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# Implementation of a Smart School Learning system with Internet of Things Technology at SMA Negeri II Binjai

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**ABSTRACT**

This research explores the transformative impact of Internet of Things (IoT) technology on learning environments, focusing on the development of a Smart School at SMA Negeri II Binjai. The study aims to investigate the integration of IoT technology to enhance educational practices, improve efficiency, and create an innovative and dynamic learning atmosphere. The research employs a mixed-methods approach, combining qualitative and quantitative methodologies. The design includes the development of a comprehensive IoT system tailored for educational settings, considering both hardware and software components. Implementation strategies involve stakeholder engagement, training sessions, and pilot testing to ensure a smooth transition. Evaluation methods encompass performance testing, usability testing, and security testing to guarantee system reliability. The findings are expected to contribute valuable insights into the effectiveness of IoT technology in fostering innovation and improving the overall learning experience in a secondary school setting. The research not only addresses the technical aspects of building a Smart School but also considers the practical implications and challenges associated with the integration of IoT in education.



## INTRODUCTION

In the modern era, the integration of technology in education has become crucial to enhance the quality of the learning experience. The utilization of technology, especially the Internet of Things (IoT), has shown promising results in improving learning efficiency in educational environments. Its significance becomes increasingly relevant at State Senior High School II

Page : 1-9
Doi. 10.54209/jurnalkomputer.v16i01.186.

Binjai, where the implementation of IoT has the potential to revolutionize the educational landscape.

The Importance of Technology in Education: Baglama et al. (2022) emphasize the significance of digital leadership in school management and the accessibility of game-based learning to support education, especially for children with special needs. This underscores the crucial role of technology in addressing diverse learning needs and improving educational outcomes for all students. Maree & Vos (2021) highlight the influence and value of science and technology in educational systems, emphasizing their importance for economic growth. This emphasizes the crucial role of technology in preparing students for the demands of a rapidly evolving technological landscape, ensuring their competitiveness in the global economy.

The Role of Information Technology in Education: The importance of information technology in higher education and science is discussed in a study by Futurity Education (2022), emphasizing its role in driving development in these fields. This underscores how technology, including IoT, can facilitate advancements in teaching methodologies, research practices, and overall educational effectiveness. Internet of Things (IoT) in Education: Al-Fuqaha et al. (2015) provide insights into the core functionalities of IoT, highlighting its capacity to enable seamless information exchange among interconnected devices. In the context of State Senior High School II Binjai, the implementation of IoT can create a smart learning environment, personalized learning experiences, and real-time data analytics for informed decision-making.

Petrović et al. (2017) focus on the development of educational games based on IoT, showcasing how IoT technologies can be integrated into educational tools to promote interactive and engaging learning experiences. By incorporating IoT into educational games, students can actively participate in their learning process, fostering deeper engagement and knowledge retention. Within the school premises, IoT devices can be utilized to monitor and manage resources such as energy, water, and infrastructure. Smart sensors can optimize the usage of utilities, contributing to cost savings and environmental sustainability. Additionally, IoT-enabled devices can enhance security measures, ensuring a safe learning environment for students and staff.

Moreover, the implementation of IoT in classrooms can facilitate interactive and dynamic learning experiences. Smart devices, equipped with sensors, can gather data on students' engagement levels, learning preferences, and progress. This data can then be analyzed to tailor teaching methods, providing a more personalized approach to education. The integration of technology, especially the Internet of Things, in education is pivotal for fostering a progressive and efficient learning environment. State Senior High School II Binjai stands to benefit from the transformative power of IoT in optimizing resource management, enhancing security, and personalizing the learning experience. As we move forward in the digital age, embracing these technological advancements will undoubtedly contribute to the continual improvement of education.

## LITERATURE REVIEW

A. The concept of the Internet of Things in Education

The Internet of Things (IoT) has emerged as a transformative technology with vast potential applications across various domains, including education. The concept of IoT involves the interconnection of devices through the internet, enabling the exchange of data

Page : 1-9
Doi. 10.54209/jurnalkomputer.v16i01.186.

and communication between physical objects and virtual systems (Abbasy & Quesada, 2017). In the educational sector, IoT offers innovative opportunities to enhance learning experiences, streamline processes, and improve overall efficiency.

One key aspect of IoT in education is its ability to bridge the gap between physical and virtual objects, creating a more interactive and immersive learning environment (Abbasy & Quesada, 2017). By integrating IoT devices such as sensors, smart boards, and wearable technologies into educational settings, educators can personalize learning experiences, track student progress in real-time, and provide targeted interventions to support individual learning needs.

