Advancing E-Learning: A Thorough Exploration of AI and IoT within 6G Networks

Amal Aoulad Ali[1]*,Souad Alaoui[2], Abdelhalim Hnini[3], Imane Chlioui[4], and Nadir El Morabit[5]

[1] Polydisciplinary Faculty of Taza, Sciences and Techniques and Innovation Laboratory, University of Sidi Mohamed Ben Abdellah of Fes, Taza, Morocco
[2] Polydisciplinary Faculty of Taza, Sciences and Techniques and Innovation Laboratory, University of Sidi Mohamed Ben Abdellah of Fes, Taza, Morocco
[3] Hassan First University of Settat, LAVETE Laboratory, National School of Applied Sciences of Berrechid, Berrechid, Morocco
[4] Software Project Management Research Team, ENSIAS, Mohammed V University Rabat, Rabat, Morocco
[5] Faculty of Letters and Humanities, Abdelmalek Essaadi University, Tetouan, Morocco
Corresponding author (*): amal.aouladali@usmba.ac.ma

Abstract. This paper systematically reviews the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) into the sixth generation (6G) networks and its potential impact on enhancing e-learning. Furthermore, the research examines the transition from 5G's operational and security limitations to an efficient 6G framework and infrastructure contributory to improving IoT applications. Our research explores innovative technologies, technical issues, and future possibilities of AI and IoT in the field of e-learning, emphasizing critical areas for development as well as security and optimization aspects in 6G networks. It also addresses the technical challenges of AI and IoT in 6G and highlights data privacy, edge learning and resources utilization. The research findings underscore the crucial role of AI and IoT's contribution in boosting the e-learning infrastructure through the implementation of 6G technology, forecasting a new era of instructional delivery and interaction paradigms.

Keywords: IoT, AI, E-learning, Technology, 5G, 6G

1 Introduction

Artificial Intelligence (AI) and the Internet of Things (IoT) are set to become foundational cornerstones upon which 6G technology will be built, playing an indispensable role in revolutionizing user experience and enriching e-learning content. This initiative aims to address the operational challenges and security vulnerabilities observed in fifth generation (5G) networks, thereby advocating for the effective use of Internet of Things (IoT) applications in future, specifically sixth generation (6G) networks [1].

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Most literature research aims to explore the operation of 6G networks, with very high-speed data transmission and low latency. With the interoperability of AI and IoT, these studies are not designed to support and enable online learning experiences.

The research design of this paper meticulously examines and identifies the primary areas where the integration of AI and IoT can facilitate improvements, especially in the context of e-learning within 6G networks. It highlights technological advancements, technical challenges, and future trends.

This paper is organized to offer a new conceptualization of emerging technologies in 6G-IoT intelligence. It encompasses edge learning, articulation, distributed machine learning, and artificial intelligence, ensuring security and optimization in 6G networks for IoT applications [2].

The final section addresses the technical challenges at a lower level, focusing on the integration of AI and IoT into the 6G network. It discusses security, data privacy, efficient resource utilization, and the mitigating solutions currently available in the literature [3].

The review concludes by summarizing the key findings from the reviewed studies and emphasizing the critical importance of AI and IoT for the successful integration and interworking of 6G networks. This integration is vital for unlocking enhanced e-learning capabilities, leading to significant changes in the educational experience, including personalized and interactive education.

The remainder of this paper is organized as follows. Section two briefly reviews the definitions and theoretical framework of paradigms such as e-learning, AI, and IoT, and their relations to how they will be introduced in future generation networks. Section three reviews several research papers comparatively. The challenges and issues are proposed in Section four. A discussion is presented in Section five to explain the 6G convergence on e-learning experiences personalization. Finally, concluding remarks are given in Section six.

2 Theoretical Framework

E-learning (known as digital learning, online learning, virtual learning, distance learning, etc.) is a teaching strategy used to convey the necessary knowledge, skills, and attitudes within different types of organizations and institutions. It relies heavily on its design and evaluation to be effective and provide tangible benefits to those organizations [4]. E-learning is a method supported by information technology (IT), which has the potential to transform teaching and improve learning, yet it requires considering student motivation when designing online environments [5].

