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The Impact of AI and IoT-Based Smart Classrooms: A Data-Driven Approach to Business Intelligence in Education

Mallari, Marvin O. [1], Cabugos, Arden C.[2], Macapas, Vergilio II A.[3], Sonza, Rolaida, L. [4]

[1, 2, 3, 4] *Nueva Ecija University of Science and Technology, City of Cabanatuan, Nueva Ecija, Philippines*
[1] *Holy Cross College Inc., Sta. Lucia, Sta. Ana, Pampanga, Philippines*
[1] *Polytechnic University of the Philippines, Sta. Mesa, Manila, Philippines*
*Corresponding author's email: mallarimarvin022@gmail.com

Abstract. The rise of the Artificial Intelligence (AI) and Internet of Things (IoT) in education is transforming the learning process, especially within the framework of Education 4.0. This research explores how smart classrooms, supported by artificial intelligence (AI) and the Internet of Things (IoT), are viewed as enhancing student engagement, optimizing the use of school resources, and enabling more prompt academic decisions. The research was conducted in a private higher education institution in Pampanga, involving 22 respondents including students, faculty, and administrators familiar with smart classroom technologies. Using a validated survey, the results show how useful and effective these technologies are in the classroom. Respondents liked that IoT makes learning a more interactive and resource-efficient experience, with AI identified as supporting personalized instruction and possible improvement in student outcomes. Concerns about data privacy, infrastructure costs, and the learning curve for faculty were raised, but the general feeling is strongly in favor of adopting smart classroom tools. This study provides useful insights for educators, school leaders, tech developers, leaders and policymakers who want to improve the learning experience. It also highlights the need for ongoing support through training, reliable infrastructure, and clear policies to effectively use these technologies in education.

Keywords: *Smart Classrooms, Internet of Things (IoT), Artificial Intelligence (AI), Education, Data-Driven Decision-Making*

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1. Introduction

With the rapid development of digital technologies, the transformation of many fields has occurred, including education. The conventional classroom spaces are also evolving into emerging smart classrooms, wherein the IoT environment brings smart solutions for the improved learning experience. Smart classrooms deployed by IoT-based facilities leverage smartboards, attendance systems in real-time, environmental sensors and adaptive learning platforms, to build an effective and data-centred educational environment (Gunasekaran et al., 2024). The spread of big data analytics and the development of business intelligence tools has created the condition for educational organisations also to base their informed decisions on data that can help students learn better and make the institution more effective. (Kumar, Perera, & Jayasekara, 2020).

Advancing technologies, such as enterprise systems, have become vital for academic institutions, including State Universities and Colleges (SUCs). These systems automate and integrate key processes such as procurement, finance, human resources, and information management (Fernando, Endaya, Mallari, & Cuison, 2022). This study focuses on system integration within an SUC to enhance operational efficiency and support the adoption of advanced technologies. Based on the study by Santos, Ramos, and Mallari (2025), integrating systems can improve facility management through real-time monitoring, predictive maintenance, and automated reporting. Furthers enhances issue tracking and accountability, as well as responsiveness, for a safer and more productive learning environment.

The integration of IoT in education is part of the broader transformation known as Education 4.0, which aligns with Industry 4.0 and the increasing role of automation, artificial intelligence, and real-time data analytics (Nanda, Pujari & Kothari, 2021). Several studies have emphasized the potential benefits of smart classrooms in enhancing interactivity and engagement (Alshammari & Korr, 2022), promoting personalized learning (Huang & Lin, 2023), and optimizing resource utilization (Khadka & Mahapatra, 2021). Learning environments that utilize IoT technology can greatly improve educational quality by promoting peer interaction, knowledge exchange, and collaboration, which results in a more efficient learning experience

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Incorporating IoT technologies in education is a subsection of an overarching transformation known as "Education 4.0" corresponding to Industry 4.0 revolution as advances in automation, artificial intelligence, and real-time data processing (Nanda, Pujari & Kothari, 2021). The smart classrooms are expected to improve interaction and participation (Alshammari & Korr, 2022), facilitate individualized learning (Huang & Lin, 2023), and ensure better resource utilization (Khadka & Mahapatra, 2021). The proposed changes to the assessment of learning environments based on IoT technology should enhance not only individual learning but also advance peer interaction, sharing of knowledge, and collaborative activities, which leads to a higher education experience.