Moreover, the Internet of Things has the potential to revolutionize traditional teaching methods by enabling remote learning, virtual classrooms, and collaborative projects beyond physical boundaries (Romeo et al., 2020). This shift towards digitalization in education aligns with the broader trend of Industry 4.0, where interconnected technologies drive automation, data exchange, and smart decision-making processes (Romeo et al., 2020). Recent research has also highlighted the global impact of IoT in education, with studies comparing Chinese and foreign perspectives on IoT implementation in educational settings (Dai et al., 2021). These comparative analyses provide valuable insights into the adoption trends, challenges, and opportunities associated with integrating IoT technologies into diverse educational systems.

Furthermore, the evolution of IoT extends beyond conventional applications to specialized fields such as the Internet of Space Things (IoST) (Priyadarshini et al., 2022). This demonstrates the versatility of IoT architectures, which can be tailored to specific domains based on unique requirements and functionalities. The development of novel cloud architectures for IoST underscores the continuous innovation and expansion of IoT technologies to address evolving needs across different sectors. The Internet of Things presents a paradigm shift in education, offering a dynamic platform for enhancing teaching methodologies, student engagement, and administrative processes. By leveraging IoT capabilities, educational institutions can embrace digital transformation, foster innovation, and prepare students for a technology-driven future.

B. Use of IoT in Learning Environments

The integration of the Internet of Things (IoT) in learning environments has the potential to revolutionize the educational sector by enhancing efficiency and effectiveness. By leveraging IoT technologies, schools can create adaptive learning environments that cater to the individual needs of students. Several concrete applications of IoT in education have been identified, showcasing the diverse ways in which IoT can be utilized to improve learning outcomes.

One key aspect highlighted in the literature is the use of deep learning for IoT within edge computing environments (Li et al., 2018). This approach allows for the processing of data closer to the source, enabling real-time insights and actions. By incorporating deep learning into IoT systems, schools can personalize learning experiences, provide targeted interventions, and offer adaptive feedback to students.

Moreover, the concept of smart education frameworks provides a comprehensive perspective on how new technologies can enhance learning (Zhu et al., 2016). Smart learning environments equipped with IoT devices offer learners the opportunity to engage with educational content more effectively and flexibly. These environments can adapt to students'

Page : 1-9
Doi. 10.54209/jurnalkomputer.v16i01.186.

preferences and learning styles, thereby optimizing the learning process. In the realm of adaptive learning environments, the identification of personal traits plays a crucial role (Normadhi1 et al., 2019). By leveraging IoT technologies to gather data on students' behaviors, preferences, and learning patterns, educational systems can tailor content and teaching methods to suit individual needs. This personalized approach fosters a more engaging and productive learning experience for students.

Furthermore, IoT solutions have been applied to monitor energy efficiency in educational buildings, showcasing the practical applications of IoT in school infrastructure management (Amaxilatis et al., 2017). By implementing IoT-based monitoring systems, schools can track energy consumption, optimize resource usage, and reduce operational costs. This not only contributes to environmental sustainability but also frees up resources that can be redirected towards enhancing the learning environment. the utilization of IoT in learning environments holds immense potential for transforming traditional educational practices. By embracing IoT technologies, schools can create adaptive, personalized, and efficient learning environments that cater to the diverse needs of students. From deep learning for personalized insights to energy-efficient infrastructure monitoring, IoT offers a wide array of applications that can revolutionize the educational landscape.

C. Needs and Challenges in Implementing IoT in Schools

Implementing the Internet of Things (IoT) in schools can bring about various benefits, along with technical, security, and privacy challenges. The needs and expected benefits of using IoT in education include enhancing learning experiences, improving operational efficiency, enabling personalized learning, facilitating remote learning, and fostering innovation in teaching methods (Sultana & Tamanna, 2021). IoT can provide real-time monitoring of students' progress, automate administrative tasks, and offer interactive learning tools that cater to individual student needs (Sultana & Tamanna, 2021). Additionally, IoT can support the integration of emerging technologies into the educational curriculum, preparing students for the digital future (Sultana & Tamanna, 2021).

However, the implementation of IoT in schools also presents technical challenges such as maintaining high throughput, low latency, low power consumption, ensuring quality of service, congestion control, reliability, scalability, and network routing (Samuyelu et al., 2022). These technical challenges need to be addressed to ensure a seamless integration of IoT devices and systems in educational settings. Moreover, the lack of robustness in connectivity and the improper introduction of IoT can hinder the effective deployment of IoT solutions in schools (Samuyelu et al., 2022). Security and privacy challenges are also significant concerns when implementing IoT in educational environments. The lack of safety and security measures, absence of documented standards, and insufficient awareness of the benefits of IoT can expose educational institutions to cybersecurity threats and privacy breaches (Abdullah et al., 2020). Safeguarding sensitive student data, ensuring data encryption, implementing access controls, and establishing secure communication channels are crucial to mitigating security risks associated with IoT in schools.

