment submissions through the Learning Management System (LMS). When a significant number of students submit their assignments through the LMS, it can create various challenges that need to be addressed. One of the primary challenges is the strain it puts on the LMS infrastructure. The sheer volume of submissions can overwhelm the system, leading to technical issues such as slow response times, system crashes, or difficulties in accessing the platform. These technical problems can disrupt the smooth submission process and cause frustration for both students and instructors.

Furthermore, the process of confirming, validating, or verifying the assignments becomes more complex when dealing with a high number of submissions. Multiple parties are involved in this process, including students, instructors, and potentially administrative staff that can further complicate the process, as recorded in the FGDs:

> "It will be difficult because there are many assignment submissions through the Learning Management System (LMS), and if there are any issues with it, it can be challenging. It requires confirmation from multiple parties and can be quite complicated."

They also highlighted the past occurrences where there were significant delays in the submission of assignments and the creation of internship letters. These delays could have been caused by various factors, such as technical issues, administrative processes, or communication gaps. Regardless of the specific reasons, the delays indicate that there were challenges in ensuring the timely completion and submission of assignments and internship-related documents. In addition to the submission delays, the statement also mentions a specific student application, referred to as application X. This application is exclusively accessible when connected to the campus Wi-Fi network. It implies that students can only utilize the functionalities of application X within the campus premises, and it becomes inaccessible when they are outside of the Wi-Fi range:

> "There have been instances in the past (technical issue) where a lot of assignment submissions or the creation of internship letters were delayed. Furthermore, our student application, called application X, can only be accessed when connected to the campus Wi-Fi. It cannot be accessed outside of that."

This limitation in accessing application X outside of the campus environment can have implications for students who may need to access the application while off-campus. It may hinder their ability to use certain features, retrieve important information, or engage with the application's resources and services. Students may

need to rely on alternative methods or platforms to access the necessary features or perform essential tasks when they are not connected to the campus Wi-Fi.

4.1.3 Research Question Three: Students' Expectations for Specific Improvements

In this section, the researcher will elaborate on students' expectations for improvements in their educational experience, with a particular emphasis on the potential contributions and support offered by the Internet of Things (IoT). The researcher would elaborate on students' expectations of IoT technology integration that will enhance accessibility within the degree program and facilitate smoother learning experiences. The detailed explanation will elaborate as the following bellows:

4.1.3.1 Server Functionalities and Maintenance Regularly

Server maintenance plays a crucial role in ensuring the smooth functioning of online platforms and systems used for educational purposes. It is vital for university to prioritize server maintenance to minimize disruptions and ensure that students have uninterrupted access to the resources they need to complete assignments and engage with course materials. Students emphasize the importance of proactive server maintenance and the need for university to have robust strategies in place to address potential downtime, as stated in survey:

> "It's more towards server maintenance because I've experienced server downtime and it has disrupted the learning process as the server was inaccessible, causing difficulties in completing assignments."

Additionally, effective communication with students about scheduled maintenance can help them plan their work accordingly and minimize the impact of any potential disruptions. This includes implementing backup systems and redundancy measures to ensure minimal downtime and quick recovery in the event of any issues. Timely and transparent communication with students about server maintenance schedules and any potential disruptions is also crucial to manage their expectations and allow

them to plan their coursework accordingly. University should establish a proactive communication strategy that includes regular updates on server maintenance schedules, clear instructions on accessing alternative resources during downtimes, and information on backup systems and redundancy measures in place. This level of transparency and timely communication not only minimizes the disruption to students' work but also fosters a sense of trust and collaboration between students and the university.

4.1.3.2 Expanding the Existing IoT Devices/Applications

In today's digital age, proficiency in technology is vital for success in various fields. By continuously improving and updating technological facilities, campuses can provide students with the tools they need to thrive in their academic pursuits and future careers. Up-to-date computers, software, and equipment can enable students to engage in cutting-edge research, develop practical skills, and enhance their overall learning experience. As mentioned by S7 in the survey, students' expectations for campus improvement is to prioritize the enhancement of technological facilities:

> "Looking ahead, my hope for campus development is for the campus to continuously improve its technological facilities, making them more advanced and student-friendly. As a specific request, I hope that computer labs can be enhanced on this campus. This is particularly important during practical sessions. I hope the campus can implement the concept of "open access labs" that allow unrestricted access for students to use computer lab facilities." stated by S7

In particular, computer labs play a significant role in facilitating hands-on learning experiences. During practical sessions, students often require access to specialized software, high-performance computers, or specific hardware. By increasing the number of computer labs, campuses can accommodate a larger number of students and reduce overcrowding, leading to a more conducive learning environment.

Furthermore, the concept of "open access labs" can bring numerous benefits to students. Open access labs would allow unrestricted access for students to utilize computer lab facilities outside of regular class hours. Additionally, open access labs foster dynamics learning, collaboration and teamwork among students who may need to work together on group projects or seek assistance from peers. This flexibility enables students to work on projects, assignments, or research at their convenience, promoting a self-directed and independent learning approach.

Not only that, by delving into a deeper understanding of this topic, researcher also exploring students' aspirations to expand existing systems and improve services to accommodate IoT devices and applications. The recognition of the transformative potential of IoT technology in supporting students' education is evident in the insights gathered from focus group discussions (FGDs). Participants in these FGDs for session one expressed the possibility of enhancing the current technology, as recorded in the field of biomedical engineering, as mentioned by the student:

> "Yes, it should be more optimal. My expectation is that the machines used should already be highly optimized, without the need to wait for them to function smoothly again before fixing them, and not solely for the convenience of the professors to continue their teaching."

The optimization of technological resources plays a crucial role in creating an efficient and productive learning environment. It is reasonable to expect that the machines used on campus should already be highly optimized, eliminating the need to wait for them to function smoothly before fixing them. Moreover, it is important to ensure that this optimization is done not solely for the convenience of professors but also to benefit the entire student community and enhance the teaching and learning experience. To address this concern, it is crucial for campus administrators and IT departments to prioritize the maintenance and optimization of technological resources. Regular check-ups, updates, and proactive troubleshooting can help identify and resolve potential issues before they impact the learning environment.

By doing so, students and professors can seamlessly utilize the machines without experiencing frustrating delays or interruptions.

4.1.3.3 Sustainable Energy Consumption: Smart Temperature and Lighting

Students specifically highlighted their hope for the campus to enhance operational efficiency by leveraging the Internet of Things (IoT) and focusing on sustainable energy consumption. They mentioned the potential use of smart temperature and lighting sensors that can regulate environmental conditions as needed. By implementing IoT technology in this manner, the campus can achieve significant improvements in its operational processes. An example of how IoT can contribute to operational efficiency is through the utilization of smart temperature sensors. These sensors can continuously monitor the temperature levels in various areas of the campus, enabling real-time data collection and analysis. With this information, the campus can optimize energy consumption by adjusting heating, ventilation, and air conditioning (HVAC) systems to maintain comfortable temperatures:

> "I hope that the campus can improve operational efficiency by utilizing IoT. An example would be the use of smart temperature and lighting sensors that can regulate environmental conditions when necessaries" stated by S12

> "In my opinion, for further improvements, the campus should implement IoT that able to optimize energy consumption." stated by S4

The suggestion to implement IoT to optimize energy consumption on campus opens up an important discussion about the potential benefits and considerations of integrating IoT technology for energy management. Implementing IoT solutions for energy optimization can significantly improve energy efficiency on campus. This allows for proactive identification of energy wastage and the implementation of targeted energy-saving strategies. Ultimately, optimizing energy consumption can lead to substantial cost reductions for the institution.

4.1.3.4 Improvements for Attendance Systems and Classroom Technology

System's Attendance

The proposal suggests the implementation of self-attendance systems in academic settings, along with the integration of door systems. Self-attendance systems refer to the use of IoT technology to automate the process of recording attendance. This can involve the deployment of IoT devices, such as smart sensors or biometric scanners, that enable students to register their attendance without manual intervention. Integrating self-attendance systems with attendance apps would allow for seamless data management and reporting. By connecting the self-attendance systems with existing attendance tracking apps, university can streamline attendance record-keeping and enhance accuracy. This integration enables real-time updates and provides a centralized database of attendance records, facilitating efficient monitoring and analysis of attendance patterns, as stated by students for FGDs session one:

> "The hope is for this campus to implement self-attendance through an application or automatic registration when students tap in using the smart door. Although the campus already has a mobile attendance app, some professors still manually take attendance. It is expected to be more efficient and convenient for professors, respecting their time. Additionally, the smart door system can directly integrate with the professors' attendance app, automatically recording student attendance. It is also important to ensure equal usage of technology in all classrooms, such as smart boards or smart cameras, so that every room is equipped with the same technology." stated by S7

> "Yes, it should be more optimal. My expectation is that the machines used should already be highly optimized, without the need to wait for them to function smoothly again before fixing them, and not solely for the convenience of the professors to continue their teaching." stated by S4

It is crucial for university to prioritize the efficient functioning of the machines used for teaching and learning, for instance, during a class, students heavily rely on the

smart boards to present materials and discussion. If the smart boards' connection are slow or encounter technical issues, it can lead to significant disruptions in the learning process. Students may experience frustration and delays in their coursework, hindering their ability to grasp programming concepts effectively. When machines are optimized, it minimizes disruptions in the classroom and allows professors to deliver their lessons smoothly. It also enhances the overall learning experience for students, as they can fully engage with the educational content without being impeded by technical difficulties. By prioritizing machine optimization, university can create an environment where teaching and learning can occur seamlessly, enhancing the educational experience for everyone involved. It is important for university to prioritize the needs of both professors and students, ensuring that machines are optimized and any technical issues are promptly addressed. This mission going to running smoothly with the collaboration between academic staff, IT departments, and maintenance teams to create an environment where machines are reliable and efficiently support the educational process.

