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# The effect of educational IoT-related services on the performance of academicians in computer science colleges: A Review Paper

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## Abstract

Technology plays a crucial role in enabling educators to access and utilize information, facilitating knowledge acquisition and effective learning. The presence of appropriate equipment is vital for creating a learning environment where educators can actively engage with ideas, process and apply them, and connect them to real-world contexts. The integration of IoT technologies in educational settings has the potential to revolutionize teaching and learning practices, but its specific impact on educators' performance requires further investigation. This review research focuses on examining the influence of IoT-related services in education on the performance of educators, with a particular emphasis on computer science colleges. The study encompasses primary research studies, academic papers, and reports that explore the effects of IoT-related services on educators' performance in computer science colleges. It identifies several factors that affect the effectiveness of educational IoT-related services, including the availability of technological infrastructure, the quality of training and professional development programs for educators, and the establishment of robust data security and privacy measures. By shedding light on the impact of educational IoT-related services on educators' performance in computer science colleges, this study contributes to the existing literature. The findings serve as a valuable resource for educational institutions seeking to understand the potential benefits and challenges associated with the successful implementation of IoT technologies in the academic field.

**Keywords** Internet of Things (IoT) , Academic Performance, IoT in Teaching and Learning, Educational Technology

# INTRODUCTION

The connection between education and technology has been lengthy and intricate. Technology aids academicians in accessing and utilizing information, which facilitate the process of transforming that information into knowledge, have been crucial in effective learning practices. Having the appropriate equipment plays a fundamental role in creating a learning environment where academicians can actively participate, process and apply ideas, and relate those ideas to their surrounding contexts. Consequently, the relationship between education and technology has been a focal point of discussions and evaluations in education policies and practices. Concerns regarding declining education standards, students lacking employable skills, outdated curricula, and inefficient institutional structures have prompted debates on the role and significance of technologies in classrooms. When we refer to technology, it encompasses more than just computers, as it includes a range of tools that extend the capabilities of the human body, such as pens, eyeglasses, and clothing. This work Highlights the impact of the emerging IoT technology on the education with emphasize on the computer science field.

The concept of the Internet of Things (IoT) is widely attributed to Kevin Ashton, who is said to have coined the term in 1999 [1]. Ashton envisioned the IoT as a system that could assist humans in processing large volumes of data [2]. According to [3], the IoT is not a single technology but rather a combination of various technologies that work together in harmony. The IoT represents the connection of seemingly insignificant physical objects to the internet. This connectivity enables these objects to remotely transmit sensory data, thereby enhancing material environments with the ability to capture and process ambient data. Once connected, each object is assigned a unique network address, allowing for its individual identification. Typically, these objects possess sensing capabilities that enable them to dynamically perceive changes in their surroundings and transmit that information over the internet. In the context of the IoT, there are four key characteristics that define a device as a 'thing' [4] . The IoT devices must operate in environments where information can be gathered and subsequently sent either to another device or directly to the Internet, can be programmed to take specific actions based on predetermined conditions, should be able to receive data from the network they are connected to, and must be able to communicate with other devices either directly or through other nodes within the same network. Gartner Hype Cycle Special Report [5], Figure 1. recognized the Internet of Things (IoT) as an emerging technology due to its significant potential and impact on various industries.

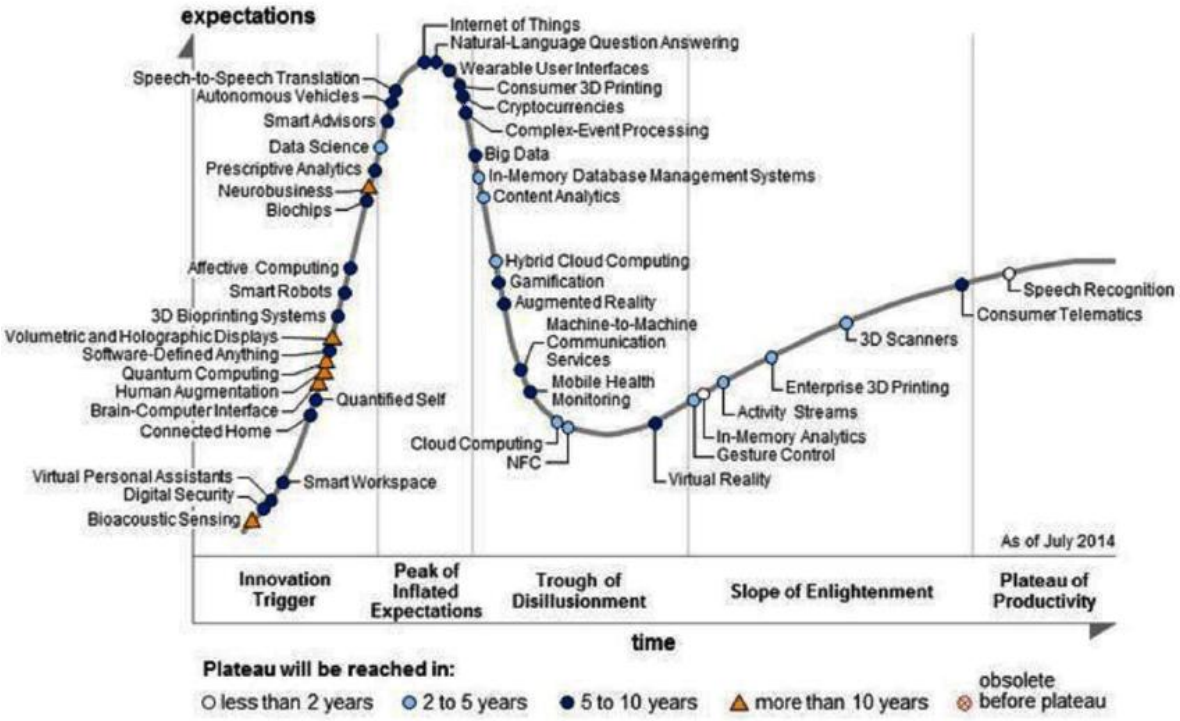


**Figure 1**. Hype Cycle for Emerging Technologies, 2014. Source: [5]

The use of IoT is already being utilized in various industries, including healthcare, retail, customer service, smart homes, environmental monitoring, and industrial applications. With its widespread presence, educational institutions and schools are now exploring the integration of IoT into educational practices to bring advantages to students, educators, and the entire education system as a whole.

