


Chapter 5

IoT for Smarter Students in Smarter Personalized Learning: Higher Education Context

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ABSTRACT

The traditional classroom is moving to rapidly evolving technologies that assist in improving teaching and learning in the 21st century and prepare students for the future workforce. The Internet of Things (IoT) has changed the betterment of education by assisting lecturers to administer it according to every student's needs. This chapter explores the avenues of IoT in education, including its applications, merits, and demerits. The chapter introduces the IoT and provides an in-depth analysis of how it is significant in education, and its current status in education is also elaborated. Applications of IoT are crucial and may be used to design smart classrooms, such as the integration of mobile technology and sensors. The merits of adaptive learning are that it can be accessed easily, provides fast feedback from the lecturers, and student engagement is also increased. For smart classrooms to be put in place, it is important to have the relevant infrastructure; lecturer development

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through short courses, workshops, and seminars; creation of relevant curriculum content; and implementation procedures. The convenience of IoT-based adaptive learning, such as increased student achievement, lecturer high remuneration rates, and increased lecturer satisfaction, is also discussed. The chapter also intends to examine the issues and challenges that need attention in IoT integration in higher education setups. The lessons learned from the accomplishment of IoT-based adaptive learning deployments are also stated. The importance of strategising on how to handle the challenges in connection with equity and access is highlighted to make sure that students at large have an equal chance to benefit from this latest technology development.

INTRODUCTION

IoT has ushered in a paradigm shift in education circles. Lecturers and students can now virtually interact, share ideas, and collaborate in real-time regardless of geographic separation. IoT integrates several hardware and software packages to create a functional internet-based network. Individual components of the system communicate via electronic sensors and cloud-based infrastructure. This chapter endeavors to elaborate on the role of IoT in improving the quality of the education delivery system and some inherent drawbacks like financial challenges faced by some academic institutions in securing required gadgets and software, and obtaining the required technical skills and aptitudes (Fitria & Simbolon, 2023; Abdul-Qawy, Pramod, Magesh, Srinivasulu, 2015).

IoT technologies, coupled with artificial intelligence (AI), have the potential to provide a more interactive and student-centred learning approach. Students are allowed to virtually interact with learning material and manipulate virtual objects as though they were real and physical. This fosters a more practical approach to learning, divorced from more theoretical traditional teaching and learning methods. Virtual platforms allow students to engage in situations that are difficult to partake in in real life and to carry out experiments they would not be able to in real life due to challenges like a lack of finance, a lack of physical apparatus, or consumables, among many other factors. IoT facilitates the creation of learning experiences and programmes specifically for particular students based on their unique needs and circumstances. This ensures that each student is allowed to learn at their own pace and get required assistance from chatbots in real time. Lecturers can also use this technology to mark attendance registers, track the progress of each student, design appropriate assessments, and give the much-needed, timely feedback (Embarak, 2022).

Functions of Some Fundamental IoT Components

Several electronic devices are integral parts of IoT systems that can work together to provide a quality educational experience. Electronic sensors detect any variations in particular physical conditions, like the motion of people or objects, and environmental conditions like temperature, humidity, and atmospheric pressure. Actuators implement necessary programmed mitigation measures according to the information given by the sensors. On the other hand, gateways are electronic components that play the role of ‘mediator’ between IoT-powered interconnected devices and the internet network to facilitate communication within the system. Cloud computing is essential in enabling the storage and timely processing of large amounts of data required for the efficient operation of IoT systems and allowing users to access the information remotely from any geographical location (Rahmani, et al., 2018; Javaid, et al., 2021; Sharma and Obaidat, 2020; Chen, et al., 2022).

Application of IoT Devices and Sensors in Educational Setups

IoT systems have the capability of providing a very interactive and immersive learning environment for students. Lecturers can obtain valuable current and accurate information about each student’s performance, strengths, and weaknesses and thus tailor their pedagogy towards assisting the students in achieving the required academic goals without wasting time on trial and error experiments (Al-Emran, et al., 2020, Shemshack & Spector, 2020; Wong & Li, 2020).

According to Abuarqoub et al. (2017), IoT technologies can monitor and control classroom environmental conditions and thus make the teaching and learning conditions comfortable and conducive. Lecturers and all other stakeholders involved in education can remotely access the information from cameras, sensors, gateways, and actuators and use it to monitor the physical participation of students, monitor their movements, and automatically mark attendance registers without physically calling out their names, like in traditional settings. Teachers are also empowered to design, administer, and grade assessments according to students’ academic needs and cognitive abilities. All this can be achieved by using readily available gadgets like smart mobile phones and laptops in real time. Discipline and focus among students can be enforced using these technologies (Yang, et al., 2019).

Evaluating data in education is fundamental since this provides insight into student learning behaviours, engagement levels, and academic performance. Data analytics plays a crucial role in education by providing insights into student learning behaviours, engagement levels, and academic performance (Kahu & Nelson, 2018; Mpofo & Chasokela, 2024; Nguyen, et al., 2020). Data that is generated from IoT devices is analysed to identify trends and patterns in students, and this supports ed-

ucators to identify areas where students need extra support or enhancement. Owan, et al., (2023) assert that providing students with immediate feedback can inform instruction, and this can help them to improve.

The Internet of Things (IoT) in Education

IoT technologies can be used to design smart classrooms that integrate technology use in education systems, and mobile communication devices can be used to access relevant information. IoT is pivotal in enhancing the 21st-century skills like critical thinking and novel problem solving by availing virtual resources that can cultivate the proliferation of these skills if physical resources are not locally available. IoT allows students from various geographic locations to collaborate and share ideas as if they were in one physical classroom. This creates one big global classroom where lecturers and students from all over the world can converge and share ideas in real time. Pedagogical styles, values, and norms vary from institution to institution. IoT technology can integrate these and take the best of each style to enrich the deficiencies of other styles. In this way the education fraternity becomes a robust and incredible force to reckon with, capable of improving the academic outcomes of numerous students and lecturers around the globe. These technologies are also able to convert verbal speech to visual sign language and interpret information from one language to another. This acts as a panacea for inclusive education. (El-Haggar, et al., 2023, Fitria & Simbolon, 2023; Rajamohan, et al., 2024).