4.2.3.3.1. Classroom Technology – Supporting Virtual Reality (VR)

Virtual Reality (VR) technology has the potential to provide immersive and interactive experiences that can enhance the learning process. By leveraging VR, university can overcome the limitations of physical hardware availability and still provide students with valuable hands-on experiences. This can be especially beneficial for courses that require expensive or rare equipment that may not be easily accessible to all students, as indicated by respondent:

> "For certain courses, especially those with limited availability of hardware in practical sessions, it is hoped that the campus will provide facilities using VR (Virtual Reality)." stated by S3

Many scholars described that VR can simulate real-world scenarios, allowing students to practice skills, conduct experiments, or explore environments that would otherwise be difficult to replicate in a traditional classroom setting (Nasyrov & Excell, 2020). By using VR, university can bridge the gap between theoretical knowledge and real-world application, making learning more interactive and

impactful. Moreover, VR can cater to different learning styles, allowing students to engage with the material in a personalized and immersive manner. By immersing themselves in virtual environments, students can gain practical skills and knowledge in a safe and controlled setting. Moreover, VR can enable collaborative learning experiences, allowing students to engage and interact with their peers in a virtual space. This fosters teamwork, critical thinking, and problem-solving skills, which are essential for success in various professional fields.

4.1.3.5 Facilitating the Socialization and Adoption of IoT Utilization

Simultaneously, students also express their expectations for campuses to provide practical guidance and support for utilizing IoT devices. This arises from the fact that many students encounter confusion and uncertainty when initially engaging with IoT technologies. During the learning process, students often find themselves having to independently explore and navigate the functions and features of IoT devices. A male student from the survey, identified as S10, emphasized the need for campuses to offer assistance in this regard:

> "The hope is that the campus can facilitate various academic needs, and ensure that socialization activities are not compromise. It is important for campuses to keep pace with technological advancements, enabling technology to enhance human life, particularly in the realm of education, thus contributing to an improved educational experience."

Therefore, students stress the significance of campuses providing practical guidance and resources to support their understanding and utilization of IoT technologies. By offering workshops, training sessions, or dedicated support services, campuses can ensure that students have the necessary knowledge and skills to effectively leverages the potential of IoT devices in their academic pursuits. This proactive approach helps minimize confusion and frustration, enabling students to fully benefits from the advantages IoT offers while fostering an environment that encourages socialization and interpersonal connections. Furthermore, by embracing and integrating IoT into the educational framework, campuses demonstrate their commitment to utilizing technology as a means of

enhancing the overall quality of education and improving the learning outcomes for students.

4.1.3.6. Improvements for the Educational Quality System

Education plays a crucial role in the successful implementation of IoT. As IoT technology becomes more prevalent, it is essential to provide comprehensive education and training to users. By delivering detailed education on how to use IoT devices and systems effectively, individuals can maximize their benefits while minimizing potential risks. This education should cover various aspects, including device setup, data management, security protocols, and troubleshooting. When users are equipped with the necessary knowledge and understanding, they can make informed decisions, ensure proper usage, and mitigate any potential challenges. Alongside education, it is equally important to focus on improving the quality of IoT systems. As with any technology, the quality of IoT devices and infrastructure directly impacts their performance and reliability. Efforts should be made to enhance the quality of IoT systems, including hardware, software, and connectivity components. This can involve rigorous testing, quality assurance measures, and adherence to industry standards. By improving the quality of IoT systems, users can have confidence in their reliability and trustworthiness, which are vital factors for widespread adoption and acceptance, as recorded in FGDs:

> "For me, as long as the education know on how to use it is delivered in detail and the quality of the system is improved, it shouldn't be a problem." recorded in FGDs

> "Certainly, hopefully the university to expand the IoT implementation."

This statement acknowledged students' expectations for university to continue evolution and advancements of IoT regularly. The potential benefits that IoT offers are immense, and it is essential for university to keep up with the advancements in technology and equip their students with the necessary knowledge and skills to thrive in the digital era. By expanding IoT implementation, university can provide cutting-edge education, foster research and innovation, and bridge the gap between

academia and industry. As IoT becomes increasingly integrated into industries, graduates with expertise in this area will have a competitive advantage. Moreover, expanding IoT implementation at university would create a conducive environment for research and collaboration. It would enable interdisciplinary projects, encourage entrepreneurial initiatives, and contribute to the development of innovative solutions that address real-world challenges.

Table 3.3 Students' Perspectives of IoT Utilization in Higher Education

Benefits	Challenges	Specific Improvements
Students Perceive Satisfaction and Fulfillment	Students Encounter Confusion at The Beginning	Server Functionalities and Maintenance Regularly
Students Perceive IoT Easy to Navigate (User-Friendly)	The Unstable Connectivity of IoT Devices and Applications	Expanding the Existing IoT Devices/Applications
Students' Technological Knowledge is Improving	The Frequent Occurrence of Errors, Technical Issues, and Server Down	Sustainable Energy Consumption: Smart Temperature and Lighting
Students Perceive the Enthusiasm in Learning Motivation	Student Frustration Over A Malfunctioning Iot Application	Facilitating the Socialization and Adoption of IoT Utilization
Students Perceive Hybrid Learning Experiences	-	Improvements for The Educational Quality System

4.2. Research Discussions

In this comprehensive section, researcher embark on an in-depth exploration and analysis of the viewpoints and opinions expressed by students concerning the integration and utilization of the transformative Internet of Things (IoT) in the context of higher education. These discussions center around three key research questions that aim to shed light on the impact and effectiveness of IoT

implementation at university. Through meticulous examination and careful consideration of the student perspective, researcher strive to deliver valuable discussion into the benefits, challenges, and expectations for improvement of IoT in higher education.

4.2.1 **Students' Views of the Positive Aspects of IoT in Higher Education**

The discussion on students' perception of the benefits of integrating the Internet of Things (IoT) in higher education, based on the Technology Acceptance Model (TAM), highlights several critical points. Firstly, students express that integrating IoT brings them convenience, satisfaction, and fulfillment, resulting in improved access to higher education. Studies from Mohite and Raverkar (2021) also emphasized the positive impact of smart boards on teaching and learning processes, digital boards offer convenience and advantages for digitalized, dynamic, and customized learning methods preparing students for the demands of the modern world. This is similar to the finding that students appreciate the ease and convenience of using IoT features such as tap records for parking and access card-based entry doors, which enhance convenience and campus security. Students specifically mention their satisfaction with the simplified processes, enhanced security measures, and improved overall experience on campus due to the integration of IoT.

Secondly, according to students' opinions, the integration of IoT in learning activities, such as connecting devices to smart projectors and interactive whiteboards, offers them more interactive and immersive learning experiences, for example, students can create multimedia presentations or videos to express their ideas creatively, integrating images, videos, and audio to enhance their learning process in the classroom. Students highlight the advantages that IoT devices like smart boards bring beyond the classroom setting. For example, they mention the availability of recreational activities in waiting areas and the provision of tablets in libraries for personal use. Additionally, they value the benefits of Learning Management Systems (LMS) and mobile applications like Moodle, which provide easy access to course materials, assignment reminders, and shuttle schedules. These

features contribute to improved efficiency, research opportunities, and collaborative learning experiences, as expressed by the students. Similarly, the research studies from Brou (2015) and Ali M. F. (2019) also provide the evidence of the positive impact of technology on students in educational processes such as assignments, security, safety, convenience, access to online resources, and assignment completion.

Thirdly, according Abdullah (n.d) in the TAM theory; the perceived ease of use is influenced by various factors, including the availability of user-friendly features. When a technology perceived as easy to use, individuals are more likely to adopt and utilize it in their daily lives (Ma & Gam, 2017). The study's finding mentioned that students appreciate the availability of IoT devices and the integration of IoT capabilities, such as large screens for notifications and campus-related information. They acknowledge that these features revolutionize communication and provide real-time updates to students. The ability to access important updates on campus events, funding opportunities, scholarships, and relevant news seen as a conducive environment for informed decision-making and active participation in campus activities. Furthermore, students mention their perception of IoT applications as user-friendly and easy to navigate. This positive perception contributes to their positive attitude and willingness to engage with IoT technologies in their educational activities. They specifically highlight the ease of synchronization, assignment management, and the use of smart boards, which they believe enhance efficiency and effectiveness in teaching and learning processes.

Even though in the Technology Acceptance Model (TAM) theory does not explicitly address users' digital knowledge improvements, it is widely recognized that students understand the significance and practicality of technological knowledge. Moreover, studies conducted by the American University (June 2020) and Lin (2021) highlight that universities aim to develop students' technological literacy, critical thinking skills, and contextual understanding of technology's impact through the utilization of technology itself. The results also shown that students recognize the importance of acquiring technological knowledge and skills

to effectively navigate various digital tools and platforms like smart board, and learning management system. They find that IoT enriches their personal experience by providing them with technology skills such as technology proficiency and analytical skills such as the ability to critically navigate the IoT features to gain a technological understandingThey express that these skills are highly sought-after in the present and future workforce.

However, students also acknowledge the significance of communication and problem-solving skills, which they consider crucial for success in the rapidly evolving professional landscape. Their opinions emphasize the importance of having a well-rounded skill set that combines technical expertise with effective communication and problem-solving abilities. Similar to the previous result, the Technology Acceptance Model (TAM) theory does not explicitly address the augmentation of inherent enthusiasm in learning motivation among students. This is similar to the results that the majority of students believe that IoT (Internet of Things) can also enhance curiosity and learning motivation.

Lastly, Bogdanović and Simić (2014) and Explorance (May 2020) support the notion of IoT could enhance the collaborative learning, critical thinking and creativity development among students. According to students' opinion, the integration of IoT and hybrid learning experiences offers them flexibility and accessibility in their educational opportunities. They appreciate the platforms like Google Meet and Zoom Meeting, as well as the use of smart cameras, which enable them to participate and interact with their instructors and peers in both offline and online learning environments. However, students also mention the limitations of smart camera functionality, which may hinder their engagement in online classes. They acknowledge that additional efforts and active involvement are required to overcome these limitations.

Overall, students believe that the integration of IoT in higher education has the potential to enhance their satisfaction, convenience, access, learning experiences, technological knowledge, and motivation. However, they emphasize the importance of addressing limitations and ensuring that IoT implementations are

user-friendly and effectively support teaching and learning processes to maximize their benefits.