Educators in various countries, including Japan [6], the United States [7], and the United Kingdom [8], have already started utilizing IoT technologies in their teaching methods. Cisco, a prominent IT and networking company, has initiated several IoT projects in the education sector, involving schools and students in smart academic initiatives [9].

Although there are existing studies on integrating IoT into education, there is still a lack of consolidated and coherent perspectives on this topic. Existing research on IoT in education primarily focuses on the technical aspects of IoT implementation such as infrastructure, connectivity, and device integration, neglecting the crucial pedagogical implications and specific applications in colleges[10-12] . The academic implications and the specific ways in which IoT-related services can enhance the academic performance of academicians in colleges have not been explored in [13, 14]. Thus, this research seeks to fill this gap by reviewing the impact of educational IoT-related services on academicians' performance, providing insights into the potential benefits and challenges associated with their use.

## REVIEW SEARCH METHODOLOGY

In order to obtain a comprehensive understanding of the existing literature, we conducted a search for articles in reputable databases, including IEEE Xplore, Scopus, Web of Science, Google Scholar, and online sources. The search encompassed articles published from January 1999 to the present. Two main criteria were used for the search keywords: the inclusion of "IoT" or "Internet of things" as the first criteria, and the inclusion of "Education" or "computer science colleges" as the second criteria. A total of 97 academic papers and publications were identified and included in the research. Duplicate articles or that with little relevance were removed, and the content of the 58 selected articles was synthesized for analysis, figure 2.

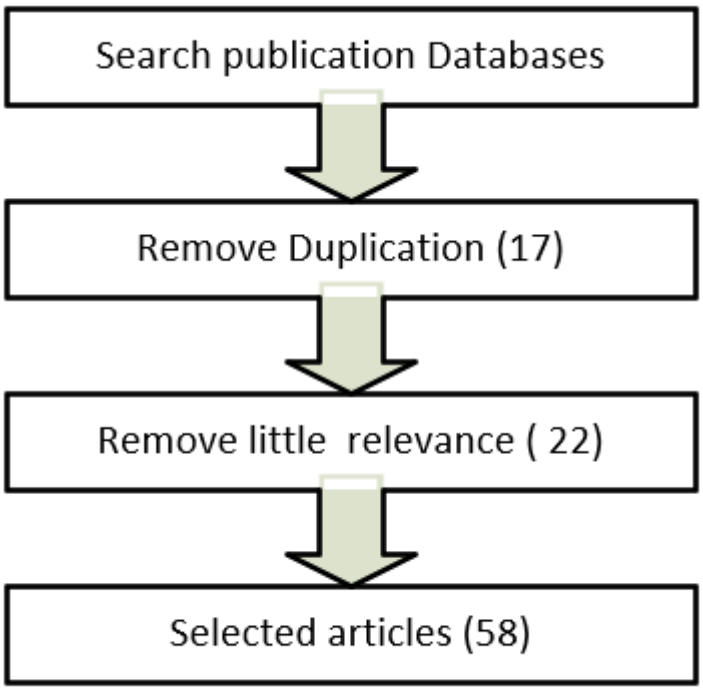


**Figure 2**: Research Articles Selection

## *Educational IoT-Related Services*

The IoT is a network of interconnected devices that can communicate with each other to collect and exchange data. IoT is increasingly being used in educational contexts to enhance the learning experience. This section provides an overview of the IoT services relevance to education.

The research article [15] presents a survey on the applications of IoT in education, highlighting the potential opportunities and challenges. The article discusses the IoT-based educational services, such as personalized learning, smart campuses, and remote learning, and their impact on students' engagement and academic performance. It also addresses the challenges associated with implementing IoT in education, including data security, technical issues, and ethical concerns. The article concludes by outlining the future research directions for IoT in education, emphasizing the need for developing robust and scalable IoT-based solutions.

The authors in [16] explore various IoT-based solutions in education, including smart classrooms, e-learning systems, personalized learning, and campus management systems. The article also discusses the challenges of implementing IoT in education, such as infrastructure, security, and privacy issues. The authors have concluded by suggesting that IoT has the potential to revolutionize education and transform the traditional classroom into an interactive and engaging learning environment.

In [17], the paper discusses the potential of IoT for enhancing various aspects of education, including personalized learning, efficient resource management, and smart campus management. The paper also presents several challenges and opportunities for the successful implementation of IoT in education, such as security and privacy concerns, interoperability issues, and the need for cross-disciplinary collaboration. Finally, the authors provide recommendations for researchers, policymakers, and practitioners to leverage the potential of IoT in education while ensuring its sustainability and social responsibility.

### *Overview of IoT-Based Educational Services*

IoT-based educational services refer to the use of IoT technologies in delivering educational services to learners. These services include smart classrooms, e-learning platforms, and educational robots. This section provides an overview of IoT-based educational services and their potential benefits.

In [18], the paper has discussed the implementation of IoT tools in higher education in Malaysia to improve the quality of teaching and learning. The authors argue that the integration of IoT tools in the curriculum can enhance the students' engagement and interaction with the learning materials, leading to better retention of knowledge and improved academic performance. The study presents a case study of an IoT course that was offered to engineering students and demonstrates the effectiveness of using IoT tools in teaching and learning. The findings suggest that the integration of IoT tools in higher education can enhance the students' learning experience and improve the quality of education.

A case study of an IoT course developed for the Master's program in Applied Mathematics and Computer Science has been discussed in [19]. The authors have described the IoT course structure and discuss the various topics covered in the course, such as IoT devices, protocols, platforms, and security. They also outlined the teaching methodology and assessment strategies used in the course, including project-based learning and practical assignments. The authors concluded that the IoT course provides students with relevant knowledge and skills required to work with IoT systems in various application areas.

## *IoT Applications in Computer Science*

Education Computer science education is a discipline that can greatly benefit from IoT-based educational services. This section provides an overview of the potential applications of IoT in computer science education, including the development of smart classrooms, e-learning platforms, and educational robots.

The article [20] has proposed a novel architecture for integrating the IoT seamlessly into university systems, as shown in figure 3. The proposed architecture includes several layers, including the sensing layer, communication layer, middleware layer, and application layer. The sensing layer has involved the deployment of various sensors to gather data from the environment. The communication layer involved communication protocols and technologies used to transmit data to the middleware layer. The middleware layer has processed and analyzed data from the sensing layer and provides a platform for developing IoT applications in the application layer. The article has concluded that the proposed architecture can be used to improve the efficiency of university systems and enhance the learning experience of students.