However, issues like data privacy, security risks, infrastructural costs, and teacher adaptation have been and still are serious barriers in the implementation of smart classroom technologies (Hossain & Cummings, 2023). This research aims to fill the gap by conducting a thorough analysis of IoT based smart classrooms and their impact on intelligence in education from a business perspective. This study intends to analyze the effects that IoT based smart classrooms have on education by taking a data centric stance.

The objective of this study is to evaluate the impact of AI and IoT-enabled smart classrooms on education in a data-centric manner. The study aims to achieve the following specific objective:

- To assess the perceived impact of smart classroom AI and IoT-based technologies on student engagement and learning outcomes.
- To describe stakeholder perceptions on the following:
    - the effectiveness of IoT-enabled devices in facilitating real-time data collection and supporting data-driven academic decision-making and;
    - the challenges and limitations in implementing AI and IoT-based smart classrooms.
- To recommend strategies for optimizing the use of AI and IoT technologies in educational institutions.

This study holds significant implications for various stakeholders in education, technology, and policymaking.

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Educational institutions can benefit from insights into the potential of IoT in enhancing classroom management, monitoring student performance, and improving administrative efficiency.

Teachers and Students: Provides a deeper understanding of how real-time, data-driven learning environments can personalize education.

Technology Developers: Guides innovation in smart classroom solutions tailored to educational needs.

Government Leaders and Policy Makers: Supports informed decision-making on investments in smart education infrastructure.

The study focuses on the implementation and impact assessment of Internet of Things (IoT)-based smart classrooms in select educational institutions. It covers:

IoT technologies such as smart boards, automated attendance, and environmental sensors; The role of business intelligence tools in analyzing classroom data; and Feedback from students and faculty regarding usability and efficiency. The study does not cover the technical development of IoT devices but rather their application and impact on education.

2. Methodology

2.1 Research Design

This research has used quantitative research design and descriptive statistical methods to investigate the perceived effect of AI- and IoT-based smart classrooms. Data were gathered through an adopted instrument, survey-based questionnaire from a similar study to examine the experiences of students, administrators and faculty.

2.2 Locale of the Study

The study was conducted in a private higher education institution located in Pampanga. This institution offers programs in engineering and technology and has experience with smart classroom technologies. It is one of the private higher education institutions that have adopted AI and IoT smart classrooms. These classrooms feature educational tools, automatic doors, attendance monitors, and environmental sensors. With the education sector moving towards technology-driven learning, the Internet of Things (IoT) holds considerable

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promise, particularly in higher education. Several of its applications are currently being utilized (Ogallo, 2018). This research includes students, faculty members, and administrators. Its purpose is to assess the perceived influence, efficiency, obstacles, and constraints of AI and IoT smart classrooms. The research will additionally examine their function in delivering real-time analytics for improved educational administration.

2.3 Population and Sample of the Study

This section discusses about the respondents of the survey and their opinion about effect of AI- and IoT-based smart classrooms. It had twenty-two (22) respondents, which were made up of students, administrators, and faculty members that had technical background in technology and engineering, or have experience in the research area.

Convenience sampling was adopted. Respondents comprise students who are actively involved themselves or are familiar with smart classroom configurations, teachers who implement AI and IoT technology while teaching their classes, and administrators in charge of smart classrooms.

2.3 Research Instruments

The research instrument was a survey questionnaire which was adopted from Gunasekaran et al. (2024), experts checked and validated. The questionnaire included Likert type items, ranging from 1 (minimum) to 4 (maximum). This research was also based on Ve et al. (2024), who highlighted the impact of integrating AI and IoT in classrooms. Their work identified key factors influencing the adoption of AI and IoT in education, which relates to the goals of this research. Another significant reference is Ogallo's (2018) research called "IoT – Improving Data-Driven Decision-Making in Higher Education: A Case Study of Ohio University."