4.2.2 **Students' Views of the Limitations of IoT in Higher Education**

The findings from the comprehensive survey conducted reveal several significant challenges and obstacles faced by students during the initial integration of IoT in higher education. As mentioned by Scheau (2018) the complexity of IoT systems poses challenges for students, particularly those who are not familiar with IoT technology. One of the primary issues identified in the results that the students' confusion at the beginning of their interaction with IoT devices or applications. The lack of formal training provided by the campus is a major contributing factor to this confusion. Without proper guidance, students find themselves unfamiliar with the intricacies of this advanced technology. This is evident from the statements of participants who expressed confusion in understanding device features and navigating interface elements on existing IoT devices, such as the smart board. The complexity of IoT systems poses challenges, particularly for students who are not familiar with this technology. However, it is important to note that with time and practice, users can overcome these initial difficulties and become proficient in operating IoT devices effectively.

As mentioned by Patel (2016) connectivity is a fundamental aspect of IoT, as it forms the backbone of a communication network that links devices together. This network enables smooth interaction, seamless communication, and efficient information exchange between devices and the internet. Ruziyev & Sultanov (2022) The availability of connectivity allows humans to effortlessly engage with IoT devices, facilitating the exchange of information and enabling various applications. Ensuring reliable connectivity is crucial for the optimal functioning of IoT systems, as they heavily rely on internet connectivity for their operations. Another common problem highlighted by students in the result is the unstable connectivity of IoT devices and applications. Students face issues when the internet connection

becomes disrupted, rendering the devices and applications unable to operate as intended.

This issue not only affects the smooth usage of IoT but also hampers access to important resources and services, such as online learning platforms and campus applications. The dependency on a stable internet connection becomes evident, as students mention the difficulties they face when the network is unstable or slow. This can lead to delays in assignments, reduced effectiveness of devices, and challenges for off-campus students who rely on campus internet networks. Ensuring reliable connectivity is crucial for the optimal functioning of IoT systems, and university needs to address this issue to provide a seamless user experience.

Furthermore, Gul (2017) mentioned that the implementation of IoT incurs costs, including internet connectivity expenses, maintenance and improvement fees, and potential application fees. The study found that the university's system frequently engage in occurrence of errors, technical issues, and server downtime poses significant challenges for students using IoT. During the initial stages of implementing online sessions and IoT technologies, university often encounter unexpected difficulties and obstacles. Students may face configuration issues, technical glitches, or encounter problems with the application system itself. This can lead to delays in submitting assignments, obtaining administrative documents, and accessing important resources. The strain on the system caused by a large volume of student submissions can overwhelm the infrastructure, resulting in slow response times, system crashes, and difficulties in the validation process. University need to address these technical issues to ensure a smooth and efficient submission process for students. However, Aldowah et al (2017) mentioned that one of the difficulties in maintaining of devices/applications is to maintaining the quality standard, and in order to achieve this purposes, the university need to allocate higher financial resources each year, encompassing expenses related to content and applications.

Moreover, the dependence on IoT devices and applications can hinder students' ability to work independently and think critically without constant aid.

Uslu (2022) mentioned that one of the challenges of IoT utilization is important students may develop a dependence or addiction to technology, including IoT devices. Although the usage of IoT in universities facilitates efficient completion of assignments, but there is a risk that students unknowingly become overly reliant on technology and hinder their ability to work on tasks independently and think critically and creatively without the constant aid of technology or internet connectivity, such as they might prefer to collaborate solely through virtual platforms, foregoing face-to-face interactions rather than in group discussions or in-person meetings There is a risk that students become overly reliant on technology which potentially compromising their creativity and critical thinking skills, for example, instead of conducting hands-on experiments or engaging in classroom, they might solely depend on the digital representation provided by the IoT-enabled boardIt is important to strike a balance between utilizing IoT for enhanced learning experiences and ensuring students develop independent problem-solving abilities.

Overall, the integration of IoT in higher education offers immense potential, but it is crucial to address the challenges and limitations that students face. University should provide comprehensive training and support to students, ensure stable connectivity, address technical issues promptly, and promote a balanced approach to technology usage like the awareness of technology's impact, mindful technology use, and digital literacy By doing so, the benefits of IoT in higher education can be maximized, leading to improved learning experiences and outcomes for students.

4.2.3 **Students' Views on Specific Enhancements in Higher Education**

The researcher's focus on students' perspectives regarding improvements in their educational experience through the integration of the Internet of Things (IoT) is commendable. However, it is important to critically examine the discussion and consider potential limitations and concerns. Firstly, regarding the server functionalities and maintenance, students highlights the importance of proactive maintenance to minimize disruptions. While this is crucial, it is also essential to consider the financial and technical resources required for effective server

maintenance. Implementing robust strategies and allocating sufficient resources for server maintenance can be challenging for university with limited budgets and IT capabilities.

Therefore, it is crucial to find a balance between the need for maintenance and the practicality of implementation within the given constraints. Expanding IoT devices and applications can undoubtedly enhance the learning experience, but there are practical considerations to address. The cost of acquiring and maintaining IoT devices, software, and infrastructure can be significant. University must carefully evaluate the cost-benefit ratio and ensure that the investments align with their educational goals. Additionally, it is essential to consider the training and support required for students to effectively use and integrate IoT devices into the curriculum. The discussion on sustainable energy consumption through smart temperature and lighting sensors is promising.

However, it is crucial to consider the environmental impact associated with manufacturing, deploying, and disposing of IoT devices. The production of these devices involves the use of natural resources, and their disposal can contribute to electronic waste.University should strive to adopt sustainable practices not only in energy consumption but also in the entire lifecycle of IoT devices, including responsible manufacturing and recycling processes. The proposal for self-attendance systems and the integration of door systems can streamline administrative processes. However, it is important to recognize potential privacy concerns associated with these systems.Collecting and managing personal data through IoT devices can pose risks if proper security measures are not in place. It is imperative for university to implement robust data protection protocols and ensure transparent communication with students regarding the collection, storage, and usage of their personal information. While virtual reality (VR) technology has the potential to enhance the learning experience, it may not be accessible to all students. VR devices can be expensive, and their availability may vary across campuses or programs. University should consider alternative approaches to ensure inclusivity and provide equitable access to learning experiences. Additionally, it is

important to conduct research on the effectiveness of VR in achieving learning outcomes compared to traditional methods to justify the investment and integration of this technology.

Facilitating the socialization and adoption of IoT devices is crucial. However, it is equally important to promote digital literacy skills among students. Merely providing guidance and support may not be sufficient if students lack the necessary skills to critically evaluate and navigate IoT technologies, for example students can quickly understand the technical interfaces of various IoT devices. University should prioritize digital literacy education, empowering students to become knowledgeable users who can adapt to emerging technologies effectively. Improving the quality of IoT systems and providing comprehensive education are commendable goals. However, it is essential to consider the rapidly evolving nature of IoT technology. Continuous updates and improvements are necessary to ensure compatibility, security, and performance. University should establish mechanisms for ongoing evaluation, monitoring, and adaptation to address any shortcomings or emerging challenges. Additionally, collaboration with industry partners and relevant stakeholders can help university stay updated with the latest trends and advancements in IoT technology.

In conclusion, while the researcher's focus on students' expectations for improvements through IoT integration is valuable, it is important to critically evaluate the practicality, feasibility, and potential limitations associated with implementing IoT in educational settings. By addressing these concerns, university can make informed decisions and effectively leverage IoT technology to enhance the educational experience for students.

CHAPTER V
CONCLUSIONS AND SUGGESTIONS

5.1. Conclusions

Based on the study's results and discussions, it can be concluded that students generally hold a positive perspective on the benefits of IoT in education. Through surveys and FGDs, students have expressed their recognition of the potential advantages that IoT technologies can bring to the educational landscape. Students find satisfaction and fulfillment in utilizing IoT technologies, primarily due to the convenience, accessibility, and seamless connectivity they provide. The integration of IoT in academic and administrative services, such as online-connected libraries and smart classrooms, enhances the quality of education by facilitating efficient access to resources and creating dynamic learning environments. Furthermore, students also recognize the importance of technological fluency and the development of strong technical skills to adapt to the advancements in technology. Students realize the IoT utilization offers opportunities for students to enhance their system-technological skills and problem-solving abilities. However, students also face challenges when integrating IoT, for instance, the lack of clear guidelines and formal training from university regarding IoT utilization leads to confusion and a lack of understanding among students.

Moreover, the stability and reliability of internet connections play a crucial role in the proper functioning of IoT devices, and any sub-optimal connectivity can hinder and disrupt the effective use of IoT applications, causing inconvenience and frustration. To address these challenges and students put certain expectations, such as the university should prioritize server functionalities and maintenance practices to ensure uninterrupted access to resources. The university also should provide guidance, support, and training for students to effectively utilize IoT devices and applications are essential. Additionally, students also expect the university to expand existing systems and improve services to accommodate IoT devices, implement VR facilities for immersive learning experiences, and incorporate sustainable energy consumption through IoT-based solutions.

5.2. Suggestions

To enhance the study and academic experience, several suggestions can be considered. First and foremost, incorporating the perspectives of not only students but also lecturers and staff members is crucial. It is also includes on how IoT devices and sensors can effectively gather data on student behavior, interactions, and learning patterns. Understanding these insights can pave the way for personalized learning approaches and instructional interventions. Secondly, investigate the role of IoT in supporting teacher professional development. Analyze the use of IoT devices and data analytics to provide educators with personalized training, feedback, and resources that align with their unique needs and teaching styles. Particularly, conducting study on how IoT can enhance curriculum delivery and content creation. Explore the seamless integration of IoT technologies in educational materials, textbooks, and multimedia resources to promote interactive and immersive learning experiences.Thirdly, assess the potential of IoT technologies in campus management and optimization. Investigate how IoT can optimize resource allocation, improve energy efficiency, and streamline processes within educational institutions. The researchers suggest to examine the feasibility and effectiveness of using IoT devices and sensors for learning assessment. Investigate how IoT data can integrate into formative and summative assessment strategies to provide real-time feedback and valuable insights into students' progress, analyze the impact of IoT-based tools and applications on student engagement and motivation and uncover how IoT can be harnessed to create interactive and captivating learning experiences that enhance student involvement in the educational process.

