# Undergraduate Students' Perception of Digital Twins Technology in Education: Uses and Challenges

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***Abstract***

*This study adopted correlational research design to examine undergraduate students' perception of digital twins technology in education: Uses and challenges. The study was carried out at University of Port Harcourt and Ignatius Ajuru University of Education. The population of the study is 277 undergraduate students in the faculty of education, department of curriculum studies and educational technology, University of Port Harcourt and 201 undergraduate students in the department of curriculum studies and instructional technology, Faculty of Education, Ignatius Ajuru University of Education. A sample size of 100 students was used for the study. A structured questionnaire was given to the students to get responses. Face and content validity was applied. Reliability coefficient of 0.74 was obtained. Mean and Z-test was used for the study. The study found that digital twins facilitate collaboration among students and educators, enabling shared learning experiences and collaborative projects; students can engage with interactive content and participate in virtual labs or experiments outside of traditional classroom hours; digital twins provide students with hands-on experience in virtual environments, allowing them to explore and interact with complex concepts and phenomena. Based on the findings, the researchers recommended that Educational institutions should establish collaborations between educational institutions, technology companies, and government agencies to share resources, expertise, and funding.*

***Keywords:*** *Digital Twins, Simulation-Based Learning, Adaptive Learning, Smart Campus Solutions, Immersive Remote Classes, Workforce Training Simulation, Personalized Learning*

## Introduction

Using digital twin technology, a physical product, system, or process can be virtually replicated (Rudra, 2023). This digital equivalent uses real-time data collection and use to replicate, analyze, and optimize its analog counterpart. Kartashova, Gurzhii, Zaichuk, and Sorochan (2024) state that the following applications of digital twin technology are found in educational technology:

1. Virtual labs and simulations: With the use of digital twins, students can perform experiments and hone their abilities in a secure, controlled environment by creating lifelike simulations of actual labs and locations. Medical students can perform surgery, while engineering students can operate on virtual machinery.
2. Adaptive Learning Platforms: Teachers may monitor students' progress, comprehend their learning methods, and customize the curriculum to meet each student's needs by building digital twins of the students. This facilitates the improvement of learning outcomes and the provision of tailored feedback (Wang, MXiaotian, & Fengsshuo, 202).
3. Smart Campus Solutions: Educational institutions' digital twins can optimize campus operations, including maintenance, security, and energy management. This results in improved learning environments and the more effective use of resources (Rathore, Shah, Shukla, Bentafat, & Bakiras, 2021).
4. Immersive Remote Learning: To develop immersive remote learning experiences, digital twins of classroom environments can be utilized. According to Allan, Mines, Rodreck, and Campbell-Meier (2023), students can engage in group activities, interact with virtual versions of their classrooms, and interact with educational information.
5. Workforce Training Simulations: Digital twins can replicate real-world work environments in corporate education and vocational training, giving employees practical experience and skill improvement without the hazards associated with in-person training (Carvajal, & Arenas, 2022).
6. Educational Research: Before putting new ideas and technologies into practice in the real world, researchers can evaluate them in a virtual setting by using digital twins to examine educational techniques and outcomes (Zhang, 2017).
7. Analytics and insights: Large volumes of data on student performance, engagement, and institutional effectiveness can be gathered and analyzed by digital twins. Alcacer and Cruz-Machado (2019) state that this data can be utilized to improve instructional tactics, make well-informed decisions, and raise the standard of education as a whole.

The advantages of digital twins are as follows:

1. Enhanced Engagement: Students' motivation and engagement can be raised through interactive and immersive learning environments.
2. Enhanced Safety: Learners can engage in risk-free virtual practice and experimentation.
3. Resource Optimization: Using data-driven insights to manage digital and physical resources effectively.
4. Personalized Learning: Educational experiences that are specifically designed to meet the needs and learning preferences of each learner.

