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Challenges of IoT integration in education: A case study of students at Al-Zaytoonah University of Jordan

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ABSTRACT

This study investigated the challenges university students face when using the Internet of Things (IoT) in education at Al-Zaytoonah University of Jordan. It also examined whether these challenges varied by gender and college affiliation. The research was conducted during the second semester of the 2023-2024 academic year with a randomly selected sample of 200 students from different colleges and academic levels. Data were collected through a structured questionnaire distributed electronically via the university's e-learning platform (Moodle). The findings highlighted significant challenges, such as technical problems, inadequate infrastructure, lack of training, security risks, and issues with the reliability of IoT-based assessments. The challenges differed based on gender and college type: male students and those in scientific colleges reported more issues related to infrastructure, security, and assessment reliability, while female students and those in humanities colleges identified more technical difficulties. The study emphasizes the importance of addressing these challenges to successfully integrate IoT technologies into education.

1. Introduction

The rapid expansion and integration of Internet of Things (IoT) devices have propelled the need for scalable, secure, and manageable network infrastructures. Recent reports indicate that there are over 25 billion IoT devices currently in use, with projections estimating over 75 billion devices by 2025 (Alam, 2018). This massive growth has exposed the limitations of traditional IoT architectures that are rigid, siloed, and ill-equipped to handle complex integrations (Kanan et al., 2023). Virtualization technology offers a promising approach to address the intricate challenges in IoT systems. By creating virtual machines and instances, virtualization provides greater flexibility, security, and efficiency to IoT infrastructures (Pan and McElhannon, 2017).

IoT refers to the network of physical objects embedded with sensors, software, electronics, and connectivity that allow them to connect, exchange data, and interact over the internet (Abualkishik et al., 2023). The key components of IoT include intelligent devices, communication networks, service interfaces, and data processing centers. Through IoT, devices can monitor events, gather data, analyze information, and initiate actions to enable advanced automation, analytics, and integration across machines, systems, and industries. However, traditional IoT architectures with dedicated hardware and pre-programmed functions can be inefficient in managing different devices, protocols, and massive amounts of data.

Virtualization refers to the abstraction and pooling of physical resources to support virtual instances and components. It provides a layer of software that separates the physical hardware from the virtual systems to enable flexible management and optimal utilization (Al-Babtain et al., 2020).

Traditionally, essential network functions like firewalls, proxies, and Deep Packet Inspections (DPIs) have been integrated into specialized hardware known as middle-boxes. However, middle-boxes are typically costly, specific to vendors, and

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fixed in location, making it difficult to manage resources dynamically and adapt flexibly (Hnaif et al., 2024).

Recently, the concept of network function virtualization (NFV) was introduced with the goal of enhancing flexibility in network service delivery and speeding up the introduction of new services. Through the utilization of virtualization technologies and readily available programmable hardware, such as general-purpose servers, storage, and switches, NFV separates the software implementation of network functions from the underlying hardware (Alam et al., 2020).

Besides, NFV is emerging as an attractive solution that shifts intricate network functions from dedicated hardware setups to software instances operating in a virtualized setting. Recognized for its numerous benefits, including flexibility, efficiency, scalability, rapid deployment cycles, and service upgrades, NFV is widely acknowledged as the paradigm for the next generation of network service provisioning. In NFV, the desired service is executed through a series of Virtual Network Functions (VNF), which can operate on generic servers by leveraging virtualization technology. These VNFs are organized in a predefined sequence through which data flows traverse, known as Service Function Chaining (SFC) (Alshehadeh et al., 2024).

Virtualization creates virtual IoT nodes, networks, and services using the same physical infrastructure leading to greater interoperability, automation, and reliability. Researchers have identified virtualization as a breakthrough technology in realizing the vision for scalable, adaptive, and cost-effective IoT systems (Chiphiko and Kim, 2023).