The next suggestions are to explore the potential of IoT technologies to support students with special needs and disabilities in their educational journey. Investigate the use of IoT-based assistive technologies and personalized learning tools to foster inclusive education, examine the role of IoT in fostering collaborative learning environments and analyze how IoT facilitates seamless communication

and collaboration among students and teachers in both physical and virtual classrooms. To conduct these studies effectively, it is essential to collaborate closely with educators, administrators, and students to gain valuable insights into their needs and perspectives. Moreover, it is crucial to uphold data protection and student privacy standards while collecting and analyzing data from IoT devices. The research outcomes in this field have the potential to significantly advance IoT in education, thereby promoting more efficient, engaging, and inclusive learning experiences for all students.

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APPENDIX A - SURVEY OPEN-ENDED QUESTIONNAIRE

The Internet of Things Adoption in Higher Education: Exploring Students' Perspectives on the Benefits and Challenges
– A Case Study in Indonesian University
(Adapted from Kranich, 2018)

English Version

1. Your current degree :
   - □ S1 (Bachelor's Degree)
   - □ S2 (Master's Degree)
   - □ S3 (Doctorate Degree)
2. Whatsapp Number :
3. Faculty/Major :
4. In what semester :
5. Gender identity :
   - □ Male
   - □ Female

Please share your experiences by responding to the following statements (the confidentiality of your responses is a top priority for us, the researcher is dedicated to protecting both your privacy and the security of any personal information we collect from you):

1. Based on your experiences with iot, how satisfied are you in using iot? please elaborate further details about your satisfaction
2. Could you elaborate the multitude benefits have you obtain in your daily activities in campus? Provide specific examples and explain in detail please
3. In your personal experiences, are you inclined continuing using IoT? If so, what are the reasons behind that? please explain your concern

4. Have you personally perceive any challenges in the implementation of iot in your university? Please elaborate any specific the obstacles
5. What are the improvements do you envision through the adoption of iot on your campus? Please elaborate your expectations in specific

Appendix A - Survei Kuesioner Terbuka

Penerapan Internet of Things di Perguruan Tinggi: Mengeksplorasi Perspektif Mahasiswa tentang Manfaat dan Tantangan –
Studi Kasus di Perguruan Tinggi di Indonesia

(Diadaptasi dari Kranich, 2018)

Versi Bahasa Indonesia

1. Nama :
2. Gelar Anda saat ini :
   - □ S1 (Gelar Sarjana)
   - □ S2 (Gelar Magister)
   - □ S3 (Gelar Doktor)
2. Fakultas/Jurusan :
3. No Whatsapp :
4. Pada semester berapa :
5. Jenis Kelamin :
   - □ Laki-laki
   - □ Perempuan

Mohon bagikan pengalaman Anda dengan menjawab pernyataan-pernyataan berikut ini (Kerahasiaan jawaban Anda merupakan prioritas utama kami, dan peneliti berdedikasi untuk melindungi privasi dan keamanan informasi pribadi yang kami kumpulkan dari Anda):

1. Dapatkah Anda menjelaskan berbagai manfaat yang telah Anda peroleh dengan menggunakan IoT dalam kegiatan sehari-hari di kampus? Berikan contoh spesifik dan jelaskan secara detail bagaimana IoT memberikan manfaat bagi Anda?
2. Menurut anda, apakah penggunaan IoT dapat membuat Anda merasa lebih percaya diri dalam menguasai materi dan mempresentasikan ide-ide?

3. Berdasarkan pengalaman pribadi Anda, apakah Anda cenderung untuk terus menggunakan IoT? Jika ya, tolong jelaskan alasan di balik itu keputusan Anda? Jika tidak, mengapa Anda merasa bahwa IoT tidak sepenting itu?
4. Apakah Anda menghadapi tantangan tertentu dalam menggunakan IoT di universitas Anda? Mohon jelaskan secara rinci hambatan-hambatan yang Anda alami (contohnya: ketika diawal penggunaan IoT, Apakah kamu merasa bingung dan mengalami kesulitan/kebingungan dalam menggunakan teknologi IoT mungkin karena kurangnya pengalamanmu dalam menggunakan perangkat atau aplikasi IoT?
5. Apa harapan Anda mengenai peningkatan melalui penerapan IoT di kampus Anda? Tolong jelaskan ekspektasi Anda secara detail?

APPENDIX B - FOCUS GROUP DISCUSSIONS (FGDS) INSTRUMENT

Benefits

1. Do you think about the integration of IoT devices/applications facilitate and elevate your daily academics in university?
    a. How does the IoT utilization affect class management, such as improve collaborative learning or interactive learning?
    b. Do you think iot technology could enhance your abilities and skills? Is it easy to use? What kind of skills and explain
    c. Is it your opinion that using iot is a seamless and effortless process? Please explain
2. Do you think that using iot will have positive impacts to completing your assignments? Please elaborate in detail
    a. How IoT devices/application help in accessing information (e.g. online libraries, research materials, or databases)?
    b. Do you think that IoT devices/application will increase your ability to concentrate and maintain focus?
    c. How do you see IoT increase your supportive learning environment and improve your confident in understanding study?

Challenges

3. Do you think that IoT-related systems are difficult to operate? please elaborate your experiences
    a. Do you think the use of iot will complicate lecture process? Or based on your experiences, have you ever obtain any technical complexity issues like network configuration, data management, and privacy concern? Kindly tell in specific

Expectations for Improvements

4. What are the improvements do you expect from iot in your university? Do you any expectation of improvements in enhancing your learning methods, administrative processes, or educational process?

Appendix B - Diskusi Kelompok/Fokus

Manfaat

1. Menurut Anda, apakah integrasi perangkat/aplikasi IoT memudahkan dan meningkatkan kegiatan akademis Anda sehari-hari di universitas?
    a. Bagaimana pemanfaatan IoT mempengaruhi manajemen kelas, seperti meningkatkan pembelajaran kolaboratif atau pembelajaran interaktif?
    b. Menurut Anda, apakah teknologi IoT dapat meningkatkan kemampuan dan keterampilan Anda? Apakah mudah digunakan? Keterampilan seperti apa dan jelaskan
    c. Apakah menurut Anda penggunaan IoT merupakan proses yang mulus dan mudah? Mohon jelaskan
2. Apakah menurut Anda penggunaan IoT akan memberikan dampak positif dalam menyelesaikan tugas Anda? Mohon jelaskan secara rinci
    a. Bagaimana perangkat/aplikasi IoT membantu dalam mengakses informasi (misal: perpustakaan online, bahan penelitian, atau database)?
    b. Menurut Anda, apakah perangkat/aplikasi IoT dapat meningkatkan kemampuan Anda untuk berkonsentrasi dan mempertahankan fokus?
    c. Bagaimana Anda melihat IoT meningkatkan lingkungan belajar yang mendukung dan meningkatkan rasa percaya diri Anda dalam memahami pelajaran?

Tantangan

3. Apakah menurut Anda sistem yang berhubungan dengan IoT sulit untuk dioperasikan? mohon jelaskan pengalaman Anda
    a. Apakah menurut Anda penggunaan IoT akan mempersulit proses perkuliahan? atau mungkin berdasarkan pengalaman Anda, apakah

Anda pernah mengalami masalah kompleksitas teknis seperti konfigurasi jaringan, manajemen data, dan masalah privasi?

Harapan untuk Perbaikan

4. Apa saja perbaikan yang Anda harapkan dari IoT di universitas Anda? Apakah Anda mengharapkan perbaikan dalam meningkatkan metode pembelajaran, proses administrasi, atau proses pendidikan?

APPENDIX C- OBSERVATION INSTRUMENTS

English Version

Name of Institution :

Location :

A. IoT devices/applications in students' university

1. Observe students' activities in utilizing IoTs; Benefits and Challenges
2. Give a comment or reflection according to the observed situation

Time/Date	Activities	Comment/Reflection

Appendix C - Instrumen Observasi

Versi Bahasa Indonesia

Nama Institusi :

Lokasi/Tempat :

A. Perangkat/aplikasi IoT di universitas mahasiswa

1. Mengamati kegiatan mahasiswa di kampus dalam memanfaatkan IoT
2. Berikan komentar atau refleksi sesuai dengan situasi yang diamati.

Tanggal/Waktu	Aktivitas	Komentar/Refleksi

APPENDIX D - TRANSCRIBING FGDS FEMALES – ENGLISH VERSION

A=S9 B=S10 C=S11

Benefits

Researcher	In your opinion, does the integration of IOT devices/applications facilitate and improve your daily academic activities at university? How does the utilization of IoT affect classroom management, such as enhancing collaborative learning or interactive learning?
Respondent A	It helps in doing homeworks with friends, presenting using smart board. I could imagine if there is no smart board, would display the images unclearly.
Respondent B	It is extremely helpful for classroom discussions, especially when there is a provision of Wi-Fi, making easier for presentations.
Respondent C	It is really helpful and more efficient. The professors can teach using PowerPoint more clearly or even annotate on the board.
Researcher	Do you think IoT technology can improve your skills and abilities? Explain
Respondent A	It is certain that skills are enhanced after using IoT. It provides a better understanding of technology, how to use it, and familiarity with IoT knowledge. For example, in my high school days, no one used smart boards or advanced technology like this. However, in college, having a smart board and its features increased my knowledge, and I became dependable in using it in class for my fellow classmates. However, not all professors are proficient in technology.