5. Scalability: The capacity to educate more pupils, especially those in underserved or rural locations, consistently and at a high standard (Ayoade, Adedigba, Adeyemi, Adeaga, & Akanbi, 2022).

Digital twins, virtual equivalents of real things have grown in importance across a number of sectors. Digital twins provide creative solutions in the field of educational technology that improve student experiences, raise academic standards, and promote long-term economic growth. Customized learning experiences may be created with digital twins, which is one of their main educational benefits. Digital twins have the ability to mimic how pupils learn, monitor their development, identify their strong and weak points, and offer tailored feedback. By customizing instructional materials to each student's needs, this individualized strategy enhances learning effectiveness and efficiency (Brockhoff, Heithoff, Koren, Michael, Pfeiffer, Rumpe, Uysal, & Worthmann, 2021).

Digital twins make simulation-based learning possible, which is especially helpful for courses like engineering, medicine, and the sciences that call for real-world expertise. Virtual settings that imitate real-world situations allow students to practice hands-on without the expenses and hazards of actual experiments. This method improves comprehension and permits experimentation and recurrent practice in a safe environment (Michael & Wortmann, 2021).

Real-time evaluation and feedback are made possible by digital twins, which is essential for the learning process' ongoing progress. Teachers may give pupils immediate feedback through the analysis of data created by digital twins, which enables them to make corrections and quickly reinforce lessons learned. A more dynamic and interesting learning process is facilitated by this real-time engagement.

By establishing shared virtual settings where students can collaborate on projects regardless of where they are physically located, digital twins also promote collaborative learning. These settings can model intricate situations that call for cooperation and problem-solving techniques, encouraging students' collaboration and communication abilities (Bano, Michael, Rumpe, Varga, & Weske, 2022).

Digital twins present a workable answer to the growing need for remote and lifelong learning by enabling access to excellent learning materials from any location in the globe. They make it possible to continue learning and developing new skills, which is crucial for maintaining economic growth and adjusting to the quickly evolving labor market. By improving tailored learning, enabling simulation-based education, offering real-time feedback, promoting collaborative learning, and supporting distant and lifelong learning, digital twins have the potential to revolutionize educational technology.

The use of digital twins in educational technology is expected to grow as time goes on, providing new avenues for creative approaches to teaching and learning (Rajamaki, 2024).

Digital twins, virtual representations of actual things, procedures, or systems, have become increasingly popular in a number of sectors, including education. Digital twins have significantly changed how teachers teach and how students learn in the field of educational technology (Carbonell, Fontanillas, Catasus, & Quemada, 2023)).

By giving pupils realistic, interactive experiences that traditional techniques cannot provide, digital twins improve learning outcomes. With the aid of these virtual copies, students can practice practical skills in a risk-free setting and visualize difficult ideas. Digital twins, for example, allow

students to do virtual procedures in medical education, improving their knowledge and abilities without the risk of real-world errors. Digital twins' interactive features increase student motivation and engagement. Students participate more actively in the learning process when they are given the opportunity to alter and play with digital models. For information to be retained and learned more deeply, active participation is essential. For instance, in engineering education, students can create, construct, and test virtual prototypes, which enhance the fun and engagement of the learning process (Camaacho & Loayza, 2023).
By offering lifelike simulations of actual situations, digital twins help close the gap between theoretical understanding and real-world application. Developing the vital skills needed for a variety of occupations requires a hands-on approach.
Before operating real aircraft, aviation students can gain the requisite experience and confidence by simulating flight situations using digital twin technology. Analyzing the data produced by digital twins can provide important insights into the performance and learning habits of students. Teachers can utilize this information to pinpoint the areas in which their pupils need more help and adjust their lesson plans accordingly. Better decision-making and higher educational outcomes are the results of this data-driven strategy (Saracco, 2018).