## METHODS.

This research will employ a mixed methods approach, combining qualitative and quantitative methods. The experimental research design will involve the implementation of IoT technology at SMA Negeri II Binjai as the independent variable, with a focus on measuring its impact on learning efficiency as the dependent variable.

Page : 1-9
Doi. 10.54209/jurnalkomputer.v16i01.186.

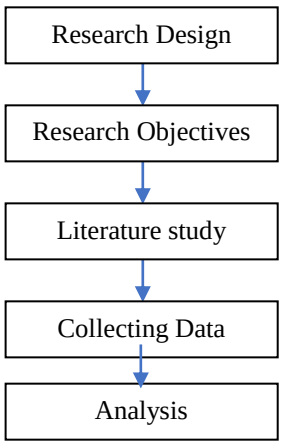


**Figure 1. Research Stages**

The study population includes students, teachers, and school staff at SMA Negeri II Binjai. Random sampling will be used to select both student and teacher participants, with the sample size adjusted based on statistical requirements and resource availability. Justification for the sample size will consider the significance level, confidence level, and potential variability in responses to IoT technology.

Data will be collected through a combination of instruments, including survey questionnaires for quantitative data from students and teachers, in-depth interviews for qualitative insights, and direct observations to monitor student interactions with IoT technology. Measurement tools such as rating scales and interview guidelines will be designed to ensure consistency and data validity.

Data collection will involve the stages of implementing IoT technology at SMA Negeri II Binjai, including sensor installation, hardware integration, and training for teachers and school staff. During implementation, quantitative data will be collected through surveys and IoT sensors, while qualitative data will be obtained through interviews and participatory observations.

## RESULTS AND DISCUSSION

A. System Design and Development

To begin with, the system architecture needs to be carefully designed to accommodate the unique requirements of schools. This involves outlining the overall structure of the system, including the various components and their interactions. Permadi et al. (2022) emphasize the importance of designing system architecture as a fundamental step in system development. This initial phase sets the foundation for the subsequent design processes and ensures that the system is well-structured and efficient. Furthermore, the functionality of the IoT system must be clearly defined to align with the educational objectives of schools. Permadi et al. (2022) highlight the significance of designing system functionality to meet the specific needs of users, in this case, students, teachers, and administrators in schools. By outlining the key features and capabilities of the system, developers can ensure that it fulfills its intended purpose effectively.

Page : 1-9
Doi. 10.54209/jurnalkomputer.v16i01.186.

In terms of hardware development for the IoT system, it is essential to consider the specific requirements of the school environment. This may involve selecting appropriate sensors, actuators, and other devices that are compatible with the educational setting. Washizaki et al. (2020) discuss the importance of utilizing IoT system design patterns to create scalable and replicable solutions. By leveraging established design patterns, developers can streamline the hardware development process and ensure compatibility and interoperability among different components. Moreover, the software development process plays a critical role in the overall success of the IoT system. Fitzgerald & Stol (2017) highlight the importance of continuous software engineering practices in modern development methodologies. By adopting agile approaches such as DevOps, developers can ensure rapid iteration, testing, and deployment of software components, leading to more efficient and reliable system development.

Integrating cloud computing capabilities into the IoT system can further enhance its functionality and performance. Botta et al. (2016) discuss the integration of cloud computing and IoT, emphasizing the importance of designing middleware that enables dynamic and self-organizing IoT applications in cloud environments. By leveraging cloud resources, schools can benefit from scalability, flexibility, and enhanced data processing capabilities within the IoT system. Designing an IoT system for schools requires a comprehensive approach that encompasses system architecture, functionality, hardware development, software engineering practices, and cloud integration. By following best practices outlined in the literature, developers can create a robust and efficient IoT system that meets the unique needs of educational institutions.

B. Implementation

Steps Taken in Introducing the System to Stakeholders

1) Needs Assessment: Before introducing a new system to stakeholders, it is essential to conduct a thorough needs assessment to identify the requirements and expectations of the users. This step involves gathering feedback from stakeholders, understanding their pain points, and determining the key features and functionalities that the new system should have to address their needs effectively.
2) Stakeholder Engagement: Engaging stakeholders throughout the implementation process is vital for ensuring their buy-in and support. Communication plays a crucial role in keeping stakeholders informed about the upcoming changes, addressing their concerns, and involving them in decision-making processes. Regular meetings, workshops, and training sessions can help in engaging stakeholders effectively.
3) Training and Education: Providing adequate training and education to stakeholders is essential for ensuring a successful implementation. Training sessions should be tailored to the specific needs of different user groups, such as end-users, administrators, and IT support staff. Hands-on training, user manuals, and online resources can help stakeholders familiarize themselves with the new system.

