


Application of Digital Technology to Improve the Quality of Learning in the Era of Revolution 4.0

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ARTICLE INFO	ABSTRACT
<p>Article history:</p> <p>Received : 28-12-2023 Revised : 15-01-2024 Accepted : 26-02-2024</p> <p>Keywords: Technology, Education, Learning.</p>	<p><i>In the era of the Fourth Industrial Revolution, digital technology has emerged as a transformative force reshaping the global education landscape. This research aims to examine the application of digital technology in enhancing the quality of learning in the era of Revolution 4.0. Through literature analysis, we explore various ways in which digital technology can be utilized to improve the effectiveness of learning, including the use of online learning platforms, integration of artificial intelligence in the learning process, implementation of augmented reality and virtual reality in learning experiences, and utilization of big data for personalized learning. The research findings indicate that the use of digital technology in education has brought positive impacts in enhancing the quality of learning by improving accessibility, interactivity, and personalization. However, challenges such as access gaps, infrastructure limitations, and integration of technology with traditional curricula remain hurdles that need to be addressed. Therefore, collaborative efforts among governments, educational institutions, and industries are required to optimize the utilization of digital technology in advancing education in the era of Revolution 4.0.</i></p> <div></div> <p>This work is licensed under a Creative Commons Attribution 4.0 International License.</p>
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1. INTRODUCTION

The industrial revolution 4.0 indirectly changed the educational paradigm in the 21st Century era (Sari et al., 2020). The shift in 21st Century learning at this time is not only in the concept of teaching methods, but what is far more essential is the way of looking at the concept of learning itself. Nowadays, humans are very dependent on technology. This makes technology a basic need for everyone. From children to adults, experts to lay people use technology in various aspects of their lives. Technology today has developed very rapidly. The increasingly rapid development of information technology in the current era of globalization cannot avoid its influence on the world of education. Global demands require the world of education to always adapt technological developments to efforts to improve the quality of education, especially adjusting the use of information and communication technology for the world of education, especially in the learning process.

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Especially in conditions where the Covid-19 pandemic caused some daily activities to be

slightly disrupted, the Minister of PAN_RB (State Apparatus Empowerment & Bureaucratic Reform) Tjahjo Kumolo issued a circular which basically stated the extension of the working from home (WFH) period & adjustments to the work system. However, this does not mean that public services are abolished, but they can be done online or, if there are still manual services, you must apply the protocols that have been determined. Based on the several cases above, according to the role of technology in the education sector in the midst of the Covid-19 pandemic, teaching staff and students are expected to be able to adapt and utilize technology. However, many students complain that online learning is felt to be less effective because students are required to learn autodidactically (on their own). Many parents are unable to teach the material contained in books, and are only able to guide them, constrained by the network, inadequate technology, and signal, which is unstable.

The existence of technology is currently considered very important in human life as a support in carrying out various activities both in carrying out work and in terms of education. Educators can use technology as a learning medium or mediator in conveying knowledge to students through several applications, such as Zoom, Google Classroom, Google Meeting or via WhatsApp groups. By using the above learning media, teaching staff can make explanations of material that are interesting and not monotonous so that students are interested and remain enthusiastic in participating in the teaching and learning activities.

While there is a growing body of literature exploring the application of digital technology to enhance learning quality in the era of Revolution 4.0, there remains a notable gap in understanding the nuanced impacts of these technologies on diverse educational contexts and learner demographics. Existing research often focuses on general trends and broad outcomes, overlooking the specific needs and challenges faced by learners in different socio-economic backgrounds, geographic locations, and educational settings. Additionally, there is a lack of comprehensive studies that assess the long-term effects of digital technology integration on learning outcomes, retention rates, and skill development. Moreover, limited attention has been given to the ethical implications of deploying advanced technologies such as artificial intelligence and big data analytics in education, particularly regarding privacy concerns, algorithmic bias, and digital divides. Addressing these research gaps is crucial for informing evidence-based policies and practices that promote inclusive and equitable access to quality education in the era of Revolution 4.0.

2. METHODS

This research uses a literature review method using the keyword "Technology in Education". The focus of this research is technological innovation and its implications in the field of education. The literature used is Google Scholar with articles taken within the last 5 years.