According to Schelling and Rubenstein (2021), to inform educational decisions at the institutional, national, or global level, large amounts of data is collected, analysed, and then processed during instruction, and students benefit the most. Ifenthaler and Yau (2020) further argued that decision makers must focus on utilising different data analytics methods that are education-related data to predict student performance. Analysing data in an institution plays a major role because it allows one to identify challenges that may be faced by the institution, enabling it to adapt quickly to changing needs and circumstances.

Several studies have concluded that many academic institutions around the globe have at least shown interest in IoT or have started using the technology in learning platforms (Al-Emran, et al., 2019); Asad, et al., 2024; Mircea, 2021). Nowadays, smart buildings focus on minimising energy consumption by incorporating IoT-based technologies that enable the collection of data between weather, and building use, which can be used for optimisation of HVAC systems (Garcia-Monge, et al., 2023). This is a cost-saving mechanism for both the institution and the service providers. Classroom temperature is controlled, thereby giving students a conducive learning environment. Chasokela (2024, 2025) and Koumpouros (2024) decree that experiences have led to the exploration of various learning platforms like virtual reality

and AR applications to enhance learning experiences. It is a set of 3-dimensional objects that can be manipulated to develop an effective virtual reality in education. Students are now able to share to enhance their learning experiences.

Examples of Global Institutions IoT has Gained Traction in the Education Sector

According to Alam (2023), virtual classrooms are only a few of the applications conducted at the University of California, Berkeley, where students have benefited from rich learning in a smart classroom. Universities like Oxford University employ radio frequency identification (RFID) tags and global positioning systems (GPS) to monitor the physical position, movement and lecture-room attendance of students. This facilitates decision-making on intervention measures on students 'activities in and around campus (Cassidy, et al., 2021).

In the United States, Chicago Public Schools introduced the Smart Board program, which saw more than one thousand classrooms in schools being furnished with interactive smart whiteboards. This greatly improved the learning experiences of thousands of students. The University of Texas introduced several physical sensing and monitoring devices, like fitness trackers, smartwatches, and smart glasses, that can provide information on the position and activities of students at any given moment. This technology assists stakeholders in maintaining control over the education system and to remotely monitoring the behaviour of students in real time (Yasar, 2022).

IoT facilitates the implementation of inclusive education. An example is the use of computerised braille and the use of interpretive devices that can convert written text to speech to assist visually impaired students, and speech-to-text converters to assist those who are hard of hearing. IoT-powered Virtual Reality (VR) and Augmented Reality (AR) technologies are pivotal in creating stimulating and interactive learning experiences for all classes of students.

Applications and Benefits of IoT in Creating Smart Classrooms

One advantage of IoT-powered systems is the ready availability of academic material online so that any student can access it at any given time from any destination in the world as long as there is internet. IoT in education has the potential to improve student performance by generating individualized learning packages and collaborative engagements using online platforms like Moodle, Google Classroom, video conferencing, and Microsoft Teams. Lecturers can also engage in staff development

programs without physical boundaries to improve their teaching strategies, adopt modern pedagogies, and be able to give prompt feedback on given assignments.

Smart classrooms leverage IoT-powered devices to access online scholarly resources such as reading material, online interactive and collaborative learning platforms, and virtually embark on educational trips. On-campus stakeholder safety can be enhanced by employing Closed-Circuit Television (CCTV) cameras to monitor the movement of all people and vehicles within the campus area in real time. This creates an environment where security officers can promptly respond to any situation that seems to compromise the security of any stakeholder on campus. These cameras can also be used in examination rooms to minimise the likelihood of cheating and copying as a measure of quality control (Ghimire, et al., 2022).

Formative and summative evaluations are carried out to ascertain the effectiveness of teaching strategies and the quality of learning outcomes in education settings. IoT technologies can collect data from different sources and use AI algorithms to analyse it critically to identify trends and patterns and ultimately suggest any relevant changes that can be made to improve the programme or teaching and learning strategies (Nguyen, et al., 2023). The University of California, Los Angeles (UCLA) developed electronic devices called wearables that can generate electricity from human movements. This makes IoT-powered devices very portable and efficient, particularly in the medical field.

Constructing Smart Classrooms with Internet of Things (IoT) Technologies

Scheming smart is essential in shifting the learning experience of learners. Lecturers can convert old-style classrooms by incorporating the Internet of Things (IoT) into collaborative, attractive, and adapted learning environments. Lecturers are able to observe student engagement, track every student's progress, and adjust their teaching strategies in real time through the incorporation of IoT instruments. There are key considerations for designing smart classrooms, thus IoT-based learning environments, devices, software, data analytics and training. Revolutionising the educational setting, the IoT-based smart classroom system represents a high point in assimilation technology and pedagogy. According to Shin (2009), comprehending the value of IoT requires integration of Information Technology infrastructures and information services like RFID tags, wireless broadband, and geographic information systems. Sensory data must be gathered from distributed smart objects and be transmitted using a communication infrastructure, which can encompass both wired and wireless communication technologies (Singha et al., 2025). IoT allows linking real-life objects with the virtual world-providing anytime, anyplace connectivity for anything (Sundmaeker et al., 2010). Furthermore, Block et al. (2015) define a

smart classroom as a mixture of technological tools used in learning activities and promote a natural-conducive technological environment applicable in education. Edsys (2016) suggested that these smart classrooms are computerised classrooms suitable for a modern pedagogy, a method that includes the element of “Show me the concept and I grasp” in the classroom. This invention is changing the teacher’s methodology and how students learn in class.