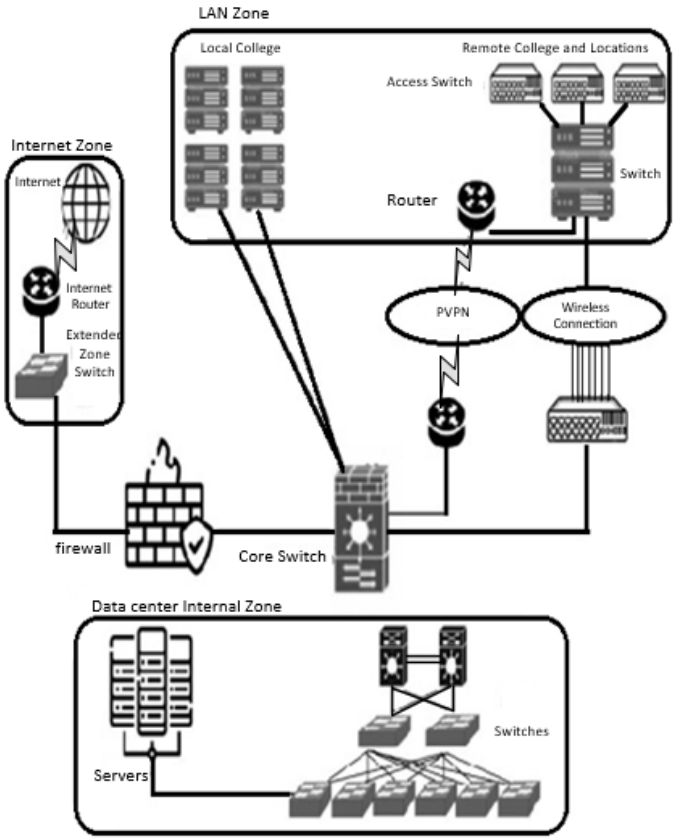


Figure 3: A scheme overview of a Typical Conventional University System , [20].

In [21], the research study has presented a teaching management system (TMS) that integrates RFID and IoT technologies to improve teaching efficiency and management in higher education. The proposed TMS includes four modules: the system architecture module, the user authentication module, the course management module, and the evaluation management module. The system utilizes RFID and IoT technologies to perform various functions, such as student attendance tracking, location-based classroom

management, and student performance evaluation. The authors conducted a pilot study at a Chinese university to evaluate the effectiveness of the system and reported positive feedback from students and teachers. The results of the study suggest that the TMS can improve teaching efficiency, reduce management costs, and enhance student learning experience.

The paper [22] has presented a system called EduTalk, which is an IoT environment that aims to enhance the learning experience of computer programming and physics for students. The system uses a microcontroller and various sensors to capture and analyze data related to programming and physics experiments. The collected data is then processed and visualized through an interactive platform, which allows students to understand and analyze the outcomes of their experiments. The authors conducted a user study to evaluate the effectiveness of EduTalk, and the results showed that the system has the potential to enhance students' learning experience and engagement in computer programming and physics.

The article presented in [23] has discussed the current state of the workforce for IoT and provides recommendations for creating a skilled workforce in the field. The authors explore the key skills needed for IoT-related jobs, the current education and training landscape, and the challenges faced by employers seeking to fill these positions. They suggest various strategies for addressing these challenges, such as creating interdisciplinary programs and offering continuing education for existing employees. The article emphasizes the importance of collaboration between industry and academia in developing the necessary skills for IoT.

The paper reviewed in [24] has presented a systematic mapping study of the use of the IoT, mobile computing, and ubiquitous computing in computer science education. The study aimed to identify research trends, teaching approaches, and technologies employed, as well as to analyze the impact of these technologies on learning outcomes. The study was conducted by analyzing 71 papers published between 2012 and 2019. The results show that IoT and mobile computing are increasingly used in computer science education, and that most studies have focused on the development of IoT-based systems and their evaluation in terms of students' performance and satisfaction. The paper concludes with a discussion of the challenges and opportunities of using these technologies in computer science education, and proposes future research directions.

### *Theoretical Perspectives on the Impact of IoT on Learning*

The use of IoT technologies in education has a long history. This section provides a brief overview of the historical background of IoT in education, from early efforts to integrate technology into the classroom to the emergence of IoT-based educational services.

The article [25] has presented a case study of integrating IoT technologies into the computer science curriculum at Prairie View A&M University (PVAMU). The study describes the process of developing and implementing a new course on IoT technology and its impact on student learning outcomes. The authors discuss the challenges and opportunities of integrating IoT technology into the CS curriculum and share their insights and recommendations for other universities that are planning to incorporate IoT in their CS programs. In addition, the article provides practical insights into how IoT technology can be effectively integrated into the computer science curriculum to enhance students' learning experiences and prepare them for careers in the digital age.

In [26], a comprehensive review of the history, technology, and deployment of IoT in various fields has been provides. The authors has discussed the development of IoT technology over time, its potential applications in fields such as healthcare, transportation, agriculture, and smart homes, and the challenges associated with

the deployment of IoT. The paper concluded with recommendations for future research and development in the field of IoT. It has also provided a useful resource for researchers, practitioners, and policymakers who are interested in the emerging field of IoT.

The research article reviewed in [27] has aimed to provide a comprehensive understanding of the current state of IoT education in China and identify the challenges and opportunities for improving IoT education. The authors conducted a survey of undergraduate IoT programs across 100 universities in China, collecting data on curriculum design, teaching methods, laboratory facilities, and student learning outcomes. The study found that IoT education in China is still in its early stages, and there is a need for more interdisciplinary courses and hands-on training to enhance students' practical skills. The authors conclude that there is a significant potential for improving IoT education in China and suggest some recommendations for future development. The article provided valuable insights into IoT education in China and serves as a useful reference for educators and policymakers who are interested in promoting IoT education.

The article presented in [28] has examines the potential of the IoT to address challenges in educational management. The author highlights the key challenges in educational management, such as monitoring student attendance, managing classroom resources, and ensuring the safety of students, and proposes IoT-based solutions to address these challenges. The paper discusses how IoT can be used to track student attendance, optimize classroom resources, and enhance the safety of students. The author also discusses some of the challenges in implementing IoT-based solutions in educational institutions and provides recommendations for addressing these challenges. Besides, the it presented a valuable perspective on the potential of IoT in educational management and provides a useful reference for educators and policymakers interested in exploring IoT-based solutions in education.