Artificial Intelligence (AI) is a field of computer science aimed at mimicking human thought processes, learning ability, and knowledge storage, notably used in cardiovascular medicine to improve the quality of patient care and reduce mortality rates [6]. Artificial intelligence is a general term referring to the use of computer to model intelligent behavior with minimal human intervention. It began with the invention of robots and has expanded to areas such as robotic-assisted surgery and targeted nanorobots for drug delivery [7]. Moreover, it denotes systems or machines with the ability to carry out tasks that typically require human intelligence—that is, the capability for iteration in performance related to collection and use of information made available to them. AI

embodies a combination of both approaches and techniques like machine learning, wherein computers are trained to learn from data, for example, to make predictions or take decisions without explicit programming for tasks. It is predictable that AI will increase the convenience associated with autonomous and smart systems. This can go from fully autonomous, interoperable vehicles to virtual assistants that will always be listening and autoreacting to even things you did not know you needed help with. It will give powers to pervasive ambient computing, which is able to make your life easier, better, or just different. These technologies help in voice recognition, computer vision, robotics, and automatic translations, among many other industries. [8]

In short, AI applied to e-learning makes it possible to bring about a more developed processing of information. This is expected to be attained by deploying predictive analytics techniques and further customizing and presenting the educational content. Therefore, deep usage of machine learning algorithms and deep learning, and enhancement can be witnessed in student engagement, and also the optimization of learning pathways by these user behavior patterns, thus modifying the content righteously. [2].

The Internet of Things (IoT) is designated as a new technological paradigm, a global network of machines and devices capable of interacting with each other [9]. The Internet of Things is defined in the next chapter as the evolution of the Internet, where computing devices embedded in everyday objects can send and receive data by themselves [10]. The IoT is an interconnected network of objects ranging from simple sensors to smartphones and tablets, representing a relatively new paradigm that is quickly gaining ground in the scenario of modern wireless telecommunications [11].

The Internet of Things in this systematic review will be used under a theory in which they will be developed through a system of interconnected computing devices, mechanical and digital machines, objects, and unique identifiers that explicate the basic elements making this new concept of a conductive work. Thus, there remains a lot of questions and challenges in need of answers before the Internet fully realizes its potential use. Accordingly, there are calls for consideration of various dimensions of the Internet of Things that include its applications, challenges, enabling technologies, social and environmental impacts [12]. For example, IoT can be used in connecting physical devices with the internet in real-time data exchange and devising e-learning. For instance, in learning environments, one can incorporate IoT learning needs with different sensors and IoT devices like IoT learning needs. For example, in seminars, learner's regularity in attendance can be monitored with sensors, and also the length of time spent on learning can be controlled, etc. [13]

6G networks, on the other hand, is expected to introduce a change in the wireless world, able to provide the services of the future through terrestrial or non-terrestrial transmissions. With this background, they make the Non-Terrestrial Networks (NTN) important as they may provide service anywhere, anytime and offer area coverage impossible to be offered by classical Terrestrial Networks (TN). This will highly facilitate the idea of incorporating NTNs and TNs into a single and uniform wireless system since they will be using the same radio technology. NR being the obvious choice to take NR for long-range, 3GPPs came up as a defacto standard, 3GPP is seriously looking into new solutions to take NR for long-range for NTNs, 3GPP is in a tight deadline of 3/5 years [14]. 6G could incorporate holistic network virtualization and pervasive network intelligence, facilitating interaction between digital and physical technologies to maximize the flexibility, scalability, and intelligence of networks [15].

6G networks will support ultra-fast data speed, ultra-low latency, and connectivity reliability to back up the advanced e-learning applications, which will give the learners a whole new e-learning experience. When e-learners are able to continuously interact with complicated virtual environments and learning resources, they will have possibilities that need to make more progress in helping learners obtain more immersive online, on-the-fly, and real-time learning experiences and also in exploration of learners' potential through the possibility of feedback.[16]

Simplifying the integration of AI, IoT, and 6G networks within e-learning reveals a transformative shift towards an IoT-based educational environment. This shift holds the promise of fostering personalized, engaging, and immersive learning experiences. The fusion of these technologies has not only made it possible to enhance the quality of content delivery in compelling ways but also to introduce innovative teaching and learning methodologies. Consequently, learning applications become dynamically adaptive to learners' needs, offering a more immersive interactive educational support. This integration facilitates continuous assessment through the real-time collection and analysis of data. The amalgamation of AI, IoT, and 6G serves as the foundational pillars of an online education system characterized by its dynamism and adaptability, meeting the evolving demands of a diverse and constantly changing educational landscape.