IoT is a recent technology that enables the development of networks connecting various items, whether in the real world or the digital one (Patel, 2016). IoT devices, which range in size from tiny wearables to massive machinery and are outfitted with actuators and sensors, can intelligently sense their environments and take action on their own (Hammoudi, 2018; Gubbi, et al., 2013). The stable and secure network infrastructure is required to support the increasing number of IoT devices and data traffic. Furthermore, wire and wireless connectivity should be provided to accommodate different devices and teaching methods. Also, power management should be prearranged for power management and energy efficiency to reduce energy consumption and costs. The electrical system and infrastructure have to be installed to support future-proofing and scalability. The designated devices have to be suitable for educational purposes, for example, tablets, laptops, interactive whiteboards, and ensure devices integrate well with existing infrastructure, such as Wi-Fi networks and power outlets. To monitor, manage device usage, security, and maintenance, a device management strategy must be developed. Moreover, the software selected must have a user-friendly interface, thus easy for educators to use and interconnect. The software must integrate well with existing systems, like learning management systems (LMS) and student information systems (SIS). The selected software must provide insights into student learning behaviors, such as learning analytics platforms. The chosen software must permit for adjustment to meet the specific needs of the school or district.

Data from various bases, such as student devices, sensors, and learning platforms, must be collected, and a data collection plan must be developed. The data has to be scrutinised to identify tendencies, patterns, and perceptions that can update teaching strategies. Also, reportage and imaging tools must be provided to support lecturers in making sense of difficult data and ensure data security measures are in place to protect student data. Training on how to effectively use IoT-based tools and technologies safely and effectively must be offered to both lecturers and students. Also, lecturers should be offered ongoing support and resources to ensure continuity in the usage of IoT-based tools and technologies effectively.

Implementation Processes: Lecturer Training, Infrastructure Development, and Content Creation

Examples of processes such as infrastructure, lecturer improvement, formation of relevant curriculum content, and application procedures, hence smart classrooms are in place.

Currently, advances in digital technologies have allowed extensive, grassroots implementation and change to all types and sizes of organisations (Scholkmann, 2021; Shahi and Sinha, 2021). The implementation of smart classrooms is a difficult process that requires careful planning, organisation, and execution. Effective execution of processes is critical to ensure that faculty members and students can benefit from the new technology and tools are integrated seamlessly into the academic environment. The application process usually involves several key steps, including lecturer training, infrastructure development, and content creation and implementation procedures.

The implementation of smart classrooms requires effective lecturer training to ensure that educators are equipped to operate the new technology and tools. The training should cover the following key areas:

- Overview of the smart classroom infrastructure and equipment, as well as interactive whiteboards, virtual reality devices, and sensors.
- Applied training on using the technology to improve teaching and learning, comprising creating interactive lessons and assessments.
- Alteration with the learning management system (LMS) and how to integrate it with the smart classroom technology.
- Greatest practices for using data analytics and student feedback to update teaching strategies.
- Upkeep for developing curriculum content that integrates the new technology and tools.

According to The University of California, Berkeley (2025), lecturers received an all-inclusive training program that covered the basics of smart classrooms, including how to use interactive whiteboards and virtual reality devices. The training also encompassed sessions on designing, engaging lessons and assessments that utilise the new technology.

The constant development of infrastructure is a vital step in implementing smart classrooms. This consists of installing essential infrastructure such as network wiring, Wi-Fi access points, and power outlets, setting up equipment such as interactive whiteboards, virtual reality devices, and sensors, ensuring that all equipment is attuned with each other and with existing systems, and conducting thorough test-

ing and quality assurance to ensure that all systems are functioning properly. The University of Oxford, invested in upgrading its network infrastructure to support the increased request for online learning and this included installing new servers, routers, and switches and upgrading its Wi-Fi network. The UK government provided about \$340 million to schools to turn traditional classrooms into smart classrooms. Presently, nearly 300,000 smart boards are being used in schools in Britain. Smart Technologies, a Canadian-based company, and Promethean, a British organisation, are the key service providers (Schachter, 2018). British lecturers are among the lecturers in the world who are enjoying and experiencing the interactive features of ever-changing technology in the classroom, ensuring students' better engagement with each other as well as lecturers, and receiving the best educational opportunities throughout their educational careers (Schachter, 2018).

The effective use of smart classrooms requires creating relevant curriculum content. This includes developing new curriculum modules that incorporate the latest technology, tools, and updating existing curriculum materials to incorporate technology-enhanced learning activities. Creating online resources such as video lectures, podcasts, and interactive simulations and developing assessment tools that utilise the new technology. The lecturers at the University of Texas at Austin developed new curriculum modules combining computer-generated reality experiences and collaborative simulations. These modules were designed to improve student commitment and learning results.

To confirm a successful implementation of smart classrooms, it is essential to develop a clear execution strategy. The execution plan outlines the timeline for implementation, roles and responsibilities of various stakeholders, budget allocation, communication plan, and quality assurance procedures. At Harvard University, the execution plan included a phased rollout of smart classrooms across different departments, with clear timelines and budget allocations. The plan also included regular communication with faculty members and staff to ensure a smooth transition to the new technology.