	Some even ask for assistance in sharing PowerPoint presentations or downloading smart applications to install on the Smart Board. Usually, if the professors are not technologically savvy, it takes around 10 minutes to understand, and then they don't need assistance from students anymore.
Respondent B	It is true that technology skills have become increasingly important, especially in today's era where everything is driven by advanced technology and keeps up with the pace of development. In the past, during high school, IoT wasn't available, but once I entered college, I became familiar with technology skills through telecommunication. It helped me avoid being technologically challenged (gaptek). Undoubtedly, I have gained numerous valuable skills through IoT, such as technology proficiency and analytical skills, which are particularly important in my own field of study.
Respondent C	Yes, it is indeed crucial because these skills will be needed when entering the workforce, and from my experience, one of the essential skills is technology proficiency. Technology skills are highly sought-after in both the present and future. Along with technology skills, communication and problem-solving skills are also important. By utilizing IoT technology in various campus facilities, it can expedite work processes and eliminate tasks that are deemed less significant.
Researcher	Do you think the use of IoT is helping in easy the learning process?
	Please explain.
Respondent A	Indeed, the learning process can be enhanced and become more engaging with the presence of technology. It sparks

	curiosity and makes learning more exciting, which in turn increases motivation and curiosity. In terms of academic achievements, it can be said that improved as well. The desire to acquire knowledge is amplified, and it aids the classroom process. For example, without a Smart Board, the class might feel less efficient and unclear for those sitting at the back. Erasing the board manually can also be messy. With technology, we able to sharing the screen and having an automated display simplifies the process.
Respondent B	I prefer the mini campus studio, I enjoy studying there using a Smart Board or Smart TV to play audio/video materials while learning.
Respondent C	Certainly, the use of IoT can contribute to enhancing understanding of course materials, although it may vary from person to person. In my opinion, IoT makes learning easier and more efficient. It is very important because the use of IoT technology helps in academic tasks such as major assignments (final exams) and makes college projects easier.
Researcher	Do you think the use of IoT will have a positive impact on completing your tasks? Please explain in detail.
Respondents A advanced and	I'm really satisfied because IoT makes learning more enjoyable. Unlike other campuses that still use whiteboards, which can stain clothes with marker ink and be quite troublesome. Moreover, erasing manually with an eraser can potentially damage the campus walls and facilities. As for the course materials, I can say that the professors teach in a more relaxed manner with the use of technology. There's no need to rush through slide presentations or class materials, making it more engaging and inspiring to learn. Especially

	when there are videos and pictures, it really helps to prevent boredom during afternoon sessions.
Respondent B	The use of IoT in the classroom feels like an enhanced learning process, as it enables users to better understand and acquire information more quickly as well.
Respondent C	IoT is very satisfying because it has provided assistance and made everything easier. Of course, the improvement is significant because the processes obtained are user-friendly, saving time and allowing for the utilization of the remaining time to gain knowledge and engage in other activities.
Researcher	How do IoT devices/applications help in accessing information (e.g., online libraries, research materials, or databases)?
Respondent A	Yes, because the implementation of IoT can provide efficiency and effectiveness in carrying out learning activities.
Respondent B	That's very helpful. Attendance recording becomes easier with the integration of tapping and students on campus, and it is very helpful in obtaining information.
Respondent C	Yes, that's correct. The ease of synchronization and assignment management makes it more effective and efficient. With the presence of IoT, it certainly facilitates the learning process itself, allowing for smoother learning activities. This, in turn, can enhance the understanding of individuals who are engaged in the learning process.
Researcher	According to you, do IoT devices/applications have the potential to enhance your ability to concentrate and maintain focus?
Respondent A	Yes, it can be extremely helpful in the learning process.

Respondent B	Not necessarily to a great extent, but it does provide significant assistance in the classroom process.
Respondent C	Yes, IoT can make the learning process much easier for students, and this convenience can indeed enhance their understanding. By providing instant access to educational resources, interactive learning experiences, and personalized feedback, IoT can facilitate a more efficient and effective learning journey for students.
Researcher	How do you see IoT improving the supportive learning environment and increasing your confidence in understanding lessons?
Respondent A	Certainly, with IoT, learning achievements can be enhanced as the use of IoT opens up new opportunities and improves the learning experience. However, the outcomes can vary depending on the implementation and other factors involved.
Respondent B	I really agree because when I have finished editing my PowerPoint and it's going to be presented, there is a sense of excitement in using a smart board during the presentation.
Respondent C	For me, it's just normal. Because even before using IoT, my motivation to learn was neutral as well.

<u>Challenges</u>

Researcher	Do you think IoT-related systems are difficult to operate? Please explain your experience.
Respondent B	I was initially confused about the smart monitor because I didn't know which feature to activate or use. So, if I didn't understand something, I would ask my friends or search for information on YouTube. During campus, I also join seminar on AI, one of the speakers, an expert in Biomedical Engineering, discussed AI in the healthcare field and I gain knowledge about technology there

Respondent C Yes, that's right. It's like being unsure of what to do with the smart board. But eventually, I started to understand how to use it

Researcher Do you think the use of IoT will complicate the teaching and learning process? Have you ever experienced technical complexities such as network configuration, data management, and privacy issues?

Respondent A never really had any difficulties, so i was able to use it right from

The first time, it's really user-friendly. Also, there are no guidelines

From the staff, so we have to rely on our own knowledge and Experimentation or rely on sharing information with each other.

Respondent B At first, I was confused about the features of IoT tools. In my opinion, the use of IoT in campus settings is quite satisfying. The university frequently organizes workshops related to Artificial Intelligence (not specifically focused on IoT), which are relevant to the technology in the university.

Respondent C I understand it right away because I'm already accustomed to other

technologies

<u>Expectations for Improvements</u>

Researcher What improvements do you expect from IoT in your university?

Do you expect improvements in enhancing learning methods, administrative processes, or educational processes?

Respondent A For me, as long as the education on how to use it is delivered in

	detail and the quality of the system is improved, it shouldn't be a problem. Of course, it will also continue to evolve as it develops.
Respondent B	Certainly, IoT will continue to evolve, and hopefully, its implementation can be expanded further.
Respondent C	For now, it seems that there isn't any expansion yet. Alhamdulillah, let's accept it as it is.

APPENDIX E - TRANSCRIBING FGDS MALES – INDONESIAN VERSION

A=S6 B=S7 C=S8

Manfaat

Researcher Menurut Anda, apakah integrasi perangkat/aplikasi IOT memudahkan dan meningkatkan kegiatan akademis Anda sehari hari di universitas? Bagaimana pemanfaatan IOT mempengaruhi manajemen kelas, seperti meningkatkan pembelajaran kolaboratif atau pembelajaran interaktif?

Respondent A Penggunaan IoT khususnya dalam urusan absensi, kita menggunakan KTM melalui koneksi Smart Attendance Application

Respondent B Kalau saya sih, gampang aja pas belajarnya jadi lebih menarik

Respondent C Lumayan, yaa boleh lah

Researcher Apakah menurut Anda penggunaan IOT merupakan proses yang mulus dan mudah? Mohon jelaskan

Respondent A Saat proses pembelajaran bisa menyeting persentasi layar tanpa colokan kabel jadi lebih gampang aja sih

Researcher Apakah menurut Anda penggunaan IOT akan memberikan dampak positif dalam menyelesaikan tugas Anda? Mohon jelaskan secara rinci

Respondent A Bisa melihat nilai akademis lewat aplikasi Telkom yang bisa scan

QR code untuk absensi secara online, bisa melihat jadwal dan informasi yang terbaru tanpa harus melihat atau membuka laptop untuk membuka informasi perkuliahan

Respondent C Karena udah pernah offline dan online, kampus membolehkan mahasiswa untuk mengikuti pembelajaran lewat googl emeet dan zoom meeting, dan bisa menyediakan layar touch screen yang ada kamera dan bisa mengikuti pembelajaran sesuai dengan yang dikelas dan ada kamera yang bisa mengikuti dosen atau para mahasiswa dan lebih berasa vibe nya seperti kuliah offline

Researcher Bagaimana perangkat/aplikasi IOT membantu dalam mengakses informasi (misal: perpustakaan online, bahan penelitian, atau database)?

Respondent A Untuk meminjam buku bisa melalui website tsb juga

Respondent B Alhamdulillah, ada fasilitas kumpulan jurnal melalui website dan didalamnya ada banyak open library, penelitian dan document thesis banyak didalam website itu untuk mencari informasi terbaru buku2

Respondent C Tugas sendiri itu ada namanya website LMS jadi bisa mengupload tugas2 melalui website tsb dan bisa submit tugas lewat online, quiz dll

Researcher Bagaimana Anda melihat IOT meningkatkan lingkungan belajar yang mendukung dan meningkatkan rasa percaya diri Anda dalam memahami pelajaran?

Respondent B ada, karena kan bisa mendaptkan informasi lebih mudah, dan bisa

mengerjakan tugas untuk mengumpulkan dan mencari referensi-referensi lebih mudah dan bisa belajar hal-hal baru juga

Tantangan

Researcher Apakah menurut Anda penggunaan IOT akan mempersulit proses perkuliahan? Pernahkah Anda mengalami masalah kompleksitas teknis seperti konfigurasi jaringan, manajemen data, dan masalah privasi?

Respondent A Bakal sulit, soalnya banyak pengumpulan tugas lewat LMS dan kalau itu bermasalah bisa susah, dan harus konfirmasi lewat banyak pihak dan bisa ribet banget

Respondent B Sempat pernah, dan banyak banget yang pengumpulan tugas atau pembuatan surat magang yang tertunda. Bahkan sekarang aplikasi untuk mahasiswa kita, namanya aplikasi X hanya dapat diakses apabila terhubung dengan wifi kampus, diluar dari itu tidak bisa diakses

Respondent C Sempat down di beda software, kalau pake chrome lebih cepat untuk aksesnya kalau pakai firefox lelet banget jadi paling dari jaringan agak susah juga menjadi salah satu penyebab nya sih

Researcher Apakah menurut Anda sistem yang berhubungan dengan IOT sulit untuk dioperasikan? mohon jelaskan pengalaman Anda

Respondent A Awal-awal iya, krn masi tahap percobaan jadi pada saat online,

soalnya kampus masih mencoba dan sekarang lumayan teratasi

serverdown

Respondent B Iya

Respondent C Enggak sih, cuman kan absen harus lewat di lokasi kampus, jadi

GPS itu ke detect dan terbatas untuk absensi nya, katanya kalau absen di kost ga bisa, harus di aplikasi X

Harapan untuk Perbaikan

Researcher Apa saja perbaikan yang Anda harapkan dari IOT di universitas Anda?