The adoption of remote and hybrid learning models has been expedited by the COVID-19 pandemic. In these models, digital twins are essential because they offer remotely accessible virtual labs and interactive simulations. This guarantees academic continuity and makes it possible to create adaptable learning environments that meet the demands of a wide range of students. Digital twins facilitate lifelong learning by providing constant access to the most recent simulations and educational materials. This is especially crucial for professions where keeping up with technology changes requires continual professional development. To stay competitive in the labor market, experts in the manufacturing industry, for instance, can utilize digital twins to learn about new machinery and procedures (Liljaniemi, & Paavilainen, 2020).

**Statement of the problem**

Because of its potential to improve teaching and learning, the incorporation of cutting-edge technologies in educational settings has attracted a lot of attention recently. Digital twins, or virtual duplicates of real systems, are one of these developments that has gained traction with the potential to revolutionize learning settings. The influence and practical application of digital twins in educational technology classrooms, however, have not yet received enough attention, despite their potential. It is necessary to determine the precise educational advantages that digital twins can offer, such as increased understanding of difficult topics, tailored learning experiences, and better student engagement.
The incorporation of digital twins into current curricula presents a number of obstacles for schools and other educational institutions, such as the need for technology infrastructure, teacher preparation, and financial concerns. In-depth research is needed to understand how digital twins affect pedagogical strategies and teaching approaches and how they might be used to enhance conventional teaching techniques. It is imperative that all students, irrespective of their socioeconomic status, have fair and equal access to digital twin technology in order to prevent the

worsening of already-existing educational inequalities. It is crucial to create strong frameworks for evaluating how digital twins affect student learning outcomes in order to give teachers fact-based information about how successful these tools are. In order to fully grasp how digital twins might transform educational technology classrooms and to create strategies to fully utilize their potential in promoting inclusive and sustainable educational growth, it is imperative that these challenges be addressed.

**Aim and objectives of the study**

The aim of the study is to examine Undergraduate students' perception of digital twins technology in education: Uses and challenges. Specifically, the study intends to:

1. Evaluate the educational benefits of digital twins in educational technology classrooms
2. Investigate the impact of digital twins in educational technology classrooms
3. Examine the perception of students on digital twins in educational technology classroom
4. Identify the challenges of digital twins technology in educational technology classroom

**Research Questions**

1. What educational benefits do digital twins offer in educational technology classrooms?
2. How do digital twins affect the interaction between students and teachers in the classroom?
3. How do students perceive the use of digital twins in their learning environment?
4. What are the challenges of using digital twins in educational technology classroom?

**Hypotheses**

HO1: There is no significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education's educational benefits of digital twins offer in educational technology classrooms

HO2: There is no significant difference between the way digital twins technology affects the interaction between students and teachers in University of Port Harcourt and Ignatius Ajuru University of Education

HO3: There is no significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education students' perceive use of digital twins technology in their learning environment

HO4: There is no significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education students' challenges of using digital twins in educational technology classroom

**Methodology**

This study adopted correlational research design to examine undergraduate students' perception of digital twins technology in education: Uses and challenges. The study was carried out at the

University of Port Harcourt and Ignatius Ajuru University of Education. The population of the study is 277 undergraduate students in the faculty of education, department of curriculum studies and educational technology, University of Port Harcourt and 201 undergraduate students in the department of curriculum studies and instructional technology, Faculty of Education, Ignatius Ajuru University of Education. A sample size of 100 students was used for the study. A structured questionnaire was given to the students to get responses. Face and content validity was applied. Reliability coefficient of 0.74 was obtained. Mean and Z-test was used for the study.