2.4 Data Collection Procedure

Permission and approval were obtained from the private higher educational institution for data collection to ensure compliance and institutional agreement. Surveys were conducted online through Google Forms, facilitating the collection of data from respondents. The responses were gathered and readied for statistical analysis. A literature review was conducted to identify relevant studies that would provide support and context for the research findings.

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2.5 Statistical Treatment

The gathered data was subjected to descriptive statistical analysis, mainly determining the mean to assess the overall awareness of respondents about IoT-enabled smart classrooms. Responses were assessed on a Likert scale ranging from (1) "Strongly Disagree" to (4) "Strongly Agree." The computed average scores indicated the general consensus or lack thereof among respondents regarding different facets of incorporating AI and IoT into the educational setting

3. Results and Discussion

Perceived impact of AI and IoT-enabled smart classroom technologies in enhancing student engagement and learning outcomes.

3.1.1. Perceived Impact of AI

Table 1

I.A Perceptions of AI in Education	SD	Mean	Verbal Description
1. AI enhances personalized learning experiences	0.50	3.41	Strongly Agree
2. AI provides real-time feedback to students	0.81	3.23	Strongly Agree
3. AI improves educational outcomes	0.63	3.27	Strongly Agree
4. AI tools are user-friendly and easy to integrate into classroom instruction	0.51	3.50	Strongly Agree
Overall Mean		**3.27**	**Strongly Agree**

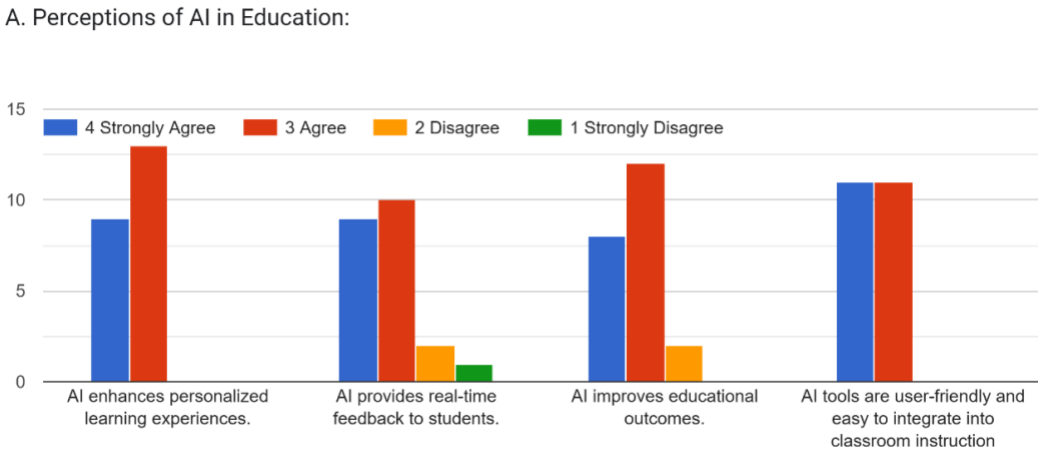

Figure 1 Perceived Impact of AI

The results show for table 1 that the indicator "AI tools are user-friendly and easy to integrate into classroom instruction" received the highest mean

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rating of 3.50 (SD = 0.51). This shows a high level of consensus among respondents. It demonstrates that educators and learners perceived AI tools as user-friendly and aligned with existing classroom methods. In comparison, the assertion "AI provides real-time feedback to students" obtained the lowest average score of 3.23 (SD = 0.81). Even though this is still regarded as "Strongly Agree" the reduced score might indicate varying degrees of familiarity with adaptive learning systems that provide instant feedback. The average score of 3.27 reflects a robust positive perception of AI in education, affirming its believed advantages for enhancing classroom teaching.

3.1.2. Perceived Impact of IoT

Table 2

I.B Perceptions of IoT in Education	SD	Mean	Verbal Description
1. IoT enhances collaboration among students and teachers	0.51	3.43	Strongly Agree
2. IoT optimizes resource management in educational institutions	0.51	3.45	Strongly Agree
3. IoT improves safety and security measures in schools	0.58	3.36	Strongly Agree
Overall Mean		**3.42**	**Strongly Agree**

The results show that the statement "IoT optimizes resource management in educational institutions" received the highest mean of 3.45 (SD = 0.51), signifying strong consensus among respondents. It demonstrates an acknowledgment of the IoT's impact on enhancing operational efficiency—like energy use, device monitoring, and facility planning—in academic setting.