3. RESULTS AND DISCUSSION

In the digital era that continues to develop rapidly, the role of technology in education is becoming increasingly important to prepare future generations. This research explores implementing the latest technologies, such as artificial intelligence (AI), 3D printing, Internet of Things (IoT), quantum computing, and cloud computing, in a learning context. Through in-depth analysis, we investigate how the use of these technologies has shifted educational paradigms, expanded access to knowledge, increased student engagement, and opened new opportunities for curriculum innovation. By understanding the implications of these technologies, we can design more dynamic and inclusive learning environments, preparing students to face future challenges more effectively.

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Now that Covid-19 is over, the development and use of technology is very fast and is already being used everywhere. However, in this research the author will be more inclined to discuss the development and implementation of technology in the field of education. After searching for materials on Google Scholar, we found that the impact of technological developments in the field of education is very large. From the large amount of material we got, we divided all the material into types of technological development, both in terms of education and implementation, after that we summarized it and these are the results we got.

Application of 3D Printing Technology in Education.

In an era of rapidly developing technological innovation, 3D printing technology has shown impressive progress in transforming the field of education. With its ability to print three-dimensional objects layer by layer based on digital designs, 3D printing technology has opened the door to a more interactive, engaging and future-oriented learning experience. Now, in classrooms all over the world, students can not only visualize abstract concepts in tangible form, but also experience the process of creating and developing physical objects with their own hands. From studying anatomy to architectural construction, 3D printing technology has revolutionized education by combining theoretical concepts with in-depth practical experience. As an innovative solution to solving challenges in learning, advances in 3D printing technology promise unlimited potential to encourage creativity, collaboration and deep understanding among students around the world.

3D printing technology (3D printing) has revolutionized various aspects of the health sector, including nursing education. This technology offers an innovative solution to improve the quality of anatomy learning and provide a more interactive and effective learning experience for students.

Advantages of 3D Printing in Anatomy Learning

1. **Detailed Visualization:** 3D printing allows the creation of realistic and accurate anatomical models with greater detail than traditional models such as drawings or plastic. This allows students to understand human anatomical structures more easily and in depth.
2. **Interactivity:** 3D models can be manipulated and observed from various viewpoints, providing a more interactive and engaging learning experience for students.
3. **Availability:** 3D models can be created as needed, so students have access to a variety of anatomical models that may be difficult to obtain using traditional methods.

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1. **Reduced Damage:** 3D models are more durable and less easily damaged than traditional models, so they can be used repeatedly for learning.
2. **Skills Development:** 3D printing encourages the development of students' metacognitive knowledge and skills in problem solving and design.

Example of Application of 3D Printing

1. Printing models of body organs and tissues to study anatomy and physiology.
2. Simulation of medical and surgical procedures with realistic 3D models.
3. Development of personalized learning aids to meet individual needs.

Challenges and Considerations

1. **Curriculum Integration:** 3D printing needs to be integrated with the existing curriculum effectively to maximize its benefits in learning.
2. **Operational Costs:** Equipment and materials for 3D printing require a fairly large initial investment.
3. **Technical Skills:** Training is required for faculty and staff to operate 3D printing equipment and develop appropriate models.

Application of Quantum Computing Technology in Education

Advances in quantum computing technology have become a highlight in the world of education because of their potential to change learning and research paradigms. Quantum computing, a new branch of computer science, uses the principles of quantum mechanics to perform information processing in a way that is very different from today's classical computers. By exploiting the unique properties of subatomic particles such as superposition and entanglement, quantum computers can solve problems that are difficult or even unsolvable by conventional computers in a much shorter time. In an educational context, the potential of quantum computing to optimize learning processes, accelerate scientific discovery, and usher in new paradigms in modeling and simulation has attracted the interest of academics and researchers around the world. As an

evolving field, the implementation of quantum computing technology in education promises new possibilities that could change the way we understand and teach science.

Quantum computing technology, with all its extraordinary potential, is starting to show its influence in the world of education, especially in mathematics learning. One interesting example is the application of Grover's algorithm to find solutions in an unordered list.

Advantages of Grover's Algorithm

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1. **Higher Efficiency:** Grover's algorithm, discovered by Lov Grover in 1996, allows finding solutions in unordered lists more efficiently than classical computers. In a classical computer, on average it takes $N/2$ steps to find a solution in a list with N items, whereas in a quantum computer, it only takes \sqrt{N} steps.
2. **Understanding Algorithms:** The application of Grover's algorithm in mathematics learning opens up opportunities to teach students about the basic concepts in search algorithms, while introducing them to the basic principles of quantum computing.
3. **Algorithmic Complexity:** Grover's Algorithm provides a concrete example of algorithmic complexity and how quantum computing technology can address these problems more efficiently.