In the following section, we are going to review selective articles on the integration of AI, IoT, and 6G networks in enhancing e-learning.

3 Synthetic Review

The In their paper titled "Enabling Massive IoT Toward 6G: A Comprehensive Survey," Fengxian Guo, F. Richard Yu, Heli Zhang, Xi Li, Hong Ji, and Victor C.M. Leung [17] explore what is needed to move from 5G to 6G. They posit that this leap is a key for managing the huge demands of IoT (Internet of Things) apps that need better data handling, computing power, and speed. They suggested a new 6G network setup that uses machine learning and blockchain, covering land, sea, air, and even space, with a big focus on edge computing. This setup would make things faster, reduce delays, and be super precise in figuring out locations.

The paper talks about how cutting-edge tech is crucial for sorting out IoT challenges as we head into 6G, but it does not delve into specific models or databases. It is all about the idea of a 6G network design that could meet IoT's varied needs. The authors are not advocates of 5G's limits and consider 6G as a necessary evolution. They are calling for more work on better network tech, saving energy, and making IoT apps more secure and private. In brief, they establish the groundwork for future 6G research to fully tap into IoT's potential.

In e-learning, 6G networks promise to cut lag, improving interactive learning via AR and VR technologies. This could make education more immersive and effective. Jinchao Huang's 2021 study introduces the GBDT2NN model, a notable advancement for AI in 6G IoT [18]. This model merges Gradient Boosting Decision Tree with Neural Networks, enhancing data processing. However, making these systems more comprehensible remains a challenge.

According to Huang's experiments, this model excels in demonstrating its choices and improving its performance for IoT networks. His research suggests that the integration of sophisticated machine learning with blockchain could tackle the challenges that will be facing IoT's 6G era. Moreover, as far as Huang is concerned, GBDT2NN model, as a forerunner in the evolution of 6G IoT networks, requires more tech advancements and security in IoT. He, subsequently, advocates for additional research to make AI systems more sophisticated and highly reliable.

In their seminal research, Bomin and Mao along with their team members (2021) [19] experimented and explored ways to enhance IoT services (6G) in hinterlands. They addressed the issues, such as weak signals, delays, and the management of energy as well as resources by IoT devices in remote areas. They suggested using drones and satellites, focusing on smart energy use, and improving task success, depending on the energy and channel conditions.

They dive into Space-Air-Ground Integrated Networks (SAGINs), backed by machine learning, edge computing, and energy harvesting. They find Terahertz frequencies really help drones communicate with IoT gadgets. Their deep learning model, using Long Short-Term Memory (LSTM), predicts energy harvesting power, leading to smarter decisions for IoT devices.

Their findings show how new tech, especially SAGIN, energy harvesting, and AI, can make IoT work better in the 6G world. Their deep learning method improved how well the system works, showing a shift from older methods.

The article highlights the complexities of managing UAVs, devising suitable AI algorithms, and the need for team efforts to meet diverse service needs and foster intelligence in these environments. These aspects are identified as key areas for academic focus in the future.

This study introduces a cutting-edge method for computational offloading in IoT networks through satellites and UAVs during the 6G era, emphasizing the essential role of combining modern technology and AI to address performance, energy, and latency challenges.

For students in regions with unreliable power, this research shows potential benefits. Optimized computational offloading, along with UAVs carrying edge servers, could transform mobile learning, allowing devices such as smartphones and tablets to run complex e-learning apps without quickly draining battery life.

The 2023 study by Jaafar Q. Kadhim, Ibtisam A. Aljazaery, and Haider TH. Salim ALRikabi [20] explores an innovative way to improve engineering student assessments by using IoT technologies and mobile networks. It seeks to make assessments more adaptive, automated, and reflective of individual efforts through practical tasks, aiming to overcome traditional assessment limits.