The article published in [29] has explored the potential impact of the IoT on higher education. The authors discuss how IoT can be used to enhance learning processes, improve institutional management, and provide new opportunities for research, academic performance, and innovation in higher education. The paper also identifies some of the challenges associated with implementing IoT in higher education, such as data security and privacy concerns, lack of standardization, and technical complexity. The authors conclude that IoT has the potential to transform higher education by improving the quality of education, enhancing the learning experience of students, and facilitating institutional management. Furthermore, it has provided a useful overview of the potential benefits and challenges of implementing IoT in higher education and serves as a valuable reference for educators and policymakers interested in exploring IoT-based solutions in education at colleges levels.

The article reviewed in [30] had explored the concept of a "smart university" and its potential application in higher education – a colleges' level. The authors provide a comprehensive review of the latest technological advancements in the IoT and their potential application in educational institutions. The paper also discussed the educational implications of IoT-based technologies, such as personalized learning, enhanced collaboration, and improved student engagement. Additionally, the authors examined the potential challenges associated with implementing IoT-based solutions in educational institutions, such as data security and privacy concerns, lack of standardization, and technical complexity. Also, the paper had presented a valuable perspective on the potential of IoT-based technologies in higher education and provides a useful reference for educators and policymakers interested in exploring the concept of a "smart university."

## 1. Empirical Studies on the Effectiveness of IoT-Based Educational Services

This section provides a review of empirical studies on the effectiveness of IoT-based educational services. These studies examine the impact of IoT on various aspects of the learning experience, including academic performance, engagement, and satisfaction.

The article explained in [31] has presented a research framework for assessing the effectiveness of web-based virtual learning environments (VLEs) in the context of basic IT skills training. The authors begin by discussing the potential advantages of VLEs, such as increased flexibility, accessibility, and scalability, as well as some of the challenges associated with their implementation, such as the need for technical support and effective instructional design. The paper then presents a research framework that includes four key components: learner characteristics, VLE characteristics, instructional design, and performance outcomes. The authors test this framework by conducting a preliminary assessment of the effectiveness of a web-based VLE in improving basic IT skills among undergraduate students. The results suggest that web-based VLEs can be effective in improving IT skills, but the authors note that further research is needed to better understand the factors that contribute to their effectiveness. Addition, the paper provides a useful framework for assessing the effectiveness of web-based VLEs in higher education and serves as a valuable reference for educators and researchers interested in exploring the potential of technology-based solutions in education.

Another article has [32] present an algorithm for evaluating the quality of computer-based teaching using the IoT technology. The author highlights the increasing use of IoT technology in educational settings, which allows for the collection and analysis of real-time data on teaching and learning activities. The proposed algorithm consists of four steps: data collection, data preprocessing, data analysis, and quality evaluation. The algorithm uses a range of metrics, including class attendance, student engagement, and teacher effectiveness, to assess the quality of computer-based teaching. The author then have applied the algorithm to a case study involving a computer-based teaching course at a Chinese university. The results demonstrate that the algorithm can effectively evaluate the quality of computer-based teaching and provide insights for improving teaching effectiveness. Also, the article provided a valuable contribution to the field of educational technology by offering a practical algorithm for assessing the quality of computer-based teaching using IoT technology.

A study on the potential use of the IoT technology in higher education has been presented in [33]. The authors conducted a survey of 200 students and 50 faculty members at a university in Saudi Arabia to explore the perceptions of IoT technology in education. The study found that the majority of participants were aware of IoT technology and believed it could enhance the learning experience. The authors also identified several potential applications of IoT technology in education, including smart classrooms, personalized learning, and real-time monitoring of student progress. The study highlights the importance of incorporating IoT technology in higher education and emphasizes the need for further research in this area. The article has then provided valuable insights into the potential of IoT technology in education and encourages the development of IoT-based solutions for enhancing the learning experience.

### *1.1 Importance of IoT services for academicians in computer science colleges in terms of education performance*

The integration of educational IoT-related services in computer science colleges has the potential to transform the way academicians teach and interact with their students [34]. Educational IoT-related services can enhance the learning experience of students by providing real-time data, personalized feedback, and

interactive learning tools. Additionally, IoT technology can improve the performance of academicians by providing them with tools for effective teaching, research, and data analysis.

Furthermore, the adoption of IoT technology in education can prepare students for the job market by providing them with skills in emerging technologies such as the IoT, artificial intelligence, and machine learning [35-37]. Therefore, it is crucial to understand the impact of educational IoT-related services on academicians' performance to optimize their use and to provide quality education to students [37].

Moreover, understanding the benefits and challenges associated with the adoption of IoT technology in education can assist policymakers in implementing effective policies to encourage the adoption of these services in computer science colleges. As the demand for technologically advanced educational services grows, understanding the impact of educational IoT-related services on academicians' performance is vital for the future of education. Therefore, this research is important to explore how academicians can leverage educational IoT-related services to improve their teaching and research activities and prepare students for the future workforce [38, 39].

### *1.2 Role of IoT-related services on academicians' performance in computer science colleges in terms of education*

The integration of educational IoT-related services in computer science colleges can play a significant role in enhancing academicians' performance. The following are the potential roles of educational IoT-related services on academicians' performance in computer science colleges that will be investigated in this research: 1) Educational IoT-related services can provide real-time data on student performance, allowing academicians to make informed decisions about teaching methods and adjust their approach to meet the needs of individual students. 2) IoT technology can support academicians' research activities by providing access to data and analysis tools. 3) Educational IoT-related services can encourage innovative teaching methods by providing tools for interactive and experiential learning. 4) IoT technology can promote collaborative learning by providing tools for communication and collaboration between students and academicians.

### *1.3 Impact(s) of IoT-related services on academicians' performance in computer science colleges*

The integration of educational IoT-related services in computer science colleges has the potential to have a significant impact on academicians' performance. A number of potential impacts of educational IoT-related services on academicians' performance in computer science colleges can be listed as follows: Educational IoT-related services can enhance teaching effectiveness by providing real-time data, personalized feedback, and interactive learning tools. Also, IoT technology can assist academicians in their research activities by providing access to data, analysis tools, and collaboration platforms. Third of which, educational IoT-related services can assist in optimizing the curriculum by providing insights into student performance, identifying gaps in knowledge, and recommending personalized learning paths. Fourth of them is that the adoption of

IoT technology in education can prepare students for the job market by providing them with skills in emerging technologies such as the IoT, artificial intelligence, and machine learning.