In Mauritius, the implementation of smart technology in schools can be traced from 2008, when interactive whiteboards (IWB) were introduced (Bahadur and Oogarah, 2013). In 2011, Mauritius became one of the first countries in Africa that introduce IWB at the primary school level. This project resulted from the "Sankoré project of 2008, a brainchild of the Franco-British Summit of 2008". Bahadur and Oogarah (2013) state that its main objective was to assist Africa in meeting its educational goals through digital empowerment. It aimed to usher in improvements in the quality of schools and bring about essential developments in the learning process (Bahadur and Oogarah, 2013). In inference, effective implementation of smart classrooms requires careful planning, coordination, and execution. By providing lecturer training, developing infrastructure, creating relevant curriculum content,

and establishing implementation procedures, institutions can ensure a successful transition to smart classrooms that enhance teaching and learning.

Outcomes and Lessons Learned from Successful Implementations

There is increased student achievement, lecturer high remuneration rates, and increased lecturer satisfaction to be discussed. The issues and challenges that need attention in IoT integration in higher education setups are cited. The lessons learned from the accomplishment of IoT-based adaptive learning deployments are also stated. The positive outcomes due to the implementation of smart classrooms in higher education institutions include increased student achievement, higher lecturer high remuneration rates, and increased lecturer satisfaction. The introduction of smart classrooms brought in the idea that the context and place where teaching and learning occur is vital as the use of technology allows users to experiment with and control aspects of real-life situations and environments in the classrooms (Gros, 2016).

The combination of IoT technology in smart classrooms has led to improved student outcomes, including better academic performance, increased student engagement, and enhanced learning experiences. The smart board is colorful, thus attracting students' attention, and this leads to more effective individual learning (Foradian, 2013). Lessons can be linked from one subject to another using programmed lessons saved on the smart board. The use of attractive audio-visual teaching tools appeals to learners, and the use of eye-catching visuals can help learners to recall and relate what they are seeing to the real component or concept (Foradian, 2013). According to Lumme (2017), the use of smart boards broadens the styles of teaching as they allow for interaction with tools on the board. Pourciau (2014) states that using technology positively affects students' results. The students who learn in smart classrooms tend to have higher grades, better attendance, and a greater sense of belonging in the academic community. This is because smart classrooms provide students with interactive and immersive learning experiences that cater to different learning styles, making it easier for them to absorb and retain information. Through educational technology, the students' cognitive comprehension has been improved, and a significant increase in their performance has been observed; indeed, the speed and quality of learning in universities have improved, as well (Chen et al., 2012).

The implementation of smart classrooms has also led to an increase in lecturer remuneration rates. This is because IoT technology allows lecturers to design more effective lesson plans, reduce their workload, and focus on higher-value tasks such as curriculum development and research. As a result, lecturers can take on more responsibilities and are rewarded with higher salaries. Some of the roles of a lecturer in a smart classroom are now being a facilitator, tutor, and administrator. This

has changed from being the source of information to using instructional teaching methods to support learners while they work independently (Thorsteinsson, 2014). The educator will only give instructions to students and guide them throughout the lesson. Lecturers guide the students and only help if the need arises.

The integration of IoT technology in smart classrooms has also led to increased lecturer satisfaction. Lecturers can use technology to create more engaging and interactive lessons, which can lead to a greater sense of job satisfaction and fulfillment. Furthermore, IoT technology allows lecturers to track student progress and assess their teaching methods, which can help them identify areas for improvement and develop more effective teaching strategies. Lesson preparation has become easier when using smart boards, using readily available materials that are on the smart board. The use of the internet is another advantage as educators can search for already-made lesson plans and modify them to suit their needs (Thorsteinsson, 2014).

Despite the many benefits of IoT integration in higher education institutions, numerous issues and challenges need attention, and some of the key challenges include technical issues, cost, integration with existing technology, and data security. The focal challenge is ensuring that the technical infrastructure is robust and reliable. This includes ensuring that network connectivity is stable, equipment is properly installed and maintained, and software is up-to-date. An additional challenge is the cost of implementing IoT technology, and the cost of equipment, software, and infrastructure can be significant, which can be a barrier for institutions with limited budgets. Integration of IoT technology with existing systems and processes is another challenge, and this comprises integrating with learning management systems, student information systems, and other campus infrastructure. Data security is a major concern when it comes to IoT technology, and Institutions need to ensure that data is protected from cyber threats and breaches.

Regardless of these challenges, many institutions have successfully implemented IoT-based adaptive learning deployments, and some of the key lessons learned from these implementations are starting small, collaborating with stakeholders, and planning for maintenance. Institutions should begin with a pilot program or a small-scale implementation before scaling up. Another important lesson is the need for collaboration with stakeholders. Institutions should work closely with faculty members, students, and IT staff to ensure that the implementation meets their needs and expectations. Lastly, institutions should plan for maintenance and support from the beginning, and this consists of developing a plan for equipment maintenance, software updates, and technical support. By understanding the outcomes and lessons learned from successful implementations of IoT technology in higher education institutions, institutions can better navigate the challenges and opportunities presented by this emerging trend.

The Role of Artificial Intelligence (AI) in Education and Its Potential Applications in Personalised Learning Pathways

Artificial Intelligence (AI) is a rapidly developing field that involves creating intelligent robots that can mimic human thought processes and behavior. These robots can be used in a variety of applications, including teaching, self-driving cars, and medical diagnosis (Wardat et al., 2023). Education is one of the many industries that are using AI-powered tools and applications to improve the quality of services offered to lecturers and students (Suh and Ahn, 2022). AI is transforming the education sector by changing the way students learn and interact with educational content. AI has the potential to personalise learning experiences, increase student engagement, and improve academic outcomes. AI-powered adaptive learning systems can create personalised learning pathways for each student, taking into account their strengths, weaknesses, and learning styles. The systems use machine learning procedures to examine student performance data and adjust the difficulty level of educational content, providing real-time feedback and recommendations for improvement. This method benefits students to learn at their own pace, fill knowledge gaps, and achieve academic success. Student-centered learning was successfully attained through the use of AI in the classroom (Huang, 2021). Testing, assessment, and evaluation in education are all improved by AI-powered tools and applications. These resources can give teachers insightful knowledge of student performance, learning objectives, and the efficacy of their instruction. To assist students in identifying their areas of strength and weakness, AI-powered assessment systems, for instance, can evaluate assignment replies from students and offer tailored feedback (Nazaretsky et al., 2022).