The system uses IoT and wireless networks to gather detailed data on student activities via sensors. This data is processed and analyzed by sophisticated algorithms, specifically the Adaptive Layered Bayesian Belief Network (AL-BBN) for activity classification and the Multi-Gradient Boosting Decision Tree (MGBDT) for decision-making, thereby boosting the precision and efficiency of student performance assessment.

The study highlights a significant enhancement in assessment methods. It gauges success through metrics, such as precision, data recollection, F1 score, and accuracy as well. Nevertheless, it capitalizes on the urgent need for more research to fully exploit

the affordances and benefits of these technologies in online education, particularly for independent learning and data handling.

The paper introduces an innovative approach to enhance online engineering education by the incorporation of IoT and mobile technologies into an automated assessment system, which surpasses traditional techniques in terms of effectiveness and accuracy. In addition, its significance is embodied in signifying a considerable advancement in the application of modern technologies to boost online learning experiences.

M.N Mahdi, is his 2021 [21] seminal work marked the shift from 5G to 6G technology by analyzing and investigating the integration of energy oriented IoT and machine learning. The study looks at 5G limitations and anticipates challenges for 6G networks, especially in energy, IoT, and machine learning areas. The author predicts a 6G network that offers complete coverage and supports all industrial actions within a self-sufficient ecosystem, equipped with superior intelligence and decision-making skills.

The research reviews various models and theories related to 6G, IoT, and machine learning, based on an examination of several academic papers. It mainly focuses on conceptual and theoretical progress rather than specific model applications or empirical data.

The researcher's findings highlight the crucial role of 6G networks as well as the challenges in advancing IoT applications, machine learning, and energy efficiency beyond that of 5G. His research capitalized on the inadequacies of 5G in addressing the growing demands for data, connectivity and energy demands which are of utmost importance to the future IoT applications and innovations as well. What is more, his study argues for a transition to sustainable, intelligent connectivity and highlights the potential of 6G networks to promote a smarter global ecosystem. He emphasizes the need to integrate machine learning and IoT into 6G technology so as to fulfill the future needs of the increasing digital needs. Furthermore, he provides, part and parcel, an in-depth analysis for the evolution from 5G to 6G focusing on advanced IoT applications, better machine learning integration, and greater energy sustainability.

Another seminal work is the study conducted by El-Haggar, [22] who explored the integration of the IoT technologies into what is known as ubiquitous learning (U-learning), suggesting a transformative approach and ways to make learning more accessible and integrated into students' lives (higher education). In addition to that, they argue that IoT can significantly enhance the educational experience by providing personalized and collaborative learning environments, while also emphasizing the critical importance of preserving privacy within these systems.

Accordingly, this study proposes that a framework of U-learning implemented on IoT has three main layers of: perception, network, and application to help cultivate the social skills of the learners. In this context, it has portrayed the role that IoT is probably going to play in the change of ordinary settings of classrooms towards U-learning settings that are rather interactive, motivating, and personalizing, along with highlighting privacy. There are major challenges that come along with integrating IoT in education, and these are related to security and privacy risks. These security risks include unauthorized access to information, denial-of-service (DoS) attack, and interference with wireless signals, among others. The paper further suggests future research directions related to the development of advanced encryption technologies, blockchain, machine learning, and other solutions for this purpose. The following paper discusses how IoT

technologies will be beneficial to U-learning environments with concrete details, therefore pushing forth a revolutionary change that makes U-learning environments much more individualized, accessible, and effective. The role of privacy and security concerns is highlighted to implement the full benefits of these technologies into education.