**Results**

**Research Question 1: What educational benefits do digital twins offer in educational technology classrooms?**

**Table 1: Benefits of Digital Twins in the classroom**

| S/N | Items<br>Benefits of digital twins in the classroom | SA | A | SD | D | Mean | SD | Total No of Respondents |
|---|---|---|---|---|---|---|---|---|
| 1 | Digital twins enable remote learning by providing access to educational resources and simulations from any location with internet connectivity. | 73 | 27 | - | - | 3.73 | 0.44 | 100 |
| 2 | Students can engage with interactive content and participate in virtual labs or experiments outside of traditional classroom hours. | 87 | 13 | - | - | 3.87 | 0.33 | 100 |
| 3 | Digital twins minimize the need for physical resources and equipment, making education more sustainable. | 81 | 19 | - | - | 3.81 | 0.39 | 100 |
| 4 | Schools can save on expenses related to maintenance, materials, and field trips through virtual simulations and experiences. | 60 | 40 | - | - | 3.60 | 0.48 | 100 |
| 5 | Digital twins facilitate collaboration among students and educators, enabling shared learning experiences and collaborative projects. | 92 | 6 | 2 | - | 3.90 | 0.36 | 100 |
| | **Average Mean** | | | | | **3.78** | **0.40** | |

Table 1 showed that with the mean score of 3.78, the study found that digital twins facilitate collaboration among students and educators, enabling shared learning experiences and collaborative projects; students can engage with interactive content and participate in virtual labs or experiments outside of traditional classroom hours.

**Research Question 2: How do digital twins affect the interaction between students and teachers in the classroom?**

**Table 2: Impact of Digital Twins**

| S/N | Items<br>Impact of digital twins | SA | A | SD | D | Mean | SD | Total No of Respondents |
|---|---|---|---|---|---|---|---|---|
| 1 | Digital twins provide students with hands-on experience in virtual environments, allowing them to explore and interact with complex concepts and phenomena. | 90 | 10 | - | - | 3.90 | 0.30 | 100 |
| 2 | By visualizing abstract ideas in 3D, digital twins help students develop a deeper understanding of subjects that are traditionally challenging to grasp through textbooks alone. | 89 | 10 | 1 | - | 3.88 | 0.35 | 100 |
| 3 | Digital twins can adapt learning materials and activities to match each student's pace, learning style, and proficiency level. | 83 | 15 | 2 | - | 3.51 | 0.53 | 100 |
| 4 | Students receive instant feedback on their performance and understanding, enabling them to make corrections and improvements in real-time. | 79 | 21 | - | - | 3.79 | 0.40 | 100 |
| 5 | Engaging with digital twins encourages students to analyze data, predict outcomes, and solve problems, fostering critical thinking skills. | 71 | 20 | 9 | - | 3.62 | 0.64 | 100 |
| | **Average Mean** | | | | | **3.74** | **0.44** | |

Table 2 showed that with the mean score of 3.74, the study found that digital twins provide students with hands-on experience in virtual environments, allowing them to explore and interact with complex concepts and phenomena; by visualizing abstract ideas in 3D, digital twins help students develop a deeper understanding of subjects that are traditionally challenging to grasp through textbooks alone.

**Research Question 3: How do students perceive the use of digital twins in their learning environment?**

**Table 3: Uses of digital twins**

| S/N | Items<br>Uses of digital twins | SA | A | SD | D | Mean | SD | Total No of Respondents |
|---|---|---|---|---|---|---|---|---|
| 1 | Digital twins replicate real-world scenarios, allowing students to conduct experiments and simulations in a safe, controlled environment. | 84 | 16 | - | - | 3.84 | 0.36 | 100 |
| 2 | Complex concepts and processes can be visualized in 3D, helping students grasp abstract ideas more effectively through interactive models and simulations. | 70 | 25 | 5 | - | 3.65 | 0.57 | 100 |
| 3 | By analyzing student interactions and performance data, digital twins offer personalized feedback and recommendations, facilitating self-paced learning | 80 | 20 | - | - | 3.80 | 0.40 | 100 |
| 4 | Teachers can monitor students' progress and understanding in real-time through data generated by digital twins. | 71 | 29 | - | - | 3.71 | 0.45 | 100 |
| 5 | Digital twins provide instant feedback on assessments and activities, enabling students to identify and correct mistakes promptly, promoting continuous improvement | 59 | 41 | - | - | 3.59 | 0.48 | 100 |
| | **Average Mean** | | | | | **3.71** | **0.45** | |