Apakah Anda mengharapkan perbaikan dalam meningkatkan metode pembelajaran, proses administrasi, atau proses pendidikan

Respondent A Banyak mahasiswa yang kehilangan sepatu, semoga kampus bisa membuat system smart lock jadi bisa nyimpen sepatu lebih aman, sehingga sepatu bisa aman dan soalnya banyak bgt kehilangan sandal di masjid, bagusnya da tracking atau smart KTM gitu

Respondent B Lebih ke maintainance server, soalnya udah ngalamin server down

dan mengalami pembelajaran terganggu dengan server ga bisa

diakses sehingga terkendala membuat tugas

Respondent C Tidak ada, cuman mungkin ditingkatkan aja lagi teknologi yang

ada

APPENDIX F- SURVEY TRANSCRIBING – ENGLISH VERSION

S1- Male – Online Survey

1. Satisfied enough
2. Ease in completing college assignments
3. In my opinion, yes, because I utilize the available technology
4. Thank God, it is safe
5. Just more flexible

S2 – Male – Online Survey

1. Satisfied enough, because as a user, the presence of IoT provides many benefits for me, especially when using internet-connected devices. I can control and monitor those devices
2. The benefits I obtain from using IoT include aiding environmental monitoring on campus. With IoT sensors, users can monitor air quality, temperature, and humidity
3. In using IoT, it is important for me to consider the goals I want to achieve. I believe that we need to avoid dependency on IoT, so the decision to use or not to use IoT should be based on how effectively and beneficially it is used for the individuals or organizations involved.
4. No
5. In my opinion, for improvement, the campus could implement IoT to help optimize energy usage on campus

S3 – Male – Online Survey

1. Very satisfied because we use IoT-related things in almost all aspects of life.
2. IoT facilitates us in obtaining monitoring data from sensors of the equipment we are monitoring in campus projects, and we can have an easier learning process due to the presence of smart board facilities.
3. Yes, because the current era is becoming more modern, which means we need to be able to use IoT, and it is highly likely that in the coming years IoT will be something we encounter every day.
4. The common obstacle experienced is when the network is unstable, which disrupts the use of IoT.
5. For certain courses, especially those with limited availability of hardware in practical sessions, it is hoped that the campus will provide facilities using VR (Virtual Reality).

S4 – Male – Online Survey

1. Satisfied enough, why? Because IoT relies heavily on the internet, and internet availability varies greatly in different regions of Indonesia due to geographical conditions.
2. IoT has a significant impact on my daily life as a student, especially because it provides access to a greater amount of information.
3. Yes, of course. You could say I'm quite lazy or, in today's language, "mager." So, IT is very important to me.
4. Going back to what I mentioned earlier about internet conditions, another challenge is the quality and reliability of IoT itself, often experiencing lags or connectivity issues.
5. Yes, it should be more optimal. My expectation is that the machines used should already be highly optimized, without the need to wait for them to

function smoothly again before fixing them, and not solely for the convenience of the professors to continue their teaching.

S5 – Female – Online Survey

1. I am satisfied because my university provides an open library that can be accessed through the internet. I can search for journals and access them as well.
2. In my daily life, the most significant use of IoT is for college assignments, ULMS (University Learning Management System), and the smart board. They are beneficial for submitting assignments, and the smart board makes learning easier. It allows for saving and recording sessions for later reference.
3. I am neutral. If there is IoT available, Alhamdulillah (praise be to God), but if not, it's also fine.
4. It doesn't seem to hinder much, but when the connection is down, it just becomes less effective.
5. So far, there haven't been any major issues. It has been satisfactory.

S6 - Female – Biomedis Engineering - Offline Survey

1. During my studies, IoT has provided benefits to me in the following ways: 1) Smart Boards that are useful for presentations and keeping up with technological advancements. 2) WiFi and internet connection with limited access, reducing the possibility of speed limitations due to increased workload. Alhamdulillah (praise be to God), every building is equipped with WiFi access that can be used by authorized users.
2. I should be very confident, but sometimes I'm not. The reason is that when creating a PowerPoint presentation, I need to be as creative as possible with

the design, and there is a sense of enthusiasm when presenting it to my peers.

3. Without the smart board, classes can become somewhat boring, and students may not have a deep understanding of technology as they do with the presence of IoT.

4. When first using the smart board, I faced some challenges: 1) Confusion in determining which features to use. When initially operating the smart board, there is often confusion in selecting the available features and starting them correctly. 2) Uncertainty in choosing the appropriate buttons. There are many buttons and controls on the smart board, which may cause new users to feel confused in selecting the right buttons to initiate or operate specific functions.

5. Looking ahead, my hope for the campus development is for campus to continuously improve their technological facilities, making them more advanced and user-friendly for students. As a specific request, I hope that computer labs can be increased on this campus. This is particularly important during practical sessions. I hope the campus can implement the concept of "open access labs" that allow unrestricted access for students to use computer lab facilities.

S7 – Female - Biomedis Engineering - Offline Survey

1. With notifications through the smart board, students can obtain important information when entering the TULT building. The large screen, similar to a smart board, inside the building provides various campus-related information, fundraising initiatives, scholarship information, and other updates. Through clear and easily accessible displays, students can quickly get updates on campus events, funding opportunities, scholarships, and relevant news.

2. I feel confident in class during presentations. Sometimes, when using a projector, it's difficult to establish a connection due to cables, but with a smart board, I feel more motivated.

3. The presence of a smart board is highly efficient in the learning process, while a smart digital library helps in searching for books and extending borrowing periods through a smartphone app. Students can borrow books by presenting their student ID and username, and they can use the smart door in the library by tapping in, similar to the TULT building.

4. I have experienced confusion about the available features of the smart board and how to use them.

5. The hope is for this campus to implement self-attendance through an application or automatic registration when students tap in using the smart door. Although the campus already has a mobile attendance app, some professors still manually take attendance. It is expected to be more efficient and convenient for professors, respecting their time. Additionally, the smart door system can directly integrate with the professors' attendance app, automatically recording student attendance. It is also important to ensure equal usage of technology in all classrooms, such as smart boards or smart cameras, so that every room is equipped with the same technology.

S8 - Female - Biomedis Engineering - Offline Survey

1. Initially, I was unaware of the Internet of Things (IoT), but in my opinion, the smart board is very helpful in classroom learning. While waiting for the professor to arrive, we can use the smart board to listen to music, watch movies, or relax before class starts. In the campus library, they provide tablets for all students to freely use for playing, refreshing, and there are also computers and mini studios for recording and performing activities like singing. The LMS (Learning Management System) and MytelU applications also provide benefits, used to remind us of assignments, store

presentations, and all the materials provided by the professors. Additionally, the campus mobile app is very useful. In the app, we can see the schedule of campus shuttles and their locations, so we can quickly depart for the campus.

2. Confidence increases when teaching becomes easier and more assisted. This facilitates the learning process and ultimately boosts self-confidence.
3. Not really, because there are some classes without smart boards, but we can still learn. It's more relative.
4. None.
5. No improvisations, as for now there haven't been any, as we are already satisfied with what we have

S9 – Male – Offline Survey

1. For example, smart lights in the campus area automatically turn on as evening approaches and turn off as morning approaches. The benefits provided are energy savings and remote control capability.
2. Yes, with the presence of IoT, it can increase confidence and mastery of course materials.
3. Yes, because IoT is crucial to learn, and in the future, Our lives will depend on technology.
4. None, I feel that IoT is advancing and becoming easier to understand in its operation.
5. Smart locks in the mosque area on campus, so students who bring their shoes can access the smart lock using their student ID cards (KTM) and not worry about losing them

S10 – Male – Offline Survey

1. The implementation of IoT in everyday life, especially on campus, brings significant benefits such as using student ID cards for organized smart door systems and as a means of access for motorized vehicles within the campus environment.
2. Yes, that's true. I am quite satisfied because there is still a lot of room for improvement in terms of user understanding, which may require more detailed training or usage guidelines.
3. As long as it remains convenient and cost-effective, I am inclined to continue using IoT.
4. There are certainly challenges. Some examples include the suboptimal quality of IoT services, such as SIRAMA being inaccessible at times, or I-MISS requiring access through the campus internet network, which can pose difficulties for students who are not on campus.
5. The hope is that IoT can facilitate various academic needs without minimizing campus socialization activities, thus leveraging technological advancements to enhance the quality of education and human life.

S11 – Male – Offline Survey

1. One of the benefits I've experienced in using IoT on campus is the use of access card-based entry doors, where the student ID card serves as the access key. This IoT implementation enhances the security of campus entrances and exits.
2. It depends on each individual's understanding and mastery of the concepts. IoT is simply a tool to facilitate tasks.
3. No, it's not because IoT is not important but rather because the usage of IoT is still limited in some areas I access (except on campus). So, it's not about

the significance of IoT itself, but rather the limited implementation of IoT in those areas.

4. Yes, one of the initial challenges I faced was a slight confusion in operating IoT devices.
5. My hope is that IoT can become a ubiquitous technological tool, such as smart devices, that facilitates communication among people in various contexts.

S12 – Male – Offline Survey

1. Yes, of course, IoT can also help its users in learning activities. For example, when doing presentations, IoT allows users to connect their devices to smart projectors, interactive whiteboards, or other presentation devices online.
2. Very satisfied.
3. Since I am in a university environment, I will continue to use IoT in my daily life.
4. Of course, I faced difficulties at first, but as time went by, I got used to it.
5. I hope the campus can improve operational efficiency by utilizing IoT. For example, the use of smart temperature and lighting sensors can regulate the environment when needed.

S13 – Male – Offline Survey

1. Very helpful, such as logging tap records when parking or integrating cards with the integrated system for easy login and access to campus facilities.
2. Very satisfied, the campus provides maximum support for the use, implementation, and utilization of IoT.