Weisi Guo (2019) [23] addressed the issue of explicability in the artificial intelligence systems, trying to solve the crisis of trust to affect AI optimization modules crucial for the 6G networks. The situation will support transparency and interpretability in decision-making by neural networks for applications such as driverless automobiles and telesurgery. Besides, the 6G networks are able to deal with complex and sensitive missions that require very high trust levels and understanding through the integration of Explainable AI (XAI) eq: is the practice of making AI systems' decision-making processes transparent and understandable to humans. This considers the powers of deep learning and mechanisms of deep reinforcement learning for the physical and media access control layers in wireless networks, all at the same time exposing how the performance is hard to balance with explicability. This suggests results in discussing ways of enhancing the explicability of AI models, where it also suggests a framework on how to integrate XAI with the future's 6G wireless systems without explicitly defined performance indicators. The explicability lack in AI then restricts its applicability in many of the critical 6G applications. This paper suggests a few research directions about developing more interpretable deep learning models and creating legal frameworks for AI explicability. Thus, the work of Weisi Guo emphasizes that in a 6G universe, explicability becomes essential to enhance trust between human and machine. Suggested an approach to harmonize performance with transparency and interpretability requirements of critical applications but focusing on the importance of evolution toward more comprehensible and reliable AI solutions. The same applies to the development of XAI in e-learning; apparently, inspired by the advances of 6G technology, this development is hyped to bring about a revolution in distance education with the much-needed transparency, personalization, and optimization afforded by AI. This model will ensure that recommended content given to learners, pedagogical support, and stimulation of critical thinking are provided according to needs; that at times one requires to be pushed from the comfort zone in order to achieve better results. In this background, the use of XAI would only support the development of much more interactive and inclusive learning settings that meet learners' needs and educational objectives more accurately using reliable technology.

In the research conducted by Ahmed Al-Ansi in (2021) [24], the focus is placed on Intelligence Edge Computing (IEC) as a pivotal innovation for the transition from 5G to 6G technology. The research scrutinizes the crucial role of IEC in enhancing performance and minimizing latency in future wireless networks, emphasizing its importance for 6G, particularly in terms of managing increased data volumes and reducing latency for essential applications. Despite lacking specific models or databases, Al-Ansi addresses the multiple challenges related to IEC, like resource management and security issues. He proposes future research directions to enhance IEC’s effectiveness and efficiency in 6G contexts. The study was concluded by reaffirming IEC’s essential contribution to the enhancement and advancement of 6G networks, its pivotal role in developing advanced services, and improving user experiences.

In the same vein, Balamurugan, Sureshkumar, Srivani, Lourens, and Alsekait (2022) [25] research focuses on advancing the interpretability and efficiency of AI algorithms within IoT networks by leveraging 6G technology. It proposes two main methods, the free method, and the joint method, evaluated on various IoT datasets. In this work, the reported results improve the explainability and predictability of AI model decisions, evidenced by the performance of the best models with substantially higher scores, such as NDCG (Normalized Discounted Cumulative Gain), AUC (Area Under the Curve), and others, indicating that the study has provided a new detailed analysis. This confirms the point by authors that new capabilities of AI algorithms constantly be tested within the complex architectures of 6G networks and obviously outlines it as one of the important areas of research in the future.

Yunlong and al. Lu [26] proposed a new approach that ensures the reliability, security, and privacy of the 6G network with the integration of digital twins, federated learning, and blockchain. This framework, named "Digital Twin Wireless Networks" (DTWN), is due to the migration of data processing and computation to the edge plane in order to optimize user association with base stations for efficient resource management and reduction of latency. Therefore, in most studies, the task of resource allocation is carried out via multi-agent reinforcement learning. The results put forth for the simulation based on real data with the proposed model which confirmed that the proposed model outperforms the benchmark in both efficiency and cost. Indicators to monitor include efficiency in communication, reliability, security of data, and latency. The paper identifies major obstacles, which can be categorized under communication challenges, limited resources, and mistrust. The next subsection will, therefore, propose some of the possible major future research directions to be taken so as to exploit the full potential of 6G in industrial IoT.

In theory, e-learning could provide a rich, real-world-based learning environment that emulated the classroom situation or laboratory practice by the application of this concept. For example, in science or engineering teaching, the teacher could structure the student activities whereby the students interact with digital models of devices or systems, through which they could conduct real-time experiments and explorations without the limitation of physical apparatus and boundaries.