Intelligent tutoring systems (ITS) are another application of AI in education, and these systems use AI-powered chatbots or virtual assistants to provide one-on-one support to students, offering real-time guidance and feedback on complex topics. ITS can be used to supplement traditional teaching methods, increasing student commitment and improving understanding of difficult concepts. Natural language processing (NLP) is a key component of AI-powered educational systems that enables machines to comprehend human language, allowing AI-powered chatbots to connect with students naturally and automatically. NLP also permits AI-powered grading systems to precisely assess student responses, providing instant feedback and reducing the workload of teachers. Vasconcelos & dos Santos, 2023 state that Artificial intelligence tools, like Bing and ChatGPT, have been labeled “objects people can think with,” particularly in the context of teaching and learning, where students can develop their capacity for critical and reflective thought, encourage originality, develop problem-solving abilities, and successfully understand concepts.

Predictive analytics is another area in which AI is making an important impact in education, and through scrutinizing large datasets on student performance, predictive analytics can identify at-risk students and provide early interventions to prevent academic failure. This method can also benefit institutions by adjusting resource allocation, improving student outcomes, and reducing costs. The other application of AI in education is Game-based learning. AI-powered games can create personalized learning experiences that are attractive, collaborative, and exciting. These games can be used to teach difficult concepts, such as mathematics and science, while promoting soft skills like critical thinking and problem-solving.

The students get instant responses via AI-powered assessment tools, helping them to track their progress and identify areas for perfection. These tools can also assist educators to identify knowledge gaps and adjust their instructions accordingly. AI-powered feedback systems can also support students in developing self-assessment skills, promoting metacognition and independent learning. Personalized learning adapts training to each student's unique needs, creating a more welcoming and productive learning environment. The use of data analytics, adaptive procedures, and intelligent tutoring systems can enhance personalised learning through the application of AI technology innovations, providing personalised learning experiences. Although AI has the potential to change education, some challenges need to be addressed, for instance, ensuring data privacy and security is crucial when dealing with sensitive student data. Additionally, favoritisms in AI algorithms need to be addressed to ensure unbiased treatment of all students. However, the opportunities offered by AI in education are huge, including increased convenience, improved academic results, and enhanced educator productivity. Additionally, advocates assert that AI is here to stay and caution educators to look for ways to mentor students in the moral use of AI technologies to enhance their advantages (Halaweh, 2023; Javaid et al., 2023; Rudolph et al, 2025).

In conclusion, AI has the potential to change the education sector by creating modified learning pathways that cater to individual needs and abilities. By way of leveraging AI-powered adaptive learning systems, intelligent tutoring systems, natural language processing, predictive analytics, game-based learning, assessment, and feedback tools, educational institutions can improve student outcomes, increase lecturer efficiency, and promote lifelong learning. Artificial Intelligence is an important technology under the Internet of Things (IoT). While AI and IoT are separate technologies, they are often used to create smart devices and systems that can interact with the physical world. AI is reflected as part of IoT for the following reasons:

- ✓ AI algorithms are used to examine the massive amounts of data generated by IoT devices, such as sensors, cameras, and other devices.

- ✓ It can make decisions based on the investigated data, such as controlling temperature, lighting, or security systems.
- ✓ AI can automate tasks and processes in IoT systems, reducing the requirement for human involvement.
- ✓ AI-powered predictive care can help identify potential issues before they occur, reducing downtime and increasing overall efficiency.
- ✓ It can provide tailored experiences for users, such as recommending products or services based on their behavior.

There are numerous examples of AI in IoT, such as smart homes, industrial automation, healthcare, and transportation. AI-powered smart home systems use sensors and cameras to monitor and control lighting, temperature, and security systems. AI-powered manufacturing automation systems use sensors and robots to monitor and control manufacturing processes. AI-powered healthcare systems use wearable devices and sensors to monitor patients' vital signs and provide custom-made health advice. AI-powered self-directed vehicles use sensors and cameras to navigate roads and make decisions in real-time.

The proceeds of combining AI with IoT are improved efficiency, leading to important improvements in efficiency, such as machines that can make decisions quicker and more precisely than humans. AI-powered systems can provide custom-made experiences for users, making it easier for them to network with IoT devices. AI-powered systems can identify potential safety risks and take action to avert accidents or damage. Lastly, AI is a key technology under the Internet of Things (IoT), supporting the analysis of vast amounts of data, decision-making, automation, predictive maintenance, and improved user experiences.

Artificial intelligence (AI)/ Machine Learning (ML) Technologies in the New IoT Ecosystem

Artificial intelligence is a wide-ranging branch of computerised decision-making without human involvement, and it covers different areas from propositional logic to neural networks. Machine Learning (ML), a subset of AI, means decisions or guesses made by data-driven technology. The Machine learning methods powered by AI include deep neural networks (DNN), also known as deep learning (DL). Machine learning, artificial intelligence, and deep learning are extensive and combined across data-driven industries that create AI-based products and services. The growing collaboration between humans and AI has resulted in the development of human-centered machine learning (HCML). Kaluarachchi, et al. (2021) assert that Artificial Intelligence (AI) and Machine Learning (ML) are transforming the education sector by providing modified learning experiences, improving student engagement, and

enhancing teacher effectiveness. AI and ML have the potential to transform the way students and lecturers learn and teach, making education more available, effective, and efficient. The key applications of AI and ML in education are:

- AI-powered systems that offer one-on-one provision to students, providing real-time response and guidance.
- AI algorithms examine student data to create modified learning paths, adapting to individual learning styles and paces.
- AI-powered chatbots assist students with queries, providing instant support and freeing up lecturers to focus on more complex tasks.
- ML algorithms analyse student data to forecast academic performance, identifying at-risk students and enabling targeted interventions.
- AI-powered grading systems reduce the workload of lecturers, freeing up time for more important tasks.
- AI-powered virtual reality and augmented reality experiences improve student engagement and interaction.
- Natural Language Processing tools support educators in creating collaborative lessons, enabling students to engage with multifaceted concepts in a more immersive way.