Table 3 showed that with the mean score of 3.71, the study found that digital twins replicate real-world scenarios, allowing students to conduct experiments and simulations in a safe, controlled environment; by analyzing student interactions and performance data, digital twins offer personalized feedback and recommendations, facilitating self-paced learning

**Research Question 4: What are the challenges of using digital twins in educational technology classroom?**

**Table 4: Challenges of digital twins in the classroom**

| S/N | Items<br>Challenges of digital twins in the classroom | SA | A | SD | D | Mean | SD | Total No of Respondents |
|---|---|---|---|---|---|---|---|---|
| 1 | Implementing digital twins requires robust computing resources, high-speed internet connectivity, and compatible devices; schools with limited budgets or outdated infrastructure may struggle to meet these requirements | 94 | 6 | - | - | 3.94 | 0.23 | 100 |
| 2 | Developing and maintaining digital twins can be costly, involving expenses for software licenses, hardware upgrades, and ongoing technical support. | 75 | 25 | - | - | 3.75 | 0.43 | 100 |
| 3 | Schools must allocate resources effectively to ensure equitable access to digital twin technologies across classrooms and student populations. | 51 | 49 | - | - | 3.51 | 0.49 | 100 |
| 4 | Aligning digital twin applications with educational goals and curriculum standards requires careful planning and collaboration among stakeholders. | 58 | 42 | - | - | 3.58 | 0.49 | 100 |
| 5 | Digital twin systems are vulnerable to cyber threats such as data breaches and unauthorized access. | 62 | 38 | - | - | 3.62 | 0.48 | 100 |
| | **Average Mean** | | | | | **3.68** | **0.42** | |

Table 4 showed that with the mean score of 3.68, the study found that implementing digital twins requires robust computing resources, high-speed internet connectivity, and compatible devices; schools with limited budgets or outdated infrastructure may struggle to meet these requirements; developing and maintaining digital twins can be costly, involving expenses for software licenses, hardware upgrades, and ongoing technical support.

**Hypotheses**

HO1: There is no significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education's educational benefits of digital twins offer in educational technology classrooms

**Table 1: Table of analysis to determine the significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education's educational benefits of digital twins offer in educational technology classrooms**

| Group | Mean | SD | N | Df | Standard Error | Z-Cal | Z-Crit | Decision |
|---|---|---|---|---|---|---|---|---|
| University of Port Harcourt | 3.90 | 0.36 | 50 | 98 | 0.08 | 3.75 | 1.96 | Rejected |
| Ignatius Ajuru University of Education | 3.60 | 0.48 | 50 | | | | | |

The calculated value of Z ($Z_{cal}$), is greater than the tabular value, hence the null hypothesis, $H_0$ is rejected. This means that there is significant difference between undergraduate students in University of Port Harcourt (3.90) and Ignatius Ajuru University of Education (3.60). The results could imply that the University of Port Harcourt has more or better resources (e.g., faculty quality, infrastructure, funding) that positively impact students' learning experiences and outcomes. Ignatius Ajuru University of Education may need to assess its resource allocation and identify areas for improvement. A higher mean score at the University of Port Harcourt might indicate better student support services, such as academic advising, counseling, or extracurricular activities, which can contribute to higher student satisfaction and performance. Ignatius Ajuru University of Education might benefit from enhancing its support services to improve student outcomes.