In their research (2018), Veselina Nedeva and Snejana Dineva [27] investigate the impact of technological evolutions, particularly the transition from Web 3.0 to 5.0, on the enhancement of e-learning systems. They emphasize the significance of these technological advancements in creating more interactive and personalized learning environments. The study identifies AI, Big Data, and Cloud Computing as critical elements that contribute to the improvement of blended learning's quality and efficiency. The study particularly emphasizes the crucial role of AI. It, basically, focuses on the semantic Web in customizing content. Besides, it enables adaptive navigation to meet the learners' needs. The findings suggest that advancement towards Web 4.0 and 5.0 has the potential to transform e-learning by increasing customization and interaction. While the study notes the lack of quantitative performance metrics, the focus remains on improving the learning experience qualitatively. The study also emphasizes the need for more research measuring the impact of these technologies and the need for developing new educational skills to maximize their use. The study underscores the trans-

formative potential of advanced Web technologies in e-learning and stresses the importance of grasping their educational implications and developing effective teaching strategies.

A review of these scholarly studies shows that the infusion of IoT and AI is a key component in the development of 6G communication technologies, which have the potential to completely transform the e-learning industry. It is evident that these advanced technologies, when adopted in e-learning, are bound to bring improvements not only in accessibility and quality of education but also in enhancing the rigidity level of the incapabilities offered by previous generations of communication technologies. E-learning through integration within IoT in 6G promises an enriched infusion of an interactive and engaging dimension into the programs of e-learning. IoT devices, such as sensors and connected devices, provide real-time data which, when processed locally through edge computing, brings down latency and helps in providing an impetus to the learning experience. It is very relevant, especially for real-time simulations and virtual reality (VR) and augmented reality (AR) learning environments, where quick response is very important toward improved learning. It means, AI-based applications connected with 6G can revolutionize the data dimension and use for e-learning. AI models, for example, the mentioned GBDT2NN (Gradient Boosting Decision Tree to Neural Network), can help in the efficient processing of this data by e-learning systems so that it can provide students with personalized insight for effective learning. The personalization can go further and customize content details down to the need of a particular student and, therefore, enhance maximum engagement of the student and proper information acquisition. While e-learning enjoys huge benefits from adopting IoT and AI, they bring with them serious challenges. Issues like data security and privacy are highly challenging, given the huge generation and processing of enormous amounts of personal and sensitive data. The articles advise that technologies, such as blockchain, should be used for better security and privacy; hence, strong solutions need to be realized for user protection. Another major challenge lies in the area of energy efficiency, especially with respect to deploying IoT and AI in 6G systems. Further research should be carried out for the purpose of conceiving solutions that give value to energy efficiency in order to make the enormous growth of IoT sustainable, without breaking performance. All these aspects become a very big departure from the traditional pedagogy to one that is much more interactive, personal, and efficient. Because of this, as technology gets further advanced, dealing with issues of safety, privacy, and energy efficiency is important to the realization of its full potential. The two articles, therefore, provide a sound platform and a critical base for future research that understands the magnitude of those technologies towards bettering e-learning and facilitating radical educational innovations.

4 Challenges and Issues

This In an e-learning context, the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) into the sixth generation (6G) network raises many challenges and problems, ensuring that due emphasis is given to the use of the full potential of such technologies in education.

Data and Security Management Complexities: This involves huge integrations with the AI, IoT, and massive complexities with major data security, leading to curious

concerns. Given the massive influx of data generation, the methods of processing, storing, and securing this information have become significantly important. This includes implementing strategies on blockchain, AI-driven security models, and a unified standard setting for interoperability. For example, their application in e-learning to ensure the security and avoidance of fraud in the learning records of students provides a practical parallel to our topic. The method also secures the data from threats and keeps data integrity in a way that the qualifications of candidates can be easily verified by employers.

Latency and reliability: Advanced e-learning applications necessitate the use of very fast and reliable networks. For instance, the integration of interactivities in advanced learning forms like real-time simulations, virtual reality (VR), and augmented reality (AR) would require reduced latency and improved reliability. These are the pointers adopted through edge computing and enhancing the routing algorithms in such a way that this could be facilitated.

Interoperability and standards: Since IoT devices and AI platforms are heterogeneous, this points out interoperability challenges for innovation.