The returns of AI and ML in education are improved student engagement, the platform has increased student engagement by 25% through modified learning experiences and real-time response. Lecturers can deliver targeted support to students who need it most, improving overall academic performance. The platform provides valuable insights for data-driven decision-making, enabling the university to enhance resources and allocate funding effectively. The platform has reduced the need for physical infrastructure upgrades, saving the university millions of dollars in repair costs. Artificial intelligence, data, analytics, and machine learning support educators in delivering educational programs to students via an immersive virtual environment. This approach assists in ensuring the quality of distance learning and effective teaching (Duggan, 2020).

There are also challenges and concerns of AI and ML; thus, ensuring the safety and privacy of sensitive student data is a top concern. Certain lecturers may struggle with changes brought about by AI-powered tools, requiring effective training and support, and ensuring fairness and bias-free decision-making in AI-powered systems is critical. There are real-world examples like Knewton, which is an adaptive learning platform that uses ML to personalize mathematics lessons for K-12 students. DreamBox is a math education platform that uses AI-powered game-based learning to advance mathematics skills for elementary school students.

Grade scope is a platform that combines expertise with the latest machine learning and artificial intelligence technologies to support lecturers in assessing student progress (Chen, et al., 2020). The platform is effective because it allows lecturers to save time usually spent on academic reviews and assessments. Grade-scope provides statistics and identifies classroom developments and student needs. Knewton's Alta is an artificial intelligence platform designed to develop learning and assist lecturers in assessing assignments (Ustun & Yavuz, 2024). Knewton's Alta is responsive learning software that provides a hands-on learning experience with detailed explanations and timely instructions. At Knewton Alta, students use the personalised pathway based on their achievements and needs.

The platform monitors student progress and adapts it in real-time to maximise learning outcomes.

The other learning platform, Knowji Alta is a research-based audiovisual application that tracks student progress. It reflects cognitive category typologies and structures academic knowledge. It helps to research the connection of Gestalt with the basic level concepts, analyses quick reasoning based on figurative-schematic structures, and explores clip thinking (mental and visual images), and visual images (high-quality memorisation, productive building of their logical relationship). The system develops the student's mental portrait. Knowji's vocabulary applications combine the best methods to provide fun for students and effective learning at the same time. Duolingo (2021) is a chatbot platform combined with artificial intelligence algorithms that allow educators to comprehend the user's context and respond to individual students' needs. Duolingo language-learning app that uses gamification, ML, and NLP to provide personalised language lessons. AI and ML have the potential to transform the education sector by providing modified learning experiences, improving student results, and increasing competence. However, it's essential to address challenges related to data privacy, educators' resistance, and bias in algorithms to ensure successful implementation.

Virtual environments provide conducive learning atmospheres in situations where physical face-to-face learning interactions are not possible, for example, during wars, disease outbreaks, and other crises. The COVID-19 pandemic saw many academic institutions physically shut down for long periods (lockdowns). Education continued through the application of online platforms like Google Classroom, Zoom, Moodle, and Microsoft Teams. Using AR and VR technologies on these platforms has great potential to enhance educational attainment despite any physical barriers encountered. (Abubakah et al. 2022).

IoT technologies facilitate the development of a network of interlinked devices that improve communications and the sharing of academic resources electronically. These resources can also be remotely monitored using RFID codes, sensors, and BLE technologies. The education process would be greatly brought to life by

incorporating AR technologies in the development of interactive and collaborative teaching and learning experiences for both lecturers and students. Different types of simulations can be created to allow students to interact with and manipulate virtual objects and visit virtual environments (Smith et al., 2023).

Once the hardware and software have been set up and installed, digital teaching and learning become very affordable, especially in an environment with stable and reliable internet. Physical educational trips can be replaced by more educational and immersive virtual trips. Laboratory-based experiments, including those involving dangerous reagents, apparatus, or procedures, can be safely carried out using simulations in a virtual environment. AR and VR technologies leveraging IoT promote inclusive education in that they cater to audio, visual, and tactile learners and have sound and speech enhancers and screen translators to accommodate visually impaired learners. Pictures and visual illustrations can be enhanced for those hard of hearing. Lessons can easily be translated into various languages so that each learner can learn using the language they understand best. 21st-century skills can be reinforced and practiced in the virtual world. Adapting to the virtual world teaches students to adapt to any other new learning environment (Ghafar et al., 2023).

Medical students in some institutions apply VR technologies to study internal body structures in depth. The VR devices used allow students to navigate the human body and locate, identify, and analyze body organs with utmost precision without physically touching the person concerned. Simulated practice surgical operations can be carried out in the virtual environment with no harm done to real patients. Only when the medical procedures are perfected do they attempt to perform them on real patients. VR takes the medical students on a virtual student on a virtual trip inside a human body where they can see and have a sensation of touching internal body organs in 3 Dimensions and real colour. This provides a crucial and unique experience that they cannot obtain in the real world. Stanford University has a functional VR laboratory for such purposes (Lanese, 2018).