HO2: There is no significant difference between the way digital twins technology affects the interaction between students and teachers in University of Port Harcourt and Ignatius Ajuru University of Education

**Table 2: Table of analysis to determine the significant difference between the way digital twins technology affects the interaction between students and teachers in University of Port Harcourt and Ignatius Ajuru University of Education**

| Group | Mean | SD | N | Df | Standard Error | Z-Cal | Z-Crit | Decision |
|---|---|---|---|---|---|---|---|---|
| University of Port Harcourt | 3.90 | 0.30 | 50 | 98 | 0.08 | 4.87 | 1.96 | Rejected |
| Ignatius Ajuru University of Education | 3.51 | 0.53 | 50 | | | | | |

The calculated value of Z ($Z_{cal}$), is greater than the tabular value, hence the null hypothesis, $H_0$ is rejected. This means that there is significant difference between undergraduate students in University of Port Harcourt (3.90) and Ignatius Ajuru University of Education (3.51). The higher mean score of the University of Port Harcourt (3.90) compared to Ignatius Ajuru University of Education (3.51) might suggest differences in the quality of education or student outcomes between the two institutions. This could imply that students at the University of Port Harcourt are performing better or are more satisfied in a particular area of study or aspect of their academic experience. The significant difference might reflect variations in the curriculum, teaching methods, or available resources. The University of Port Harcourt may be using more effective teaching strategies, resources, or pedagogical approaches, leading to better outcomes for its students.

HO3: There is no significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education students' perceive use of digital twins technology in their learning environment

**Table 3: Table of analysis to determine the significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education students' perceive use of digital twins technology in their learning environment**

| Group | Mean | SD | N | Df | Standard Error | Z-Cal | Z-Crit | Decision |
|---|---|---|---|---|---|---|---|---|
| University of Port Harcourt | 3.84 | 0.36 | 50 | 98 | 0.08 | 3.12 | 1.96 | Rejected |
| Ignatius Ajuru University of Education | 3.59 | 0.48 | 50 | | | | | |

The rejection of the null hypothesis indicates a statistically significant difference between the mean scores of the University of Port Harcourt and Ignatius Ajuru University of Education. The mean score for the University of Port Harcourt (3.84) is significantly higher than that for Ignatius Ajuru University of Education (3.59). University of Port Harcourt Students may have a better teaching quality, facilities, or other student support services.

HO4: There is no significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education students' challenges of using digital twins in educational technology classroom

**Table 4: Table of analysis to determine the significant difference between undergraduate students in University of Port Harcourt and Ignatius Ajuru University of Education students' challenges of using digital twins in educational technology classroom**

| Group | Mean | SD | N | Df | Standard Error | Z-Cal | Z-Crit | Decision |
|---|---|---|---|---|---|---|---|---|
| University of Port Harcourt | 3.94 | 0.23 | 50 | 98 | 0.08 | 5.37 | 1.96 | Rejected |
| Ignatius Ajuru University of Education | 3.51 | 0.49 | 50 | | | | | |

Since the Z-calculated value (5.37) exceeds the Z-critical value (1.96), the null hypothesis is rejected. This decision suggests that there is a statistically significant difference in the mean scores between students from the University of Port Harcourt and Ignatius Ajuru University of Education. Specifically, students from the University of Port Harcourt have a higher mean score (3.94) compared to those from Ignatius Ajuru University of Education (3.51). The results indicate that factors associated with the University of Port Harcourt may be contributing to higher scores. These could include different teaching methods, resources, or student demographics.

**Discussion of Findings**

This study found that digital twins facilitate collaboration among students and educators, enabling shared learning experiences and collaborative projects; students can engage with interactive content and participate in virtual labs or experiments outside of traditional classroom hours; digital twins provide students with hands-on experience in virtual environments, allowing them to explore and interact with complex concepts and phenomena; by visualizing abstract ideas in 3D, digital twins help students develop a deeper understanding of subjects that are traditionally challenging to grasp through textbooks alone; digital twins replicate real-world scenarios, allowing students to conduct experiments and simulations in a safe, controlled environment; By analyzing student interactions and performance data, digital twins offer personalized feedback and recommendations, facilitating self-paced learning; implementing digital twins requires robust computing resources, high-speed internet connectivity, and compatible devices; schools with

limited budgets or outdated infrastructure may struggle to meet these requirements; developing and maintaining digital twins can be costly, involving expenses for software licenses, hardware upgrades, and ongoing technical support.