Benefits in Learning Mathematics

1. **Improve Understanding of Concepts:** Students can gain better insight into the potential and limitations of classical computers as well as quantum computers through the exploration and implementation of Grover's algorithm.
2. **Encouraging Interest in Learning:** The use of quantum technology in mathematics learning can spark students' interest in learning more about quantum mechanics and its applications in information processing.
3. **Preparing for the Future:** By integrating quantum computing technology in learning, teachers can help students prepare to face the increasingly complex technological challenges of the future.

Application of Cloud Computing Technology in Education.

In the ever-evolving digital era, advances in cloud computing technology have brought profound changes to education. The concept of cloud computing allows flexible access and use of computing resources and applications over the internet, without the need for expensive or sophisticated computer infrastructure. This has changed the educational landscape by providing wider access to information, data processing, and educational applications, which were previously limited by physical and financial boundaries. Now, educational institutions from elementary to tertiary level can utilize cloud computing technology to provide online learning platforms, collaboration between students and teachers, and integration of diverse educational resources. Thus, cloud computing technology is not only changing the way education is delivered and accessed, but also expanding the possibilities for dynamic curriculum development, personalized learning, and further educational innovation. As a result, cloud computing has become a key element in realizing education that is inclusive, adaptive, and relevant to the demands of today's digital age.

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Cloud computing technology, or cloud computing, has revolutionized the world of education by providing various benefits for students, lecturers and educational institutions. Following are some of the significant impacts of implementing cloud computing in education:

Wider and Flexible Accessibility

1. Users can access educational data and applications from anywhere and at any time via the internet, without needing to be tied to a specific location or device.
2. This allows for easier and more effective distance learning, opening up opportunities for individuals who live in remote areas or have limited mobility to continue their education.

Increased Efficiency and Productivity

1. Cloud computing provides IT services that can be tailored to user needs, so that educational institutions can save on infrastructure costs and IT resources.
2. Web-based applications such as Google Docs and Dropbox facilitate collaboration between students and lecturers, and increase productivity in processing documents and presentations.

High Scalability and Reliability

1. Cloud computing services can be easily scaled and adapted to changing needs, so educational institutions can adapt quickly to changes in the number of users or workload.
2. High availability and low response times ensure smooth access to educational data and applications, minimizing downtime and disruption to the teaching and learning process.

Better Innovation and Collaboration

1. Cloud computing platforms enable the development of innovative and interactive educational applications, encouraging active student participation in the learning process.
2. Collaboration between educational institutions and experts in various fields becomes easier and more efficient through cloud platforms, enabling wider exchange of information and knowledge.

Wider and Affordable Access to Education

1. Cloud computing makes it possible to provide educational services more widely and affordably at all levels of society.
2. Individuals can access high-quality educational resources via the internet, without being restricted by geographic or infrastructure boundaries.

Examples of the Application of Cloud Computing in Education

Google Apps for Education: Provides various online applications such as Gmail, Google Drive, and Google Classroom for collaboration, data storage, and learning management.

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1. Microsoft Office 365: Provides an online platform for processing documents, spreadsheets and presentations, as well as access to various other educational tools.
2. Learning Management System (LMS): An online platform that allows online class management, distribution of learning materials, assessments, and interaction between lecturers and students.
3. Cloud-based e-learning platforms: Provides access to a variety of online courses and learning materials from various educational institutions around the world.

Application of Internet of Things (IoT) Technology in Education.

Advances in Internet of Things (IoT) technology have fundamentally changed the digital landscape, ushering in an era of increasingly equal connectivity between the devices around us. IoT is no longer just a futuristic concept, but has become a reality that impacts various aspects of daily life. From smart homes that can automatically regulate temperature and lighting, to smart cities that monitor traffic and air quality, IoT has enabled integration between the physical and digital worlds in unprecedented ways. With millions of sensors connected online, the data generated by IoT provides valuable insights for businesses, governments, and individuals to improve efficiency, productivity, and overall quality of life. As this technology continues to develop, we can anticipate more innovations that change the way we interact with our surroundings and the way we live our daily lives.