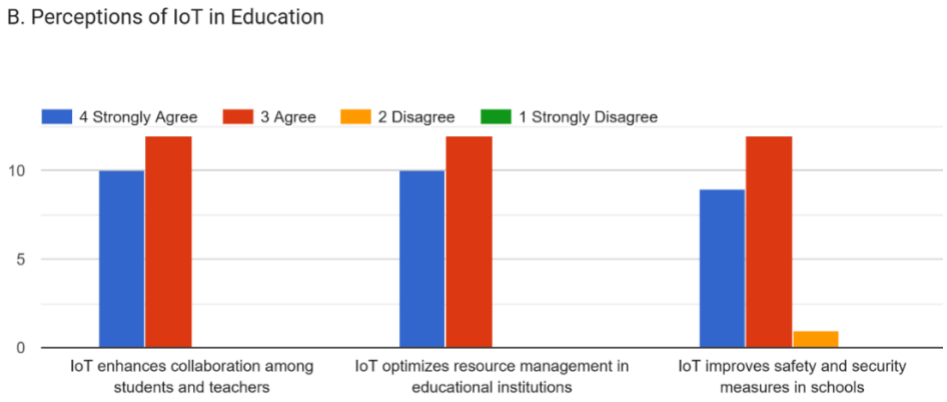

Figure 2 Perceived Impact of IoT

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The lowest average of 3.36 (SD = 0.58) was noted for the assertion "IoT improves safety and security measures in schools." Even though it remains classified as "Strongly Agree", the marginally reduced rating could indicate a lack of exposure or practical use of IoT-enabled safety technologies, including smart surveillance and environmental sensors. The average score of 3.42 indicates a robust positively perceived of IoT in education, especially in improving collaboration and optimizing resources

3.1.3. Perceived Impact of AI and IoT in Smart Classroom

Table 3

I.C Perceptions of AI and IoT in enhancing student engagement and learning outcomes.	SD	Mean	Verbal Description
1. AI tools help increase students participation in class activities.	0.92	2.91	Agree
2. IoT-enabled devices make class sessions more interactive and engaging.	0.60	3.45	Strongly Agree
3. The use of AI and IoT has improved students' academic performance.	0.70	3.27	Strongly Agree
Overall Mean		**3.21**	**Strongly Agree**