Integrating virtualization can address several limitations of traditional IoT architectures. First, it enables more efficient utilization of the underlying physical resources through on-demand provisioning and consolidation. Second, it supports real-time data processing and analytics by dynamically allocating resources based on application needs. Third, it improves security and isolation by logically separating applications, data, and tenants on shared infrastructure. Finally, it allows simplified management and control of diverse systems through software abstractions. However, fully realizing the potential of virtualization faces certain technical and adoption challenges. Hypervisor overhead, performance issues, and complex integrations can limit effectiveness in IoT environments. Lack of standardization and costs of redesigning legacy systems also inhibit uptake (Ramakrishnan et al., 2020).

The rapid expansion of the IoT has led to a surge in internet-connected smart devices, resulting in extensive data issues within traditional cloud computing models. Problems such as bandwidth overload, slow response times, inadequate security, and compromised privacy have become apparent. Traditional cloud computing is no longer sufficient to provide for the diverse demands of today's intelligent society for data processing. Cloud-based big data processing, due to the continuous and massive growth of data volume and varied processing requirements, exhibits several shortcomings. In terms of real-time processing, the transmission of large amounts of data from numerous edge devices to the cloud leads to increased intermediate data transmission, reduced data transmission performance, and delays. This is particularly problematic in scenarios requiring real-time feedback, such as traffic monitoring, where cloud computing falls short of meeting business real-time requirements (Alhoul et al., 2023; Al-Dwairi and Jditawi, 2022).

The main objective of this research is to identify the challenges facing university students when using the IoT in the educational process by answering the following questions:

- Are there any differences in the challenges facing university students when using the IoT in the educational process due to gender variables?
- Are there any differences in the challenges facing university students when using the IoT in the educational process due to college variables?

The structure of this paper is organized as follows. Section 2 presents a review of related works. Section 3 explains the research methodology. Finally, Section 4 presents the results of this research and their analysis, and Section 5 concludes the conclusions of this research.

2. Literature survey

The integration of virtualization technologies in IoT networks has attracted significant research interest in recent years. This literature review summarizes key studies exploring the applications, benefits, and approaches for using IoT in education.

Chopra and Arora (2023) discussed the integration of IoT in higher education to maximize benefits and minimize risks. It emphasizes leveraging IoT technologies to enhance the learning experience and educational outcomes. The research paper explored novel methodologies for minimizing risks associated with IoT implementation in higher education. It likely delves into strategies such as data encryption, network security protocols, and user authentication mechanisms to safeguard sensitive information and ensure the integrity of educational processes. Also, it discussed how institutions can leverage data analytics tools to extract valuable insights, improve decision-making processes, and enhance overall educational quality.

In addition, Kolhe (2022) introduced a systematic review methodology to explore IoT concepts. By analyzing scholarly research papers, corporate white papers, and engaging in professional discussions with experts, the study ensures a comprehensive understanding of IoT definitions, requirements, characteristics, and aliases. The paper specifically delves into the challenges faced by the education

sector in adopting IoT technologies. This targeted approach allows for a detailed examination of the unique obstacles and opportunities present in integrating IoT into educational settings. The paper provides an overview of how IoT works and highlights vital technologies associated with IoT applications in daily life. This approach helps readers grasp the fundamental principles behind IoT and its practical implications.

Potter et al. (2024) presented a novel approach by proposing a four-layer IoT security framework. This framework aims to address security threats at the perception, network, and service levels within the IoT infrastructure. The research emphasized the importance of data integrity and authentication in IoT security. It highlights the need for ensuring data accuracy and verifying the legitimacy of information sources to mitigate security risks. The authors suggested a proactive approach to IoT security by emphasizing the regular updating of IoT devices. Automated renewals for authorized updates from system vendors are recommended to address potential security vulnerabilities and prevent unauthorized access.