## 2. Potential Benefits and Limitations of IoT-Based Educational Services in Computer Science Education

### *2.1 Advantages of IoT-Based Educational Services in Computer Science Education*

This section provides an overview of the potential benefits of IoT-based educational services in computer science education, including improved learning outcomes, increased engagement, and personalized learning experiences.

In one of the related studies [40], it was aimed to investigate the potential role of IoT in the education sector. The study includes a survey conducted with 70 individuals including students, teachers, and other staff members in the education sector. The results of the survey indicate that IoT can be a useful tool to improve the quality of education by enhancing the teaching and learning process, providing personalized learning, and enabling remote access to educational resources. Additionally, IoT can play a significant role in improving the administrative and management processes of educational institutions by facilitating automation and real-time monitoring of various activities. The paper concludes that IoT has enormous potential in the education sector and suggests further research in this area.

In [41], the article has examined the incorporation of the IoT into undergraduate computer and information science education. The authors identify IoT as a growing field that has the potential to significantly impact future technologies, but also poses new challenges for computer science educators. Therefore, the authors aim to explore the current state of IoT integration in undergraduate curricula and examine the pedagogical approaches used in teaching IoT.

To achieve this, the authors in [41] conducted a survey of faculty members in computer and information science programs in the United States to identify how IoT is currently incorporated into undergraduate curricula. The survey collected data on the extent to which IoT topics are covered, the courses in which they are taught, and the pedagogical methods used. In addition, the authors analyzed course syllabi from a sample of undergraduate programs to identify the types of IoT-related assignments and projects that students are given.

The results of the survey and syllabi analysis suggest that IoT is not widely integrated into undergraduate curricula, with less than half of the surveyed faculty reporting the inclusion of IoT-related topics. The authors identify several challenges that may be hindering the integration of IoT into curricula, including the interdisciplinary nature of the field and the need for specialized equipment and software. Furthermore, the authors note that when IoT is included in curricula, the pedagogical approaches vary significantly, with some courses focusing on theory while others are more project-based [41].

Based on these findings, the authors suggest several recommendations for incorporating IoT into undergraduate education, including the need for interdisciplinary collaboration and project-based learning. They argue that these approaches can help to address the challenges posed by IoT and ensure that undergraduate students are well-prepared for the demands of the field. Ultimately, the authors hope that this study will encourage computer science educators to explore new ways to incorporate IoT into their curricula and develop innovative pedagogical approaches that prepare students for the future of technology.

A framework highlighted in [42] has been proposed for incorporating the IoT into performance management in higher education institutions. The authors recognize the potential benefits of IoT in improving performance management in higher education, such as facilitating data collection and analysis. However, they note that there is currently no comprehensive framework that outlines how to integrate IoT into performance management. Therefore, the authors aim to develop a framework that can guide the integration of IoT into performance management in higher education institutions.

This can be achieved thru a conduction of a literature review to identify the key components of IoT and performance management. They then used this information to develop a framework that outlines the steps involved in integrating IoT into performance management. The framework includes four stages: planning, data collection, analysis, and feedback. The authors describe each stage in detail and provide examples of how IoT can be used to improve performance management in higher education.

The authors also discuss the potential challenges of implementing this framework, such as data privacy concerns and the need for specialized skills and resources. They suggest that these challenges can be addressed through effective planning and collaboration among stakeholders.

To conclude, the authors has argued that their framework can serve as a useful guide for higher education institutions seeking to incorporate IoT into performance management. They hope that this framework will encourage institutions to explore new ways of leveraging IoT to improve their performance management processes and ultimately enhance the quality of education they provide.

A paper presented in [43] has proposed a blockchain-based educational framework and credential system for IoT applications. The system includes a set of standards for creating and managing educational content in IoT-based learning environments, a blockchain-based credentialing system for secure and tamper-proof recording of student achievements and credentials, and a smart contract-based verification system for authenticating student credentials. The authors discuss the potential benefits of this system, such as increased security, transparency, and efficiency in the management of educational credentials. They suggest that this system can be further developed and customized to meet the specific needs of different educational institutions and industries.

In [44], the application of IoT and virtual reality (VR) technology in college physical education has been explored. The authors discuss how IoT devices can be used to collect and analyze data related to physical activity and fitness, and how VR technology can be used to create immersive and engaging exercise environments. The article also discusses the potential benefits of using IoT and VR technology in physical education, such as increased motivation, personalized feedback, and improved learning outcomes. The authors suggest that the integration of IoT and VR technology can lead to a more effective and engaging physical education experience for college students.

### *2.2 Limitations and Criticisms of IoT-Based Educational Services*

This section explores the potential limitations and criticisms of IoT-based educational services. These include concerns over data privacy and security, the potential for technology to replace human interaction, and the need for appropriate technological infrastructure.

A review of swarm intelligence-based algorithms within IoT-based systems has been provided [45]. The authors discuss how swarm intelligence can be applied in various IoT domains such as healthcare, transportation, and smart cities. The article also provides an overview of different swarm intelligence-based

algorithms such as ant colony optimization, particle swarm optimization, and artificial bee colony optimization. The authors highlight the potential benefits of using swarm intelligence-based algorithms in IoT-based systems, such as improved efficiency, scalability, and robustness. The article concludes with a discussion of future research directions in this area.

Another systematic review regarding benefits and challenges of implementing the IoT in education has been presented in [46]. The authors review a total of 34 studies and identify several benefits of using IoT in education, such as increased student engagement, personalized learning experiences, and improved student performance. It has also discussed the challenges associated with IoT implementation in education, including issues related to data privacy and security, as well as technical challenges such as interoperability and scalability. The authors suggest that despite the challenges, the potential benefits of IoT in education warrant further exploration and research in this area.

Key problems associated with long-distance learning and training have been introduced in [47]. The authors discuss how the use of technology and mobile networks can facilitate remote learning and training, but also highlight several challenges associated with these methods. The article identifies issues related to network connectivity and bandwidth, as well as challenges related to learner engagement and motivation. The authors also discuss the need for effective instructional design and the importance of providing adequate support for learners engaged in remote learning and training. The article concludes with a call for further research and development in this area to address the key problems associated with long-distance learning and training.