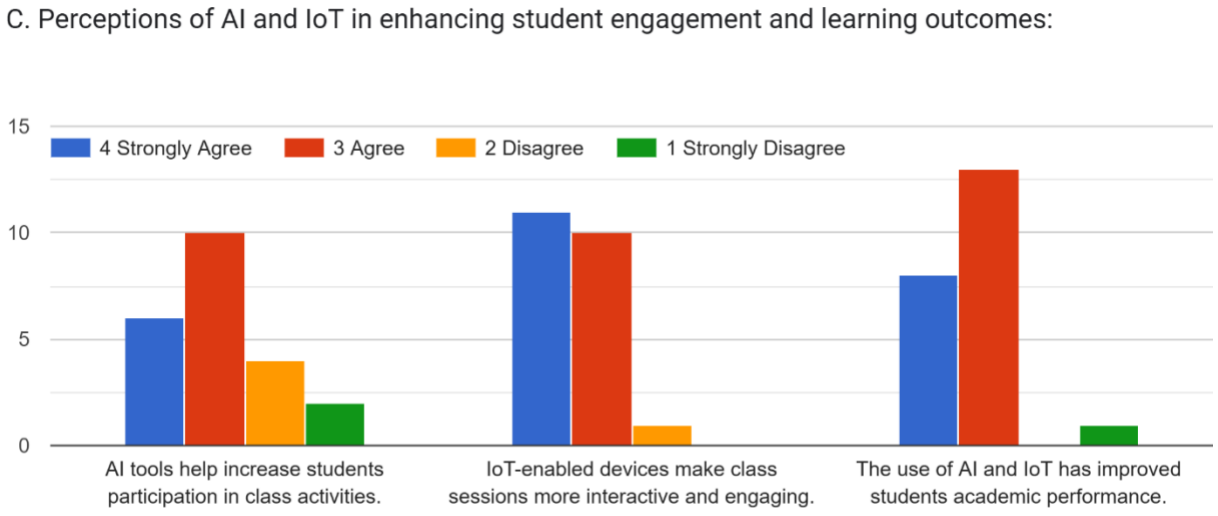

Figure 3 Perceived Impact of AI and IoT in Smart Classroom

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Data from Table 3 indicate that the statement " IoT-enabled devices make class sessions more interactive and engaging " attained the highest mean of 3.45 (SD = 0.60), reflecting a strong consensus among respondents that IoT technology improves engagement in the classroom. Likewise, the assertion "The use of AI and IoT has improved students' academic performance" garnered a mean of 3.27, supporting the notion that these technologies aid in achieving improved learning results.

On the other hand, the statement "AI tools contribute to enhancing students' involvement in classroom activities" received the lowest mean score of 2.91 (SD = 0.92), interpreted as "Agree". It may indicate that while AI is recognized for its potential, its direct impact on classroom participation may still be limited by factors such as tool accessibility, familiarity, or teaching strategies. Despite this, the overall mean of 3.21 still reflects a strong perceived impact of the role of AI and IoT in improving both engagement and learning outcomes.

3.2 Stakeholders Perceptions on the Effectiveness and Challenges of AI and IoT-Enabled Smart Classrooms

3.2.1 Effectiveness of IoT-enabled devices for data collection and data-driven decision-making

Table 4

II.A Effectiveness of IoT-enabled devices in facilitating real-time data collection and supporting data-driven academic decision-making.	SD	Mean	Verbal Description
1. IoT devices provide accurate and timely data for academic planning.	0.69	3.23	Strongly Agree
2. Data from IoT-enabled systems are used to improve classroom or curriculum decisions.	0.58	3.36	Strongly Agree
3. IoT helps school administrators make informed decisions based on real-time student performance or attendance data.	0.71	3.14	Agree
4. The school uses IoT-based data in its business intelligence systems for decision-making.	0.72	3.32	Strongly Agree
Overall Mean		**3.26**	**Strongly Agree**

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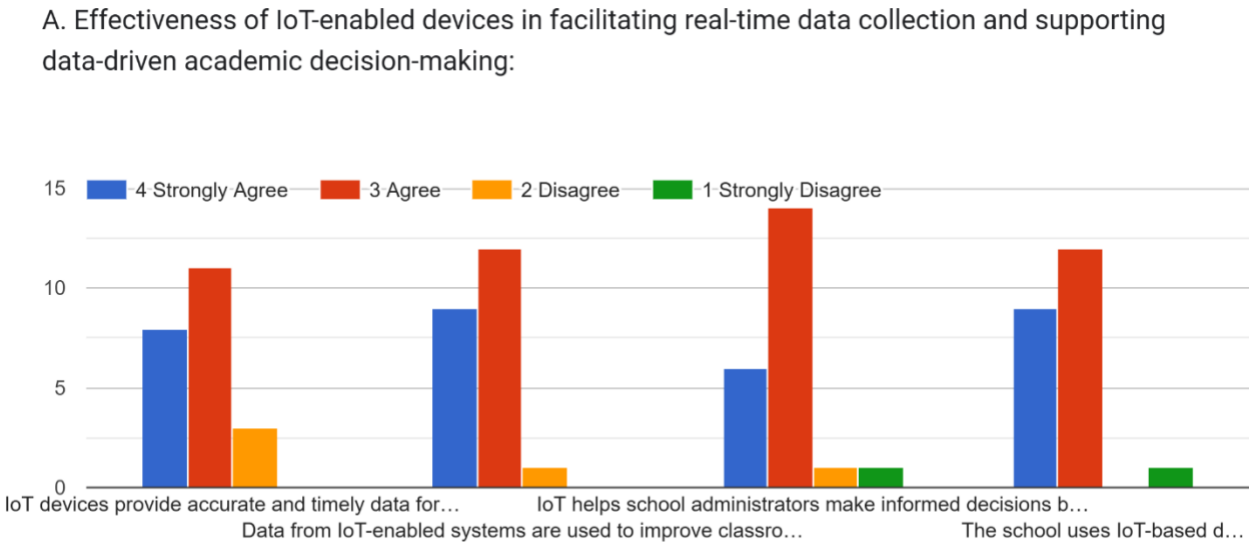