3. Not too many benefits, as I adapt to the cultural environment around me, but when on campus, I tend to utilize IoT more often.

4. Initially confused, but it would be better if the campus provided guidance and user manuals for IoT usage. It has great potential for development, but discussing the technical aspects may be complex.

5. Massive awareness campaigns and encouragement for all academic members to utilize IoT in campus activities, as well as providing IoT facilities five times more than before.

APPENDIX G - SURVEY TRANCRIBING – INDONESIAN VERSION

S1- Male – Online Survey

1. Cukup puas
2. Kemudahan dalam mengerjakan tugas kuliah
3. Menurut saya ya karna saya memanfaatkan teknologi yang ada
4. Alhamdulilah aman
5. Lebih flexibel aja

S2 – Male – Online Survey

1. Cukup puas, karena sebagai pengguna dengan adanya (IoT) dapat memberikan banyak manfaat bagi saya, apalagi dengan menggunakan perangkat yang terhubung ke internet, saya dapat mengontrol dan memantau perangkat tersebut.
2. Manfaat yang saya dapatkan dalam penggunaan IoT adalah dapat membantu pemantauan lingkungan di kampus, seperti dengan menggunakan sensor IoT, pengguna dapat memantau kualitas udara, suhu, dan kelembaban.
3. Dalam penggunaan IoT, penting bagi saya untuk mempertimbangkan tujuan yang ingin dicapai. Saya berpendapat bahwa kita perlu menghindari ketergantungan pada IoT sehingga keputusan untuk menggunakan atau tidak menggunakan IoT harus didasarkan pada sejauh mana penggunaannya efektif dan menguntungkan bagi individu atau organisasi yang bersangkutan.
4. Tidak
5. Menurut saya, untuk improvisasinya mungkin kampus bisa menerapkan IoT yang dapat membantu mengoptimalkan penggunaan energi di kampus

S3 – Male – Online Survey

1. Sangat puas, karena hampir sebagian besar kehidupan itu kita menggunakan hal-hal berkaitan IoT
2. IoT memudahkan kita dalam mendapatkan data monitoring dari sensor alat yang sedang kita pantau diproject kampus, dan kita bisa lebih mudah dalam proses pembelajaran karena adanya fasilitas smart board
3. Iya, karena jaman yang kini sudah semakin modern sehingga membuat kita pastinya harus bisa menggunakan IoT dan kemungkinan besar beberapa tahun kedepan mungkin IoT ini akan jadi hal yang pasti kita jumpai setiap harinya
4. Hambatan yang sering dialami itu ketika jaringan tidak stabil membuat proses penggunaan IOT menjadi terganggu
5. Untuk beberapa mata kuliah khususnya praktikum yang memiliki keterbatasan ketersediaan hardwarenya, diharapkannya kampus menyediakan fasilitas menggunakan VR (virtual Reality)

S4 – Male – Online Survey

1. cukup puas, kenapa? karena IOT sangat bergantung dengan internet sedangkan internet diberbagai wilayah di indonesia sangat berbeda2 kerena kondisi geografis
2. IOT sangat berpengaruh dalam kehidupan sehari-hari saya sebagai mahasiswa, terutama karena dapat memberikan sumber informasi yang lebih banyak
3. Ya tentu saja, bisa dibilang saya orangnya sangat pemalas atau bahasa jaman sekarangnya tuh "mager". jadi IT sangat penting bagi saya
4. Balik lagi saya bilang tentang kondisi internet dan 1 lagi kualitas kemampuan dari IOT itu sendiri, sering ngehang atau enggk

5. Ya harusnya lebih optimal lagi sih, expetasi saya mesin yang digunakan sudah harus sangat optimal, tidak perlu munggu hang nya lancar kembali baru diperbaiki dan hanya untuk dosen melanjutkan belajar

S5 – Female – Online Survey

1. Puas sih, soalnya kan telkom tu ada open library bisa akses lewat internet, bisa nyari jurnal dan bisa akses juga
2. sehari-hari, paling tugas kuliah ya, ULMS, Smart board, bermanfaat sebagai pengumpulan tugas, smart board bisa enak belajar nya, bisa save dan bisa recording untuk didengar lagi
3. Netral, kalau ada Alhamdulillah kalau gak ada ya tidak apa-apa juga
4. Menghambat kayanya enggak, cuman kalau koneksi mati cuman memang membuat kurang efektif aja
5. Belum ada sih, sampai sejauh ini masih cukup

S6 - Female – Biomedis Engineering - Offline Survey

1. Selama saya kuliah, IoT yang memberikan manfaat kepada saya adalah: 1) Smart Board yang berguna untuk presentasi mengikuti perkembangan zaman 2) Koneksi WiFi dan internet yang diatur dengan limited time agar tidak sembarang orang dapat mengakses, serta mengurangi kemungkinan terjadinya keterbatasan kecepatan karena beban tugas yang meningkat dan Alhamdulillah setiap gedung sudah dilengkapi dengan akses WiFi yang dapat digunakan oleh pengguna yang berwenang,
2. Harusnya percaya diri banget tapi ga banget juga sih, alasannya karena kita bikin PPT harus se-kreativ mungkin desainnya dan ketika itu akan dipersentasikan ke kawan-kawan disitu ada rasa semangat

3. Jika tidak ada smart board, kelas dapat menjadi agak membosankan dan mungkin mahasiswa tidak akan memiliki pemahaman yang mendalam tentang teknologi seperti yang mereka miliki dengan adanya IoT.

4. Ketika pertama kali menggunakan smart board, terdapat beberapa tantangan yang dihadapi: 1) Bingung menentukan fitur mana yang harus digunakan. Saat baru mengoperasikan smart board, seringkali terjadi kebingungan dalam memilih fitur-fitur yang tersedia dan memulainya dengan benar 2) Bingung memilih tombol yang harus digunakan. Terdapat banyak tombol dan kontrol pada smart board, sehingga pengguna baru mungkin merasa kebingungan dalam memilih tombol yang sesuai untuk memulai atau mengoperasikan fungsi tertentu.

5. Harapan kedepan terhadap perkembangan kampus adalah agar Telkom dapat terus meningkatkan fasilitas teknologi mereka sehingga semakin canggih dan mudah dipahami oleh mahasiswa. Sebagai permintaan khusus, aku berharap bahwa lab komputer dapat diperbanyak di kampus ini. Hal ini menjadi penting terutama saat pelaksanaan praktikum. Aku berharap kampus bisa menerapkan konsep "open access lab" yang memungkinkan akses terbuka bagi mahasiswa untuk menggunakan fasilitas lab komputer tanpa batasan tertentu

S7 – Female - Biomedis Engineering - Offline Survey

1. Dengan adanya pemberitahuan melalui large screen, mahasiswa dapat memperoleh informasi penting ketika memasuki gedung TULT. Layar besar yang mirip smart board di dalam gedung tersebut menyajikan berbagai informasi seputar kegiatan kampus, penanggulan dana, informasi beasiswa, dan informasi terbaru lainnya. Melalui tampilan yang jelas dan mudah diakses, mahasiswa dapat dengan cepat mendapatkan pembaruan terkait acara kampus, kesempatan pendanaan, peluang beasiswa, serta berita terkini yang relevan.

2. Percaya diri dikelas pas persentasi, kadang klo pake projector susah terkoneksi soalnya ada kabel juga dan kalau pake smart board lebih semangat jadinya
3. Keberadaan smart board sangat efisien dalam proses pembelajaran, sedangkan smart digital library membantu mencari buku dan memperpanjang peminjaman melalui aplikasi di handphone. Mahasiswa dapat meminjam buku dengan menyerahkan KTM dan user name, serta menggunakan smart door di perpustakaan dengan melakukan tap in seperti di gedung TULT.
4. Pernah mengalami kebingungan tentang fitur-fitur apa saja yang ada di smart board dan bagaimana menggunakannya.
5. Harapannya adalah agar kampus ini menerapkan absensi mandiri melalui aplikasi atau secara otomatis ketika mahasiswa melakukan tap in di smart door. Meskipun kampus sudah memiliki aplikasi absensi melalui handphone, masih ada beberapa dosen yang melakukan absensi secara manual. Diharapkan bahwa ini bisa menjadi lebih efisien dan memudahkan dosen, serta menghargai waktu mereka. Selain itu, sistem smart door juga dapat terhubung secara langsung dengan aplikasi absensi dosen, sehingga kehadiran mahasiswa dapat terdaftar secara otomatis. Selain itu, penting untuk meratakan penggunaan teknologi di seluruh ruang kelas, seperti penggunaan smart board atau smart camera, sehingga setiap ruangan dapat dilengkapi dengan teknologi yang sama.

S8 - Female - Biomedis Engineering - Offline Survey

1. Awalnya saya tidak tahu tentang Internet of Things (IoT), tetapi menurut pendapat saya, smart board sangat membantu dalam pembelajaran di kelas. Sambil menunggu dosen datang, kami dapat menggunakan smart board untuk mendengarkan lagu, menonton film, atau merilekskan diri sebelum kelas dimulai. Di perpustakaan kampus, mereka menyediakan tablet untuk

semua mahasiswa yang dapat digunakan secara bebas untuk bermain, refreshing, dan juga terdapat komputer dan studio mini untuk merekam dan melakukan performa seperti bernyanyi. Aplikasi LMS (Learning Management System) dan MytelU juga memberikan manfaat, digunakan untuk mengingatkan tugas-tugas, menyimpan presentasi, dan semua materi yang diberikan oleh dosen. Selain itu, aplikasi mobil kampus juga sangat berguna. Dalam aplikasi tersebut, kami dapat melihat jadwal mobil dan lokasinya sehingga kami dapat dengan cepat berangkat ke kampus.

2. Percaya diri meningkat saat pengajaran menjadi lebih mudah dan terbantu. Hal ini memudahkan proses pembelajaran dan pada akhirnya meningkatkan kepercayaan diri.
3. Enggak sih, soalnya ada beberapa kelas tidak ada smart board dan masih bisa belajar. Ini lebih cenderung relative
4. Tidak ada
5. Tidak ada improvisasi, buat saat ini belum ada, karena udah cukup puas dengan yang ada.