Research in the smart campus sector is still expanding, with each researcher defining the notion of smart campus with a less complete viewpoint that has not been integrated in the same conception of the term. In [48], the current state of smart campus development have been outlined in terms of features, supported technologies, and applications constructed utilizing systematic literature review (SLR) as the standard approach used to address any problems by tracing the outcomes of prior research. The concerns disclosed in SLR are frequently referred to as research questions (RQ). To do this, authors create several RQs linked to that area and explain each issue by tracking past research publications that are indexed in renowned journal databases such as IEEE Xplore, Scopus, and ScienceDirect. After synthesizing 29 articles, the following conclusions were reached: contactless technology provides an easier way to enter data when accessing a specific room or equipment than using a keyboard; IoT supports an easier way to report real-time environment status; cloud computing is used to effectively organize various information and provide data services; iCampus becomes a popular smart campus model and if applications built into iCampus were mapped; there are no applications as of yet. Based on prior research, the major contribution of smart campus construction is to make all areas of campus life easier. The intended contribution is to offer an overview for academics who wish to create apps on a campus as a research challenge so that they may utilise relevant technology and match the features of a smart campus.

## 3. Examining the Effectiveness of IoT-Based Educational Services on Academicians' Performance

In [49], an empirical study on the use of e-learning services to enhance sustainable learning and academic performance was presented. The study involved a survey of university students in Saudi Arabia and found that the use of e-learning services positively affects sustainable learning and academic performance. The authors discuss the implications of these findings for the design and implementation of e-learning services in

educational institutions, emphasizing the need for a user-centered approach and ongoing evaluation of effectiveness. The study provides insights into the potential of e-learning to support sustainable and effective learning.

El-Sofany and El-Haggar (2020) in their paper [50] conducted a study to investigate the effectiveness of using mobile learning techniques to improve learning outcomes in higher education. They reviewed previous studies and found that mobile learning can positively impact learning outcomes in higher education, especially when combined with traditional classroom instruction. The authors suggest that the use of mobile learning techniques can provide students with flexible and personalized learning experiences, increase their motivation and engagement, and enhance their knowledge retention and critical thinking skills. However, they also note that the success of mobile learning depends on several factors, such as the quality of instructional design, the usability of the mobile devices and apps used, and the support provided to students and instructors. Totally, the authors conclude that mobile learning can be an effective tool for improving learning outcomes in higher education, but its implementation should be carefully planned and evaluated.

A case study has been conducted in order to investigate the impact of emergency remote teaching on students' academic performance in higher education during the COVID-19 pandemic [51]. Authors analyzed the grades of 1,670 students from a Spanish university before and after the transition to emergency remote teaching. The study found that, in general, students' grades decreased after the transition to emergency remote teaching. However, the authors also found that the decrease in grades was more significant for students with lower academic performance before the pandemic and for courses with a higher level of difficulty. Additionally, the authors found that students who participated more actively in the online activities and had access to more resources, such as online tutoring and communication with instructors, had better academic performance. The authors suggest that instructors and universities should take into account the differential impact of emergency remote teaching on students and provide appropriate support to mitigate its negative effects.

### 3.1 Metrics for Assessing the Impact of IoT on Academicians' Performance

The utilization of standardized college entrance metrics to predict undergraduate student success in chemistry has been investigated [52]. The authors analyzed the academic performance of 844 students enrolled in first-year chemistry courses at a large public university in the United States. They examined the correlation between students' standardized test scores, including ACT and SAT scores, and their performance in chemistry courses, such as final grades and course completion rates. The study found that standardized test scores were predictive of students' performance in chemistry courses, particularly in terms of their final grades. The authors also found that other factors, such as gender and high school chemistry coursework, were significant predictors of student success in chemistry. The authors suggest that the use of standardized test scores in combination with other factors can be a useful tool for predicting student success in chemistry courses and informing targeted interventions to support students who may be at risk of poor performance. They also emphasize the need to consider the limitations of standardized test scores and to use multiple measures to assess student performance and potential.

In [53], student success metrics at a transfer-friendly institution in a New Directions for Teaching and Learning article has been discussed. The authors highlight the importance of transfer students in higher education and the need to measure their success using appropriate metrics. They present a case study of a community college in the United States that implemented a comprehensive student success initiative that

focused on transfer students. The initiative involved several strategies, such as the development of transfer pathways, academic advising, mentoring, and student engagement activities. The authors present data showing that the initiative had a positive impact on transfer student success, including increases in transfer rates, degree completion, and retention rates. The authors suggest that the success of the initiative was due to a collaborative effort among faculty, staff, and administrators, a focus on data-informed decision-making, and a commitment to continuous improvement. They conclude that transfer-friendly institutions should adopt a comprehensive approach to student success and use appropriate metrics to measure their impact.

Authors in [54] have conducted a meta-analysis of literature on the application of machine learning in higher education to assess student academic performance, at-risk, and attrition. The authors reviewed 109 studies published between 2010 and 2020 that used machine learning techniques to predict student performance, identify at-risk students, and reduce student attrition. The study found that machine learning techniques can be effective in predicting student performance and identifying at-risk students with high accuracy. The authors also identified several factors that influence the effectiveness of machine learning models, including the quality and quantity of data, the choice of machine learning algorithm, and the interpretation and use of model results. The study also found that interventions based on machine learning models, such as personalized support and targeted interventions, can be effective in improving student success and reducing attrition rates. The authors suggest that the use of machine learning techniques in higher education can provide valuable insights into student performance and inform the development of targeted interventions to support students who may be at risk of academic failure or attrition. They emphasize the need for transparency and ethical considerations in the use of machine learning models and the importance of involving students in the design and implementation of interventions based on these models.

### 3.2 Evaluating the Effectiveness of IoT-Based Educational Services on Academic Outcomes

In [11], the authors have used data science methods to assess the educational performance of different school cycles in Brazil. The authors collected data from 5,571 schools across the country and analyzed it using machine learning and network analysis techniques. The study found that different school cycles, including elementary, middle, and high school, have distinct patterns of educational performance. The authors identified several factors that influence educational performance, including school size, location, and socioeconomic status. Additionally, the authors found that schools with higher levels of educational performance tend to have stronger connections with other schools and organizations, such as universities and community groups. The authors suggest that the use of data science methods can provide valuable insights into educational performance and inform the development of policies and interventions to improve the quality of education in Brazil. The authors also emphasize the importance of considering the social and economic context in which schools operate and the need for collaborative efforts to address educational inequalities.