Initial Setup and Testing of the System

1) System Configuration: The initial setup of the system involves configuring the software and hardware components according to the organization's requirements. This step includes installing the necessary software, setting up user accounts and permissions, and integrating the system with existing IT infrastructure.

Page : 1-9
Doi. 10.54209/jurnalkomputer.v16i01.186.

2) Data Migration: Migrating data from legacy systems to the new system is a critical task that requires careful planning and execution. Data migration involves extracting data from the old system, transforming it into a compatible format, and loading it into the new system. Data validation and testing are essential to ensure the accuracy and integrity of the migrated data.
3) System Testing: Testing the system is a crucial step in ensuring its functionality, performance, and reliability. Different types of testing, such as unit testing, integration testing, and user acceptance testing, should be conducted to identify and resolve any issues or bugs. Testing should cover various scenarios and use cases to validate the system's capabilities thoroughly.

C. Evaluation and Monitoring

Evaluation and Monitoring play a crucial role in ensuring the performance and reliability of systems. This section discusses various evaluation methods to guarantee system performance and reliability, as well as continuous monitoring and improvement procedures.

Evaluation Methods to Ensure System Performance and Reliability:

1) Performance Testing: Performance testing is a key evaluation method used to assess how a system behaves under various conditions. This method involves measuring response times, throughput, and resource utilization to ensure that the system meets performance requirements. By conducting performance testing, organizations can identify bottlenecks, optimize system performance, and enhance reliability.
2) Load Testing: Load testing is another important evaluation method that involves applying a load to the system to assess its performance under normal and peak conditions. By simulating real-world scenarios, load testing helps organizations determine the system's capacity, scalability, and reliability. This method is essential for identifying performance issues and ensuring that the system can handle the expected workload.
3) Stress Testing: Stress testing involves pushing the system beyond its limits to evaluate its behavior under extreme conditions. By subjecting the system to high loads or unexpected events, organizations can identify vulnerabilities, weaknesses, and failure points. Stress testing helps ensure that the system remains reliable and performs well under stressful conditions.

F. Discussion

In analyzing the key findings, an identification of patterns, trends, or significant changes in the data obtained through the implementation of IoT system at SMA Negeri II Binjai will be conducted. The focus of the analysis will include questions about whether learning efficiency improved after the implementation of IoT and whether there were significant differences in student performance before and after the use of IoT technology.

The findings will be critically evaluated to understand their implications for the effectiveness of education at SMA Negeri II Binjai, detailing the relationship between the findings and the research objectives while linking them to the theoretical framework from the literature review. For example, the improvement in learning efficiency can be linked to learning theories supporting the benefits of technology in enhancing student interaction and participation.

Interpreting the findings will involve comparisons with relevant previous research, if available, to strengthen the validity of the findings and contribute to the existing academic literature. Practical implications of the findings will be discussed, providing concrete guidance for the development of policies and educational practices in the school

Page : 1-9
Doi. 10.54209/jurnalkomputer.v16i01.186.

environment. The conclusion of the analysis will comprehensively summarize the impact of implementing the IoT system on learning efficiency and effectiveness at SMA Negeri II Binjai, providing a holistic perspective on the future development of education.

## CONCLUSION AND RECOMMENDATION

In summarizing the results of the IoT system implementation analysis at SMA Negeri II Binjai, several key findings have been identified. Firstly, an improvement in learning efficiency is evident after the adoption of IoT technology, as reflected in the patterns of student participation and learning performance. Secondly, the significance of differences before and after the use of IoT technology indicates its positive impact on the student learning experience.

The analysis of these findings has significant implications for the effectiveness of education at SMA Negeri II Binjai. The implementation of the IoT system not only enhances learning efficiency but also positively contributes to the academic achievements of students. These findings align with the research objectives and support existing literature highlighting the benefits of technology in the educational context.

Comparisons with previous research indicate the consistency of the findings, reinforcing the validity of the analysis results. Practical implications include the development of education policies that further support the integration of technology, additional training for teachers and school staff, and investments in the maintenance and development of technological infrastructure.

Overall, the implementation of the IoT system at SMA Negeri II Binjai opens up new opportunities for educational improvement. By understanding these findings, educational institutions can continue to optimize the use of technology to achieve better learning outcomes for students.

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