Some universities have started using innovative teaching strategies in their STEM curricula. The University of California has established an AR Biology Laboratory that can employ AR and VR technologies to bring biological concepts to life, making students and lecturers engage with and manipulate virtual biological specimens as though they were real. Some higher learning institutions apply VR to let students virtually participate in trips to destinations that would be impossible, very difficult, expensive, or dangerous to visit in real life. This enables students to interact with people from different cultural and economic backgrounds and thus broaden their socio-cultural understanding. AI is capable of utilizing vast information resources to more or less accurately narrate and explain the phenomena that students encounter on their virtual trips and pose questions that can broaden their 21st-century skills like critical thinking, adaptability, communication, and novel problem-solving

(Augstein, 2023). Some important life lessons are obtained through exposure to uncomfortable situations. During the COVID-19 pandemic, most public physical encounters were banned or were taken at a safe distance (called social distancing at that time), physical traveling to faraway places was also banned, and the education sector was forced to innovatively enter the virtual world to continue its primary mandate of teaching. Prolonged engagement in the virtual world resulted in the adoption and development of AI, VR, and AR technologies to revolutionise the education sector. Students with special Educational Needs (SEN) are given the power by IoT and simulative technologies to virtually embark on field trips and experience various learning activities that are beyond their capabilities in the real world. Harvard Business School is an example of a higher learning institution that has taken the lead in venturing into VR technology for academic purposes. (Ciloglu & Ustun, 2023; Midles, 2024).

The full utilisation of digital technologies comes at a financial, human, and material resource cost. Financially challenged people or institutions may not afford to buy the hardware and software required to obtain access to IoT-powered VR and AR resources despite their desire to do so. Some areas in the physical world have limited or no access to stable internet connections. These modern technologies require a strong and stable internet connection. The World Bank (2019) asserted that globally, less than 53% of the population has access to the internet either through broadband, Wi-Fi, or other means. This leaves about more than 47% with no access at all, the greater portion of this being in the Global South, with Africa taking the bigger chunk. This situation shows that much investment is required, mostly in Africa, to boost the number of people in the global community who have access to the internet and all associated technologies so that everyone is operating equally on the same page. This could be achieved by applying a paradigm shift regarding budgetary issues by affected communities and a robust global policy framework to assist the less resource-privileged. Massive technical and infrastructural development is required in many regions of the world to enable the general citizens, academics, and students to embrace and enjoy the benefits of IoT-powered modern technologies (Kuhn et al., 2023; Hlongwane et al., 2024).

Many institutions of higher learning are at various stages of fully embracing IoT-based teaching pedagogies. One big challenge is the lack of technical expertise to create and develop customized and conducive learning platforms and set up and maintain IoT networks. Comprehensive policies dealing with personal data usage, ethical issues, and cybersecurity need to be put in place and implemented with rigor (Tsimba et al., 2023).

AI technologies work on available large datasets on various subject matter and personal information about students to marry the two and develop personalised learning programmes for particular students. The challenge with many developing

nations in the Global South is the lack of large amounts of information about students; therefore, machine learning is carried out mainly on data from developed countries. Students from other regions are now forced to adapt to foreign learning styles, cultures, and languages other than their own. This can polarise the education landscape and perpetuate the inequalities prevalent in the physical world. If students fail to identify themselves with or fit within the cultural norms on which the machines have been trained, they may reject modern technologies (Vincent & Van, 2022). A huge investment in large-scale training of technicians and teachers, procurement, and development of hardware and software is required to fully embrace technology-driven pedagogies (Ade-Ibijola & Okonkwo, 2023).

To cut operational costs, locally based technical experts are required to quickly solve challenges associated with gadget compatibility, installing appropriate software packages and settings, monitoring the operation of electronic sensors for IoT systems, and upgrading AR and VR systems as technology advances or new programs become available on the market (Lam, 2023; Soori et al., 2023).

The implementation of high-quality online education is reliant on the possession of state-of-the-art electronic equipment, including high-speed processing computers, laptops, smartphones, and peripheral devices like VR headgear, digital cameras, and input devices like keyboards, mice, joysticks, and voice-to-text translators. Unfortunately, some or all of these devices may be out of reach for some students. This may create digital segregation, making quality education available to those with resources. This calls for a paradigm shift among institutions of higher learning to source funding and sponsorship packages and engage in private-public partnerships (PPP) to fund the projects and also pool resources together. Infrastructural development and reskilling and upskilling of personnel are required to allow for massive digitisation (Olaniyi et al., 2024). Students and other stakeholders may individually afford state-of-the-art gadgets, combining these to generate a robust and efficient IoT education system, with all protocols and ethical considerations observed may be very costly. Issues regarding data security need to be taken seriously, especially when dealing with sensitive personal information. Cyberbullying, unlawful personification, hacking, and other cybercrimes become rampant if data security systems are not tight enough.

Examples of IoT Programmes in Zimbabwe Higher Education Institutions

There are several cutting-edge examples of IoT programs in Zimbabwean higher education institutions related to smarter students and personalized learning, such as:

- **Smart Campus Infrastructure Monitoring at the University of Zimbabwe (UZ):** UZ has integrated IoT sensors across its campuses to monitor energy consumption, water usage, and environmental conditions. These systems enable real-time data collection, allowing campus administrators to optimise resource usage, reduce costs, and create a more sustainable learning environment. Students and staff benefit from improved facilities and a greener campus experience. (Madyira & Botha, 2020)
- **IoT-Enabled Laboratory Automation at Zimbabwe Institute of Engineers and Technicians (ZIET):** ZIET has adopted IoT devices in engineering labs to automate experiments and collect data remotely. Students can control experiments via mobile apps, access real-time sensor data, and analyze results digitally. This enhances personalized learning by allowing students to learn at their own pace and access experimental data anytime, anywhere.
- **Personalised Learning Environments Using IoT at Africa University:** Africa University has piloted IoT-based classroom systems that adjust lighting, temperature, and acoustics based on student presence and preferences. Such environments promote active engagement and cater to individual comfort, making learning more effective and personalised. (Maphosa, 2020).
- **Smart Student Attendance and Engagement Tracking at Midlands State University (MSU):** MSU has implemented Radio Frequency Identification (RFID) and IoT-enabled attendance systems that automatically log student presence in lectures and labs. Data analytics then provide insights into student engagement patterns, enabling lecturers to tailor their teaching approaches to improve student retention and success.
- **IoT-Driven Agricultural Research and Education at Bindura University of Science Education:** While primarily research-focused, the university uses IoT sensors in agricultural modules to monitor soil moisture, weather conditions, and crop health. Students involved in these projects gain hands-on experience with IoT applications in agriculture, fostering innovative, personalized learning in sustainable farming practices.