Figure 4 Effectiveness of IoT-enabled devices for data collection and data-driven decision-making

As shown in Table 4, the indicator, "Data from IoT-enabled systems are used to improve classroom or curriculum decisions", received the highest mean score of 3.36 (SD = 0.58), reflecting a strong consensus that IoT tools significantly contribute to the academic planning process. Respondents also significantly concurred that IoT aids in wider organizational decision-making, with a mean of 3.32 regarding the use of IoT-based data in business intelligence systems.

On the other hand, the item with the lowest rating was "IoT helps school administrators make informed decisions based on real-time student performance or attendance data", which received a mean of 3.14 (SD = 0.71). Even though still viewed as "Agree", this marginally reduced score might indicate insufficient real-time data merging into top-tier administrative practices or a gap in data analytics skills. The overall mean score of 3.26 indicates a robust view of IoT's role in enhancing data-driven decision-making within educational settings.

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3.2.2. Challenges and limitations in implementing AI and IoT-based smart classrooms

Table 5

II. B Challenges and limitations in implementing AI and IoT-based smart classrooms	SD	Mean	Verbal Description
1. School lacks sufficient internet connectivity and technological infrastructure to support AI and IoT-based smart classrooms.	0.66	3.36	Strongly Agree
2. Teachers are not adequately trained to implement AI and IoT technologies in the classroom.	0.75	3.36	Strongly Agree
3. School does not have clear policies addressing data privacy and protection when using AI and IoT technologies.	0.81	3.23	Strongly Agree
4. School is resistant to innovation and slow to adopt new technologies like AI and IoT.	0.87	3.09	Agree
Overall Mean		**3.19**	**Agree**

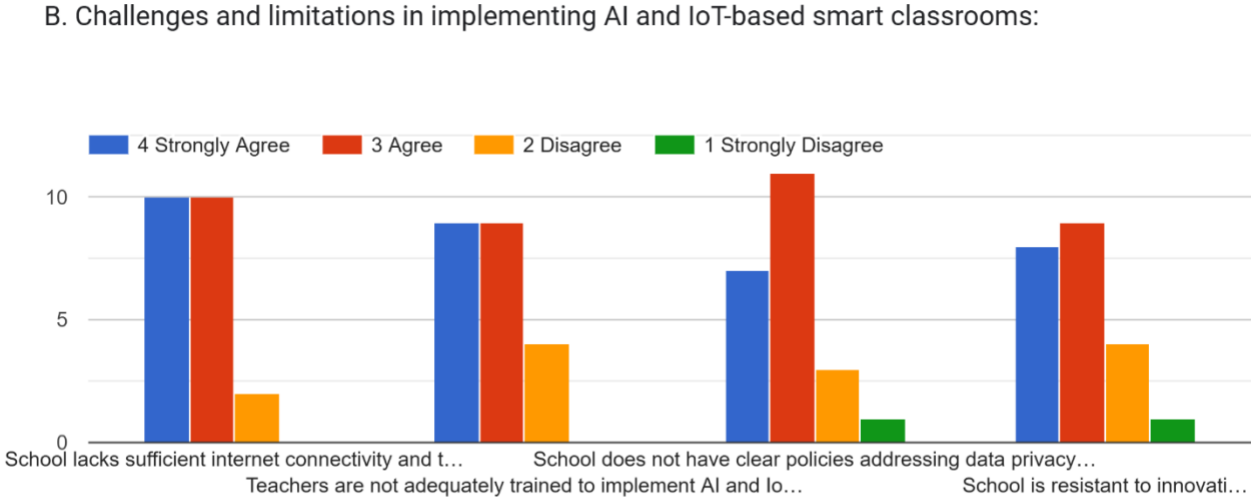

Figure 5 Challenges and limitations in implementing AI and IoT-based smart classrooms