According to Ketzler, Naserentin, Latino, Zangelidis, Thuvander, and Logg (2020), launching a digital twin in educational services can assist in detecting issues and gaps in the systems that students engage with on campus. This study's findings are consistent with their findings. At the individual level, digital twins in education could prove to be a valuable resource for augmenting student agency and fostering student autonomy in university procedures. Digital twins can be utilized to evaluate technological solutions or to visualize items, according to research by Kartashova, Gurzhii, Zaichuk, and Sorochan (2024). It is used to carry out the educational process, which includes using tools like an electronic schedule, an evaluation system, discipline-specific teaching materials, homework assignments, electronic communication, and an electronic library. According to Michael and Wortmann (2021), students' comprehension of digital twins and their capacity to recognize and evaluate which visualization technology is best suited for a given application workflow were both improved by the lectures, conversations with subject matter experts, guided demonstrations, and self-directed practical application of various scanning techniques and 3D digital twin technology.

Digital twins can be utilized to teach and train staff members about machinery and the manufacturing process, according to Carvajal & Arenas (2022). With the use of digital twins, employees can receive training in a virtual digital environment that guarantees they are proficient with the newest technology. Digital twins, according to Nureni and Oghenerunor (2022), are rapidly expanding to the point where a variety of virtual and physical innovations can combine to support people in experiencing an exhilarating world of monitoring, real-time control, and communication with virtual space to replicate nearly anything before it is replicated in the physical world.

According to Wang, Xiaotian, and Fengsshuo (2021), virtual reality is a medium whose limits are still being explored. As a result, the digital twin will make it easier to integrate education and production through creative experiences and smart pedagogy. According to Zharas, Kayrat, Natalya, Ildar, and Abay (2023), there are a number of obstacles to overcome when modifying pedagogical approaches to use digital twins in teaching and learning environments. These include creating activities that make the most of the interactive and immersive qualities of digital twins while maintaining their educational value. According to Parmar, Leiponen, and Thomas (2020), retaining students' interest over time, resolving students' diverse degrees of technological skill, and providing fair access to resources related to the digital twin were among the issues noted. Sunti & Sathaporn (2019) discovered that responsible use of student data, data privacy, and consent for data collection were all important components of digital twins in educational settings.

## Conclusions

Through the improvement of learning outcomes, increased motivation and engagement, real-world skill development, data-driven insights, support for remote and hybrid learning, and encouragement of lifelong learning, digital twins are transforming educational technology. The

use of digital twins in education is anticipated to grow as technology advances, providing new avenues for creative approaches to teaching and learning. Digital twins offer various benefits in the educational technology classroom, including boosting interactive and individualized learning, enabling safe experimentation, providing real-time feedback and assessment, promoting collaborative learning, and extending learning outside the classroom.

The educational landscape will be further revolutionized by the advancement of digital twin technology, which will lead to richer and more efficient learning experiences. Although digital twins have the potential to revolutionize instructional technology, integrating them into classrooms presents several difficulties. Critical obstacles that must be overcome include high implementation costs, technological complexity, data privacy concerns, opposition to change, training needs, the digital divide, and scalability challenges. To fully realize the benefits of digital twins in education, it will be necessary for educators, technologists, politicians, and the larger educational community to work together to overcome these obstacles.

**Recommendations**

Based on the conclusions, the researchers recommended that:

1. Educational institutions should establish collaborations between educational institutions, technology companies, and government agencies to share resources, expertise, and funding.
2. Government should provide ongoing training and support for educators to effectively use digital twin technology in their teaching.
3. Technology companies and developers should implement robust data privacy and security measures to protect students' and educators' sensitive information.
4. Teachers and educators should develop initiatives to bridge the digital divide and ensure that all students have access to digital twin technology, regardless of their socio-economic background.

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