S9 – Male – Offline Survey

1. Contohnya lampu pintar diarea kampus, ketika waktu menjelang malam lampu nyala secara automatis begitu juga saat menjelang pagi lampu tsb mati. Manfaat yang diberikan yaitu menghemat listrik dan juga bias dikontrol jarak jauh.
2. Ya dengan adanya IOT bisa meningkatkan percaya diri serta menguasai materi perkuliahan
3. Ya karena IOT sangat penting untuk dipelajari serta di kehidupan kedepan nanti akan bergantung dengan teknologi
4. Tidak ada, saya merasa IOT semakin berkembang dan semakin mudah dipahami dalam pengoperasiannya

5. Smart Lock di area masjid kampus, sehingga mahasiswa yang membawa sepatu tidak kehilangan untuk mengakses smart lock tsb bisa menggunakan KTM

S10 – Male – Offline Survey

1. Dalam penerapan IOT dikehidupan sehari-hari, terutama dikampus begitu terasa manfaatnya seperti kartu tanda mahasiswa yang dapat digunakan untuk smart door system yang terorganisir selain itu juga sebagai alat keluar masuk kendaraan bermotor didalam lingkungan kampus
2. Iya betul sekali, cukup puas, dikarenakan masih banyak juga penggunaanya kurang begitu dipahami oleh user sehingga butuh pelatihan ataupun petunjuk pengunaan yang lebih detail
3. Selama pengunaannya dapat mempermudah dan tidak memakan biaya yang tinggi, saya cenderung untuk terus menggunakannya
4. Rintangan tentu ada. Diantaranya kurang maksimal kualitas dari pelayanan IOT tsb seperti SIRAMA yang pernah tidak bisa diakses, I-MISS yang masih harus diakses melalui jaringan internet kampus dan akhirnya menyulitkan mahasiswa/I yang tidak berada dilingkungan kampus
5. Harapannya dapat mempermudahkan berbagai keperluan-keperluan akademik, namun tidak meminimalisirkan kegiatan sosialisasi kampus sehingga perkembangan teknologi akan terus membantu kehidupan manusia terutama dalam peningkatan kualitas pendidikan

S11 – Male – Offline Survey

1. Manfaat yang saya dapatkan dalam menggunakan IOT dikampus salah satunya dalam bentuk penggunaan pintu masuk kampus yang menggunakan kartu akses dari KTM. Penggunaan IOT ini bisa memberikan peningkatan keamanan untuk akses keluar masuk dari kampus saya sendiri
2. Realitis, tergantung dari masing-masing orang dalam memahami atau menguasai ide-ide tsb, IOT hanya sebagai sarana untuk memudahkan saja.

3. Tidak, karena memanfaatkan IOT dibeberapa sempat yang saya akses masih minim (kecuali dikampus), jadi bukan karena tidak pentingnya IOT itu sendiri melainkan karena masih minimnya penggunaan IOT tsb
4. Iya, hambatan yang saya alami diawal-awal adalah ketika penggunaan IOT ada sedikit kebingungan dalam mengoperasikannya
5. Harapan saya adalah IOT bisa menjadi sarana teknologi yang pengunaanya dimana-mana misalnya seperti smart devices yang akan memudahkan komunikasi antar manusia dalam komunikasi

S12 – Male – Offline Survey

1. Ya, tentu IOT juga dapat membantu penggunanya dalam kegiatan pembelajaran, contoh dalam hal ini ketika melakukan presentasi, IOT memungkinan penggunanya untuk menghubungkan perangkatnya ke proyektor cerdas, papan tulis interaktif atau perangkat presentasi lainnya secara online
2. Sangat puas
3. Karena saya berada dilingkungan kuliah, maka tentu penggunaan IOT akan terus saya pakai dalam kesehariannya
4. Tentu, saat pertama kali saya mengalami kesulitan, namun lama kelamaan terbiasa dengan hal itu
5. Saya harap kampus dapat meningkatkan efesiensi operasional dengan menggunakan IOT. Contoh penggunaan sensor suhu dan pencahayaan cerdas dapat mengatur kondisi lingkungan saat diperlukan

S13 – Male – Offline Survey

1. Sangat membantu, seperti pencatatan log tapping saat parkir atau juga integrasi kartu dengan system terpadu memudahkan untuk login dan mengakses fasilitas kampus
2. Sangat puas, kampus memberikan dukungan sangat maksimal terhadap penggunaan, penerapan serta pemanfaatan IOT

3. Tidak terlalu banyak manfaatnya, karena saya menyesuaikan dengan kultur lingkungan sekitar, namun apabila dikampus lebih sering untuk memanfaatkan IOT
4. Awalnya bingung, akan tetapi akan lebih baik jika kampus memberikan sosialisasi terhadap panduan penggunaan dan sangat berkembang, akan tetapi kalau bicara unsur belakangnya mungkin akan ribet
5. Sosialisasi dan anjuran secara massive untuk seluruh antar akademik dalam pemanfaatan penggunaan IOT dalam melakukan kegiatan diampus, serta penyediaan fasilitas IOT ditambah lagi 5kali dari sebelumnya

APPENDIX H - OBSERVATION – INDONESIAN VERSION

INSTRUMEN OBSERVASI

Versi Bahasa Indonesia

Nama Institusi :

Lokasi/Tempat :

B. Perangkat/aplikasi IoT di universitas mahasiswa

3. Mengamati kegiatan mahasiswa di kampus dalam memanfaatkan IoT
4. Berikan komentar atau refleksi sesuai dengan situasi yang diamati.

Tanggal/Waktu	Aktivitas	Komentar/Refleksi
3 June 2023 14.20 WIB	• Terdapat Smart Board, Papan Tulis manual dan juga Kamera ditengah-tengah ruang kelas • Dosen mengabsen melalui aplikasi mobile phone • Terdapat kamera berdiri ditengah-tengah ruang kelas yang terhubung ke Zoom Meeting • Terdapat Ipad diatas meja yang terhubung dengan Zoom Meeting • Mahasiswa menggunakan Smart Board untuk mempersentasikan Power Point • Terdapat fasilitas ruang kelas seperti AC, Papan	Dalam hasil observasi yang disampaikan, terlihat beberapa elemen yang mencerminkan penggunaan teknologi dalam ruang kelas. Salah satu elemen yang mencolok adalah adanya Smart Board, Papan Tulis manual, dan Kamera yang terhubung dengan Zoom Meeting. Smart Board merupakan perangkat interaktif yang memungkinkan mahasiswa untuk menampilkan dan berinteraksi dengan materi pembelajaran secara digital. Papan Tulis manual tetap ada sebagai opsi alternatif untuk keperluan yang tidak memerlukan penggunaan Smart Board. Sementara itu, adanya Kamera yang terhubung dengan Zoom Meeting

	Tulis dan juga Lampu yang masih manual • Smart Board digunakan untuk mengkoneksi kan layar desktop laptop/handphone melalui kabel • Mahasiswa mempersentasikan persentasi sesuai dengan jurusan mereka yang meliputi X-Tray, CT Scan dan juga anatomi tubuh manusia • Mahasiswa terlihat familiar dalam menavigasi smart board tools • Posisi Smart Board bersejajaran dengan posisi mahasiswa • Smart Board harus terkoneksi dengan internet • Smart Board tidak sensitive, namun apabila terdapat weak signal smart board akan memberikan himbauan • Mahasiswa menavigasi Smart Board melalui remote	memungkinkan mahasiswa yang tidak hadir fisik di ruang kelas untuk tetap mengikuti proses perkuliahan secara virtual. Dalam observasi juga disebutkan adanya penggunaan iPad yang terhubung dengan Zoom Meeting. Hal ini menunjukkan adanya upaya untuk memfasilitasi komunikasi dan partisipasi mahasiswa yang berada di luar ruang kelas secara interaktif melalui perangkat mobile. Mahasiswa juga menggunakan Smart Board untuk mempresentasikan materi pembelajaran, seperti X-Tray, CT Scan, dan anatomi tubuh manusia sesuai dengan jurusan mereka. Hal ini menunjukkan adanya integrasi antara teknologi dan konten pembelajaran yang relevan dengan bidang studi mahasiswa. Dalam hal pengaturan ruang kelas, posisi Smart Board yang bersejajaran dengan posisi mahasiswa memungkinkan mereka untuk melihat dengan jelas tampilan yang ditampilkan. CCTV yang terhubung dengan petugas juga

	• Terdapat CCTV diruang kelas yang terhubung dengan petugas • Terdapat mahasiswa yang juga mengikuti proses perkuliahan melalui zoom meeting • Kamera tidak melakukan pergerakan secara automatis • Terdapat Mahasiswa yang menavigasi kamera agar mengarah pada dosen pengampu mata kuliah	memberikan tambahan keamanan dan pengawasan dalam ruang kelas. Pada sisi teknis, Smart Board harus terkoneksi dengan internet agar dapat digunakan. Selain itu, Smart Board juga memiliki fitur yang memberikan himbauan saat sinyal lemah untuk memastikan kualitas tampilan yang optimal. Mahasiswa menggunakan remote untuk menavigasi Smart Board dan menjalankan fungsi-fungsi yang tersedia, menunjukkan pemahaman dan kecakapan mereka dalam menggunakan perangkat tersebut. Namun, penggunaan kamera tidak dilengkapi dengan pergerakan otomatis, sehingga ada mahasiswa yang perlu menavigasi kamera secara manual agar dapat mengarahkan pandangan pada dosen pengampu mata kuliah. Hal ini menunjukkan adanya kebutuhan untuk meningkatkan fungsionalitas kamera agar dapat memperbaiki pengalaman pembelajaran dan memastikan fokus pada dosen.

		Secara keseluruhan, hasil observasi ini menggambarkan integrasi teknologi dalam ruang kelas yang dapat meningkatkan interaksi dan partisipasi mahasiswa, serta memberikan fleksibilitas akses bagi mereka yang tidak dapat hadir fisik.