### 3.3 Factors that Influence the Adoption and Use of IoT in Education

To identify the factors that contribute to the success of IoT services in academic libraries and their impact on performance, a study was conducted [55]. The authors conducted a survey of 235 academic participants from Pakistan and analyzed the data using structural equation modelling. The study found that factors such as librarians' leadership, staff skills, infrastructure, security, and user involvement significantly influence the success of IoT services in academic institutes. The authors also found that the success of IoT services positively impacts related performance, including user satisfaction, usage, and efficiency. Additionally, the

authors suggest that the implementation of IoT services in academic institutes can improve access to information resources, enhance the related services, and increase the visibility and relevance of academic colleges. The authors conclude that academic institutes should invest in IoT services and focus on the factors that contribute to their success to improve the related performance and meet the changing needs of users. This study is implemented in an academic environment but it is applied on librarians and other associated staff for library related services.

The paper described in [56] has presented a paper on the development of an attendance and information system for the academic sector using RFID and web-based applications in the International Journal of Advanced Computer Science and Applications. The authors developed a system that uses radio-frequency identification (RFID) technology to track student attendance and store information in a database. The system also includes a web-based application that allows faculty members to access real-time attendance records and track student performance. The study found that the system was effective in improving attendance and reducing absenteeism rates, which can have a positive impact on student academic performance. The authors suggest that the use of RFID technology in combination with web-based applications can provide an efficient and reliable way to track student attendance and monitor student performance in the academic sector. They also highlight the potential of the system to enhance student engagement and learning outcomes by providing faculty members with timely and accurate information on student attendance and performance.

The adoption and use of IoT in education can be influenced by several factors. Understanding these factors is crucial for successful implementation. The availability and robustness of the technological infrastructure play a significant role in IoT adoption. As presented by [57], educational institutions need to have reliable and high-speed internet connectivity, as well as the necessary hardware and software infrastructure to support IoT devices and systems . The resources required for IoT implementation can be a determining factor. The cost of IoT devices, sensors, connectivity, and maintenance can impact adoption. Thus, institutions need to assess their budgets and determine the feasibility of investment in IoT technologies. Concerns over data security and privacy can influence the adoption of IoT in education. They need to address these concerns by implementing robust security measures and ensuring compliance with privacy regulations to gain the trust of educators [58]. Providing adequate training and professional development opportunities for educators is crucial for their effective integration of IoT into teaching practices. Educators need to understand how IoT can enhance education experiences, and how it aligns with their instructional strategies and curriculum objectives [59]. The scalability and sustainability of IoT implementations are important considerations. Institutions need to assess the long-term viability and scalability of IoT solutions, including factors such as device management, system upgrades, and ongoing technical support. The policy and regulatory environment can impact IoT adoption in education, institutions need to understand and comply with relevant regulations, guidelines, and standards related to data protection, privacy, and educational technology implementation.

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The paper presented in (Asad, Naz et al. 2022) aims to investigate the impact of IoT-based smart laboratories on students' academic performance in higher education. The study involved the implementation of IoT-based smart laboratories in a university in Saudi Arabia, where students' academic performance was measured using their final grades. The authors found that the implementation of IoT-based smart laboratories had a positive impact on students' academic performance, as indicated by an improvement in their final grades. The study also identified several factors that contributed to the success of the IoT-based smart laboratories, including ease of use, accessibility, and availability of resources. The authors suggest that the use of IoT-based smart laboratories in higher education can provide an innovative and effective way to enhance students' learning experiences and improve their academic performance. They also emphasize the need for further research to explore the potential of IoT-based smart laboratories in different educational settings and to evaluate their impact on student learning outcomes.

The impact of using smartphones on the academic performance of undergraduate students has been investigate by (Ifeanyi and Chukwuere 2018). The study involved a survey of 310 undergraduate students from two universities in Nigeria, and the data collected was analyzed using descriptive statistics and regression analysis. The authors found that there is a significant relationship between the use of smartphones and academic performance, with students who use smartphones having better academic performance than those who do not. The study also found that the frequency and duration of smartphone use significantly influenced academic performance, with moderate usage being associated with better academic performance than excessive or limited usage. However, the authors caution that the use of smartphones in class should be regulated to avoid distractions and to promote active engagement in the learning process. The study provides insights into the potential benefits of smartphone use in promoting academic performance, but also highlights the need for responsible use to avoid negative impacts.

The paper by (Bagheri and Movahed 2016) explores the potential impact of the IoT on the education business model. The authors discuss the concept of IoT and its potential to transform various industries, including education. They argue that IoT can enhance the learning experience by providing access to a vast amount of data and enabling personalized learning. Additionally, IoT can improve the operational efficiency of educational institutions by automating administrative tasks and facilitating communication between students, teachers, and administrators. The authors propose a model for integrating IoT into the education business model, which includes the use of sensors and devices to collect data on student behavior and learning outcomes, the analysis of this data to personalize the learning experience, and the development of new revenue streams based on IoT-enabled services. The paper also has highlights the potential of IoT to transform the education sector and offers a framework for leveraging IoT to improve educational outcomes and drive innovation in the industry.

The paper presented by (Francisti, Balogh et al. 2020) has provided a review of the literature on the application of IoT devices in education, with a focus on their potential to enhance the learning experience and improve educational outcomes. The authors discuss the use of various IoT devices, including sensors, wearables, and smart objects, in different educational settings, such as classrooms, laboratories, and outdoor environments. They highlight the benefits of IoT devices, such as real-time data collection, personalized learning, and increased student engagement. The paper also addresses the challenges associated with the use of IoT devices in education, such as privacy concerns, technical issues, and the need for effective data management and analysis. The authors conclude that IoT devices have the potential to transform education by providing new opportunities for teaching and learning and enabling a more personalized and interactive learning experience. They suggest that further research is needed to address the challenges associated with the use of IoT devices in education and to fully realize their potential in the field.

A new interaction system based on the IoT for educational purposes has been propoed by (Gómez, Huete et al. 2013). The system aims to enhance the educational process by providing a more interactive and dynamic environment. The system utilizes sensors and actuators to monitor and control different aspects of the educational process, such as attendance, performance, and behavior. The proposed system provides a more personalized and adaptive learning experience for students and allows teachers to have a better understanding of students' needs and progress. The paper also presents a case study where the proposed system was implemented and evaluated in a real educational environment. The results showed that the system had a positive impact on students' engagement and learning outcomes.