CONCLUSION

Modern technologies like IoT, AI, AR, and VR have the potential to provide innovative ways of improving the education landscape by generating individualised, collaborative, and interactive teaching and learning environments. The virtual world can provide opportunities for students to carry out laboratory experiments using equipment, apparatus, and materials that are not readily available in their immediate physical environments. These technologies also allow the exploration of locations

around the globe without leaving your physical location. Students can manipulate several variables and obtain results and feedback in real-time. This may improve 21st-century skills like critical thinking, problem-solving, communication, and adaptability. Learners with SEN could utilise the audio-visual effects and interactive interfaces to obtain a unique and rewarding educational experience that would not be possible in their given physical settings. Stakeholders in education could utilise these tools to collaborate, pool resources together, and develop world-standard curricula in their respective educational institutions. Teachers can also collaborate on different platforms and share ideas to improve their practice by forming Communities of Practice (CoP) (Sonsupap & Cojorn, 2024). This chapter has discussed several applications of these modern technologies in enhancing lecturer training, the development of effective teaching and assessment pedagogies, and student motivation and active participation in the learning environment. Challenges like internet connectivity, the cost of establishing robust IoT systems, cybersecurity, ethical considerations, and technical expertise have been discussed. The chapter aims to stimulate interest in the uptake and utilisation of modern technology in education whilst being cognisant of the inherent challenges involved.

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KEY TERMS AND DEFINITIONS

Artificial Intelligence: Refers to Artificial intelligence is the application of advanced computer technologies to develop machines that apply algorithms and neural networks to exhibit human-like cognitive abilities, including learning, interacting with the environment, and problem-solving. In education, AI can generate student-specific learning content, assist teachers with routine duties like marking attendance registers, respond to content-based questions, and create and grade assignments in real time. (Pietikäinen and Silvén, 2021).

Adaptive Learning: Leverages advanced computer-based technologies that employ algorithms and machine learning to generate learning experiences suited to particular students based on their individual academic needs and cognitive abilities. The system analyses interactions with the learner, using continuous assessments to give appropriate real-time suggestions and feedback to facilitate positive academic progress at the learner's pace. Learning can occur virtually using appropriate chatbots and intelligent tutoring systems to achieve improved learning outcomes in an efficient, safe, and environmentally friendly atmosphere (Buckley et al., 2022).

Augmented Reality (AR): A computer system-based technology that uses algorithms to combine virtual 3-dimensional objects with real objects or enhance the real world environment by projecting virtual objects into it using a device's camera and display unit to blend the digital and physical objects, creating an immersive and interactive experience. In education, AR can be used to create interactive lessons where students can interact and manipulate variables or characters in a book to create real-world visual and audio sensations in real time (Sutopo, 2022; Zailani, 2022).

Educational Technology: Refers to the blending of hardware like whiteboards, smartboards, digital cameras, sensors, AR headsets, with software packages to enhance communication between the teacher and students and create a collaborative and interactive learning environment that can also be individualised. This can improve academic performance, motivation, and stimulate critical thinking (Subran & Mahmud, 2024,

The Internet of Things (IoT): The interlinking of several physical, electrical, and electronic bodies fitted with sensors to create a network that is connected to the internet so that they can communicate and be controlled remotely. This facilitates efficient utilisation of resources. In education, IoT is used to generate virtual classrooms, monitor student activities, generate immersive learning environments, and monitor all connected physical assets (Fitria, 2023; Zhang, 2023).

Machine Learning: A facet of AI that employs algorithms to search through large amounts of data to identify patterns and make decisions, suggest solutions to novel problems, and understand human language without being specifically programmed to do such. Such computerised systems can be employed in education settings to develop student-specific learning content to cater for different learning styles and cognitive abilities to enhance their academic output (Ramlakhan et al., 2022).

Personalized Learning: A student-centered learning model tailored to cater to diverse students' needs and cognitive abilities so that they learn at their own pace and unique style. Computer systems can use machine learning to develop data-driven learning activities and assessments to generate interactive learning pedagogies that stimulate motivation, student engagement, and improved academic achievement (Durham et al., 2023).

Smart Classrooms: Data driven virtual or physical learning environments that employ sophisticated modern computer-based technologies to provide interactive, inclusive, effective and engaging learning environments designed to foster collaboration, critical thinking, creativity, adaptability and problem solving using audio-visual equipment and internet resources in a bid to enhance learning outcomes (Fengfeng et al., 2023).

Virtual Reality: A computer-based technology that enables learners to interact with virtual, digitally generated objects as if they are physically real. The computer system can generate 3-dimensional objects and sound effects and give the learner a sensation of being in an environment where these objects are real and can be manipulated using appropriate hardware and software. In some cases, people can virtually visit remote places, carry out laboratory experiments, or view internal body structures without physically leaving their homes or work stations. This simulative technology facilitates interactive, collaborative, and engaging learning that stimulates critical thinking, problem solving, and cultural exploration (Fitria, 2023).