Internet of Things (IoT) technology has revolutionized various aspects of life, including education. By connecting various devices and objects into a network, IoT offers various opportunities to improve the quality of learning and education. Following are some advances in IoT technology in the education sector:

Utilization of Biometric Data for Student Monitoring

1. Student attendance can be monitored accurately using fingerprints, facial or retina scans.
2. Attendance data can be analyzed to identify learning patterns and potential attendance problems.
3. Smart campus:
4. Lights, air conditioning and other electronic equipment on campus can be controlled automatically to save energy and increase efficiency.
5. Advanced security systems can be implemented to protect students and staff.

Education Database Management

1. Books, assignments and theses can be borrowed and returned independently by students.
2. Alumni data can be managed more easily and efficiently.

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Blended learning

Students can learn anytime and anywhere through a combination of online and offline learning.

Learning materials can be personalized according to each student's needs and learning style.

System equipped with Augmented Reality (AR)

1. AR can be used to make learning more interactive and interesting.
2. Students can see and interact with virtual objects in the real world.

Application of wearable technology

1. Wearable devices such as smartwatches can be used to track students' physical activity and monitor their health.
2. The data collected can be used to improve student learning performance and health.

Use of educational robots

Robots can be used as teacher assistants in teaching and helping students learn.

Robots can interact with students personally and provide real-time feedback.

Application of Artificial Intelligence (AI) Technology in Education

Advances in artificial intelligence (AI) technology have had a significant impact on the education sector, opening up new opportunities and expanding the boundaries of learning. AI is not only changing the way we teach and learn, but also bringing innovative solutions to increase the effectiveness and accessibility of education. With its ability to quickly analyze data and identify patterns, AI enables greater personalization of learning, tailoring learning materials and methods to individual needs. Additionally, the use of chatbots and virtual assistants in educational contexts provides students with fast and personalized assistance in answering questions or providing guidance. Moreover, AI also facilitates the development of adaptive e-learning platforms, enabling access to course materials from anywhere and at any time. As AI technology continues to develop, we can anticipate more innovations that will change the educational landscape, strengthen the quality of learning and bring equality of access to education throughout the world. Artificial Intelligence (AI) technology has developed rapidly and is starting to be applied in various fields, including education. In this research, it was found what applications support the use of AI to help learning activities and what the positive and negative impacts of AI are.

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Use of AI Platforms

1. Canva: An easy-to-use online graphic design platform for creating presentation designs, posters, and infographics. Many students use Canva for their assignments.
2. SlidesGo: Powerpoint template provider platform that makes it easy to create presentations and helps overcome boredom in reading material.
3. Grammarly: An automated proofreading system that helps students correct grammar and

- improve writing quality.
- 4. Google Meet: E-Learning platform that enables virtual face-to-face distance learning. Almost all students use Google Meet for online classes.

Positive Impact of AI

1. Increase efficiency and productivity: AI helps students complete assignments more quickly and easily.
2. Improving the quality of learning: AI can provide a more personalized and interactive learning experience.
3. Increase motivation and engagement: AI can make learning more interesting and fun.
4. Helps overcome study anxiety: AI can provide support and positive feedback to students.
5. Improve skills: AI can help students develop skills such as graphic design, presentation, and writing.

Negative Impact of AI

1. Over-reliance: AI can make students rely too much on technology and not put enough effort into themselves.
2. Algorithmic bias: AI can produce bias in assessments and recommendations, which can have a negative impact on students.
3. Data security: The use of AI may pose a risk of personal data leakage.

4. CONCLUSION

In the ever-growing digital era, the role of technology in education is becoming increasingly important to prepare future generations. This research has investigated the implementation of emerging technologies, such as artificial intelligence (AI), 3D printing, Internet of Things (IoT), quantum computing, and cloud computing, in a learning context. Through in-depth analysis, we explore how the use of these technologies has shifted educational paradigms, expanded access to knowledge, increased student engagement, and opened new opportunities for curriculum innovation. By understanding the implications of these technologies, we can design more dynamic and inclusive learning environments, preparing students to face future challenges more effectively.

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After studying various applications of AI technology in education, it can be concluded that the use of AI has had a significant positive impact. The use of AI platforms such as Canva, SlidesGo, Grammarly, and Google Meet has helped increase student efficiency and productivity, improve the quality of learning, increase motivation and engagement, and help overcome study anxiety. However, there are also negative impacts that need to be considered, such as over-reliance on technology, algorithm bias, and data security risks. Therefore, there is a need for a balanced approach in integrating AI technology in education, taking into account the associated benefits and risks. Thus, AI technology has great potential to change the educational paradigm towards more personalized, interactive and inclusive learning, but it needs to be managed wisely to maximize its benefits for students and educational institutions.

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