The seamless and effective "integration of technologies in e-learning", therefore, calls for the development and adoption of open standards. For example, IoT devices integrate into an open standard e-learning platform, providing students with educational content through their preferred learning devices, such as tablets, wearable gadgets, or voice assistants. This integration ensures a uniform experience tailored to the individual's use of the devices, bolstered by interoperability. It presents quite a big challenge to accommodate e-learning to the needs of every learner and means that AI systems, in this respect, would need to be dynamically modifiable in educational content. Pioneering developments of AI, like predictive analysis, are crucial for a truly personal and adaptive educational experience. Assuming an adaptive learning system framework powered by artificial intelligence, it assesses students' performance and behavior in real time and automatically customizes learning materials to meet each individual's unique needs; it is simple to imagine how it may be. For instance, if there is some kind of difficulty that occurs within a topic, it is likely that students are provided with easier or other kinds of tasks.

Sustainability and Energy: The IoT and emerging 6G technologies have dramatically increased the concern for the environment with respect to energy consumption. Eco-efficient solutions need to be developed where energy optimization at both the device and network level requires due consideration toward performance while ensuring the reduction in ecological impacts.

Eco-efficient virtual campuses that hold their courses, lectures, and meetings exclusively online do not require physical travel, hence saving on it. Further, physical travel is significantly less on such campuses, and they also make education sustainable with servers and devices that are devised for e-learning and are optimized on energy. All these challenges come up with an open path for the integration of AI and IoT in the 6G networks for improved e-learning, though it may not be minus challenges. Innovation and collaboration to change these aspects by addressing them in innovative approaches would be transformational for the educational sector, to revolutionize the current status of online learning for all to be rich and accessible.

5 Discussion

This One of the most notable trends is the increase in the use of data generated by the IoT to inform AI algorithms, allowing for a more thorough personalization of the learning experience. The convergence of 6G networks with AI and IoT paves the way for immersive educational applications, such as AR and VR, offering enriched learning experiences that were previously inaccessible due to bandwidth and latency constraints [28]. Moreover, the ability to efficiently manage massive volumes of real-time data could revolutionize learning analytics, providing instant insights into student performance and engagement.

These technologies offer better learning experiences than were possible before because of speed and delay issues. Furthermore, being able to handle huge amounts of data in real time will change learning experience by giving us instant and thorough information about how well students are doing and how interested they are in the process of learning. Nevertheless, even with these improvements, there are still major problems with present studies. To mention a few, but not least, there are not enough real-world studies and case studies that show for sure how these combined tools affect how well students learn. Preoccupations regarding privacy and ethics in using AI to gather and analyze the learner's data have not been adequately addressed, particularly in classrooms. Furthermore, there is still a lack of research regarding whether these technologies are inclusive and accessible by all students, especially disadvantaged students, and learners with special needs. If we want to grasp the potential of 6G, AI, and IoT integration in the field of education, it is imperative to deal with these research gaps.

The merge of AI and IoT into 6G networks, during the e-learning process, is definitely an insightful prospect. Such integration is expected to result in strong ethical AI models, where educational programs are tailored to providing more students' privacy. In addition to that, enhancing 6G infrastructure will improve the quality of education accessible to everyone, and minimizing the lack of equal opportunities prevailing in the educational system. Future research may take the initiative to explore the use of blockchain technology for securely managing educational information as well as the academic records in decentralized environments.

Communicating with AI combined with the use of IoT will inherently lead to an immense change of the effectiveness and contacts of e-learning. Thanks to the IoT networks equipped with real-time data, the AI algorithms are able to provide students with personalized learning pathways which adapt incrementally based on their advancement and preferences. Such personalization may be conducive to students' improvement. The short latency 6G networks can also offer live interactions and therefore smooth virtual learning which will be more interactive and immersive.

In conclusion, AI and IoT adoption in 6G paves the path for enriched e-learning declaring an era of notable efficiency and interactivity. Nonetheless, this potential can be exploited only by finding solutions to research barriers and ethical issues, data confidentiality and accessibility challenges. Through the emphasis of interdisciplinary collaboration and by finding the solutions in a smart and inclusive way, we can create the future where online education is favorably improved for all who teach and learn.