By creating an E-Learning-based IoT adoption Model, the research study (1) investigated the important factors that affect the adoption of IoT in E-Learning within higher learning institutions in developing countries. These factors were classified into four groups: individual, organizational, environmental, and technological. The outcomes of this study will provide valuable insights for educational authorities and government entities to understand and address these factors. Consequently, they can make informed decisions regarding the implementation of IoT in education, ultimately leading to improved educational outcomes of high quality, figure.

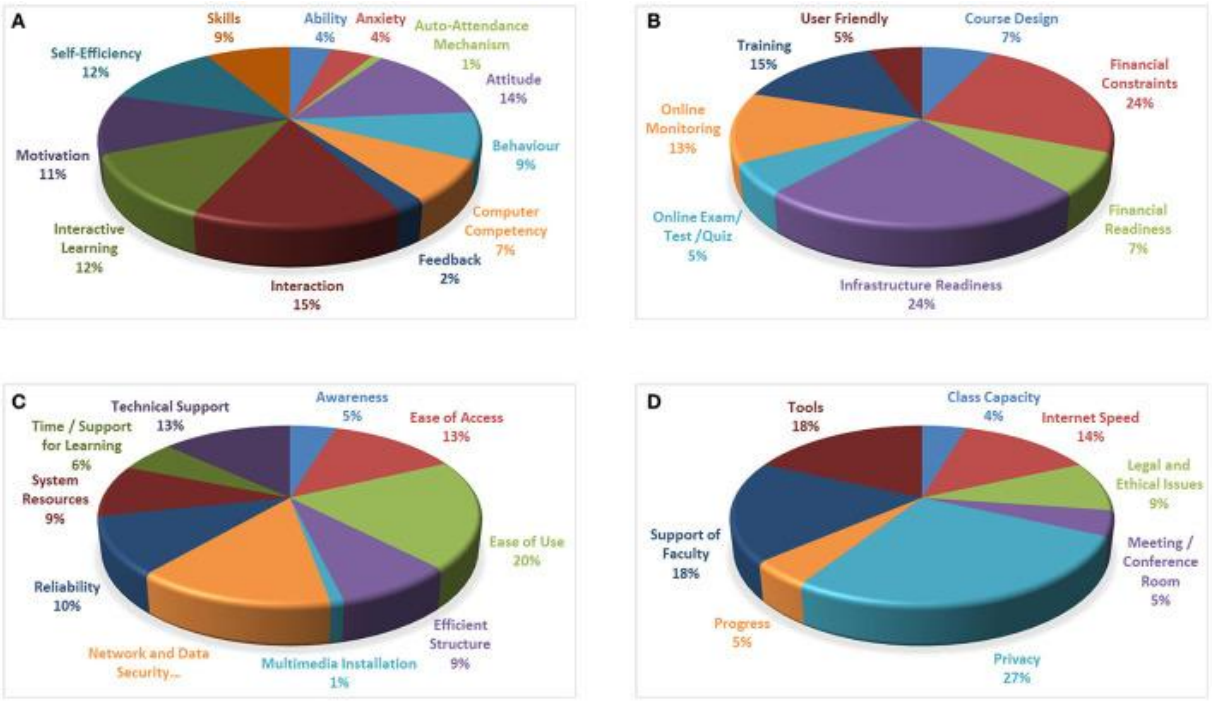


**Figure 3**: Percentage of E-Learning influencing factors for IoT adoption in HEIs. (A) Individual factors. (B) Organizational factors. (C) Technological factors. (D) Environmental factors. Source (Madni, Ali et al. 2022).

## 4. Main factors influencing the academic performance of academicians in CS colleges

Educational institutions, including computer science colleges, are exploring the adoption of IoT-related services to enhance academic performance and improve educators' effectiveness. This literature review provides an overview of relevant studies that have investigated the factors influencing the successful implementation and utilization of IoT-related services among academicians, as well as the impact of these services on their academic performance.

### 4.1 Factors Influencing Adoption and Utilization of IoT-Related Services

Several studies have explored the factors that influence educators' adoption and utilization of educational IoT-related services. Perceived usefulness, identified as a critical factor, has been found to positively impact educators' intentions to use IoT technologies [60, 61]. Ease of use is another crucial factor influencing the adoption of technology in education. Additionally, self-efficacy, the belief in one's capability to utilize technology effectively, has been identified as a significant predictor of technology adoption and usage [62, 63]. Moreover, social influence, including peer support, organizational culture, and administrative encouragement, plays a vital role in shaping educators' attitudes towards technology adoption [63].

### 4.2 Impact of IoT-Related Services on Academic Performance:

The literature provides evidence of the impact of educational IoT-related services on the academic performance of academicians in computer science colleges. the integration of IoT technologies in classrooms enhances student engagement, knowledge retention, and collaborative learning experiences is preferable. Furthermore, IoT-based adaptive learning platforms have been linked to improved learning outcomes and personalized learning experiences for students. In terms of research productivity, IoT-enabled data collection and analytics have been lauded for their potential to facilitate data-driven research in various fields. Moreover, educators' utilization of IoT services has been associated with improved teaching effectiveness and innovative pedagogical practices [16].

## CONCLUSION

The impact of educational IoT-related services on academicians' performance in computer science colleges is a topic of significant importance. Through the review of various primary research studies, academic papers, and reports, this study has shed light on the factors influencing the effectiveness of IoT-related services in education. It has been found that factors such as the availability of technological infrastructure, the quality of training and professional development programs for academicians, and the establishment of robust data security and privacy measures play a crucial role in determining the impact of IoT on academic performance. The findings of this study emphasize the potential benefits and challenges associated with the implementation of IoT technologies in computer science colleges. It is clear that when properly integrated and supported, educational IoT-related services have the potential to positively transform teaching and learning practices, enabling academicians to enhance their performance and improve the educational experience for students. However, the successful implementation of IoT technologies in computer science colleges requires careful consideration of these factors and a comprehensive approach to addressing potential challenges. This includes investing in the necessary technological infrastructure, providing adequate training and professional development opportunities for academicians, and ensuring robust data security and privacy measures are in place.

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## AUTHOR CONTRIBUTION

Experimental design; Shi Ruixuan; Article Writing; Shi Ruixuan; Supervising: Sharipah Ruzaina Syed Aris

## CONFLICT OF INTEREST

Authors declare no conflict of interest.

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