Based on Table 5, the highest mean of 3.36 (SD = 0.66 and 0.75) was reported by two indicators: "School lacks sufficient internet connectivity and technological infrastructure" and "Teachers are not adequately trained to implement AI and IoT technologies" It indicates that respondents seriously believe that both infrastructure and training pose major obstacles to the effective implementation of smart classroom technologies.

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The item with the lowest rating, "School is resistant to innovation and slow to adopt new technologies" had an average mean of 3.09 (SD = 0.87), suggesting merely an "Agree" response. It suggests that although resistance to innovation is present, it is not seen as intensely as the constraints related to technology and training. The average score of 3.19 indicates a widespread consensus that schools encounter significant challenges in implementation. Achieving a successful integration of AI and IoT in education necessitates not only sophisticated tools but also conducive policy frameworks, training initiatives, and strong infrastructure to close the gaps in preparedness and implementation.

3.3 Recommended Strategies for Optimizing AI and IoT Integration in Educational Institutions

The results and feedback from the respondents indicate that although AI and IoT technologies offer considerable promise for improving personalized learning, student engagement, and data-driven decision-making, numerous challenges need to be tackled to guarantee their effective integration into educational institutions. Furthermore, respondents expressed worries not included in the survey itself. These included lack of finance, limited technical skills of staff and students, and a misconception about how the technology might be properly used. Others cited infrastructure limitations such as poor internet connectivity and general readiness by organizations to embrace innovation. On the basis of the above challenges, the following strategies are proposed to promote the deployment of AI and IoT in the educational setting

1. Use hybrid approach – Schools can start with mixed model, which combines traditional teaching methods with certain AI and IoT tools. It allows for slow adjustment and minimal disturbance.
2. Invest in training and capable personnel – AI and IoT can't just be integrated if you lack AI and IoT experts. Institutions should look to hire tech-savvy employees, or provide enough training to current staff.
3. Raising awareness campaigns and training programs – Teachers, students and school management or leaders have to be informed about the purposes, roles and benefits of these technologies. Regular orientations, workshops or trainings can lay this groundwork.

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4. Develop clear data privacy and data security guidelines –Because these technologies often handle sensitive and time-critical data, strict institutional guidelines are required to ensure an ethical, secure application.
5. Develop a plan for long term sustainability – Schools should be establishing budgets and investing in cost effective tools to yield the most return possible. Scalability needs to be factored into the game plan, scaling up as capacity is added.
6. Promote transformational leadership and administrative support – Transformational leadership nurtures creativity and cooperation, vital for innovation, as emphasized in the research by Nilo, Dungca, Mallari, and Florencondia (2025). Domingo, Cruz, Mallari, and Florencondia (2025) highlighted the importance of incorporating transformational characteristics into faculty development initiatives to enhance student performance and engagement or involvement in their study.
7. Encourage transformational leadership and administrative support — Encouragement by transformational leadership is defined as the process of encouraging employees to take effective actions and supervising them closely to improve work-related performance (Nilo, Dungca, Mallari, & Florencondia, 2025). A study of Domingo, Cruz, Mallari, and Florencondia (2025) underscored the need to infuse transformational qualities into faculty development programs to improve student performance, and the engagement or involvement in their studies.

4 Conclusions

This study shows that AI and IoT technologies are positively considered by schools for developing personalized learning, enhancing student engagement and supporting data-driven decisions-making. However, for some optimistic benefits, they have been hindered by obstacles such as budget limitations, lack of technical know-how, and infrastructure constraints for their full implementation. The implications provide some timely messages to educational leaders and policymakers, which emphasizes the significance of strategic planning, capacity building and supporting institutions in fostering the integration of these emerging technologies. This study offers a basic lesson, which is valuable if AI and IoT technologies are to be used effectively and sustainably to impact upon learning settings.

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