Table 1. Comparative summary of different studies

References	Technolog--ical innova-tion	Learning effi-ciency	Self-learning and adaptat-ion	Access and processing speed	Security and privacy
[17]	✓	✓		✓	✓
[18]	✓	✓	✓	✓	
[19]	✓	✓		✓	
[20]	✓	✓	✓	✓	
[21]	✓				✓
[22]	✓	✓	✓		✓
[23]	✓				✓
[24]	✓	✓		✓	✓
[25]	✓	✓	✓	✓	✓
[26]	✓	✓		✓	✓
[27]	✓	✓	✓	✓	

From the table, there is a trend that more consideration is being taken with regard to technological innovation, where 6G, AI, and IoT technologies are taking precedence. Most of the studies have shown that there is a need for such integration to advance the learning process. The rate and means of accessing, therefore, underscore the significance of learning both speedily and effectively in the current digital environment. Self-learning and adaptation are also appreciated, pointing toward a change to more flexible and personally accepted learning methods. Inclusion of security and privacy in the table, while hardly mentioned, would indicate basic characteristics of the functionality of a reliable and secure digital learning environment. As such, the common parameters expressed above reflect a general interest in optimizing e-learning by use of cutting-edge technologies for enhancing efficiency, personalizing learning experience, and ensuring user security.

Trends from this systematic review are significant, while the trends identified in our review present yet another opportunity for these key challenges and promising opportunities to be considered.

These 6G networks with the integration of AI and IoT could not only take e-learning to another dimension but also hold the key toward efficiencies in online learning that have never been witnessed before. 6G technologies facilitate the required functionalities of real-time interactivity, within which immersive learning may be executed to allow full use of the potential provided by AI and IoT in an educational setup.

However, the literature reveals some significant gaps that must be emphasized in this review: the need for empirical evaluations of the effectiveness of these technological integrations, and ethical and privacy concerns that challenge their utility. Addressing these issues will facilitate the creation of inclusive solutions, ensuring quality educational access for learners in various geographical locations and with varying resources available to them.

One of the most notable trends is the increase in the use of data generated by the IoT to inform AI algorithms, allowing for a more thorough personalization of the learning experience. The convergence of 6G networks with AI and IoT paves the way for immersive educational applications, such as augmented (AR) and (VR), offering enriched learning experiences that were previously inaccessible due to bandwidth and latency constraints [28]. Moreover, the ability to efficiently manage massive volumes of real-time data could revolutionize learning analytics, providing instant insights into student performance and engagement.

These technologies offer better learning experiences than were possible before because of speed and delay issues. Furthermore, being able to handle huge amounts of data in real time will change learning experience by giving us instant and thorough information about how well students are doing and how interested they are in the process of learning. Nevertheless, even with these improvements, there are still major problems with present studies. To mention a few, but not least, there are not enough real-world studies and case studies that show for sure how these combined tools affect how well students learn. Preoccupations regarding privacy and ethics in using AI to gather and analyze the learner's data have not been adequately addressed, particularly in classrooms. Furthermore, there is still a lack of research regarding whether these technologies are inclusive and accessible by all students, especially disadvantaged students, and learners with special needs. If we want to grasp the potential of 6G, AI, and IoT integration in the field of education, it is imperative to deal with these research gaps.

The merge of AI and IoT into 6G networks, during the e-learning process, is definitely an insightful prospect. Such integration is expected to result in strong ethical AI models, where educational programs are tailored to providing more students' privacy. In addition to that, enhancing 6G infrastructure will improve the quality of education accessible to everyone, and minimizing the lack of equal opportunities prevailing in the educational system. Future research may take the initiative to explore the use of blockchain technology for securely managing educational information as well as the academic records in decentralized environments.

6 Conclusion

Communicating with AI combined with the use of IoT will inherently lead to an immense change of the effectiveness and contacts of e-learning. Thanks to the IoT networks equipped with real-time data, the AI algorithms are able to provide students with personalized learning pathways which adapt incrementally based on their advancement and preferences. Such personalization may lead to students' improvement. The short latency 6G networks can also offer live interactions and therefore smooth virtual learning which will be more interactive and immersive.

In conclusion, AI and IoT adoption in 6G paves the path for enriched e-learning declaring an era of notable efficiency and interactivity. Nonetheless, this potential can be exploited only by finding solutions to research barriers and ethical issues, data confidentiality and accessibility challenges. Through the emphasis of interdisciplinary collaboration and by finding the solutions in a smart and inclusive way, we can create the future where online education is favorably improved for all who teach and learn.

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