While Kolhe (2022) obtained a novel approach by integrating blockchain technology into IoT systems. This integration enhances security and transparency by creating a decentralized and tamper-proof ledger for IoT data transactions. The research paper employs machine learning algorithms as a novel methodology to analyze IoT data. By leveraging machine learning, the study aims to extract valuable insights, detect patterns, and improve decision-making processes in IoT applications. The paper explored the concept of edge computing as a novel approach in IoT systems. By processing data closer to the data source at the network edge, edge computing reduces latency, enhances efficiency, and improves real-time decision-making in IoT environments (Jebril et al., 2024).

With three potential applications to be merged with students' progressive assessment, the integration of current teaching platforms, and the development of educational middleware—higher education offers a great opportunity to develop technology. It is difficult to integrate IoT in the context of higher education since not all the systems that were in place before now match the standards for IoT integration (Al-Omari et al., 2024; Derbas et al., 2023).

Several of the IoT designs are sophisticated enough to meet the requirements of applications that facilitate user experience. Every suggested architecture that is put forth includes the first five major IoT idea layers. This indicates that IoT architecture design is getting more sophisticated to benefit users in an environment of higher learning. One of the best sectors to implement IoT technologies is seen to be education. This review study's primary goal is to present an overview of the IoT architecture that is appropriate for usage in higher education, along with a comprehensive perspective on the use of IoT applications. Building an IoT-based learning framework has been shown to be effective in numerous studies that have been proposed and conducted. Such a move aids in the development of a new paradigm for education. The teaching and learning process is enhanced by this cutting-edge learning paradigm (Soegoto et al., 2022).

Qushtom et al. (2023) argued that accounting students in Jordanian universities perceive e-learning systems as ineffective for teaching scientific and humanities disciplines, hindering the development of practical skills necessary for the accounting profession. In addition, the lack of complete and appropriate technological infrastructure is identified as a key barrier to the effectiveness of e-learning in providing practical skills to accounting students. Moreover, issues such as the limited experience of lecturers in using technology, lack of direct interaction between students and lecturers, and technical problems during e-learning lectures contribute to the ineffectiveness of e-learning in enhancing practical skills. As a result, the paper underscored the importance of evaluating e-learning systems regularly, creating effective mechanisms for testing students' skills and enhancing lecturer and student technological competencies to improve the effectiveness of e-learning in providing practical skills to students.

Several studies have provided a thorough review of IoT education identified best practices, and offered practical strategies for educators to enhance STEM education through IoT technologies (Abichandani et al., 2022). In addition, Khan et al. (2022) donated the understanding of how IoT can be harnessed to improve educational outcomes, enhance operational efficiency, and create a more engaging learning environment.

Chawla et al. (2021) used IoT in education by enabling real-time data collection and analysis, improving decision-making, student monitoring, and integrating technology into teaching, ultimately boosting learning outcomes and campus safety. Besides, Wambuaa and Oduorb (2022) used IoT to enhance educational activities by integrating interconnected devices, promoting inclusive and equitable learning experiences, particularly for students with disabilities, despite its adoption being in the early stages. As well, Laoha et al. (2019) discussed digital activity portfolio system architecture to enhance student learning via IoT technology (Wambuaa and Oduorb, 2022; Shamsan and Faridi, 2022).

3. The proposed method

The integration of virtualization techniques with IoT is the most crucial step to enable flexible management and optimal utilization of resources. This paper identifies the challenges facing university students when using the IoT in the educational process. In this paper, a survey was performed on a group of 200 students from Al-Zaytoonah University

of Jordan, who were chosen randomly from the second semester of the academic year 2023-2024 as shown in Table 1. A structured questionnaire was used to collect primary data. The survey included two parts. First, the demographic information section consists of three main questions: respondents' gender, college, and academic level. Then, the following section includes six questions about challenges facing university students when using the IoT in the educational process. The authors prepared a questionnaire by referring to some studies, presenting them to a group of arbitrators, and coming up with the final version of the questionnaire, then distributed it through the e-learning system (Moodle), to bachelor's students and they could fill out the questionnaire electronically. The study relied on the analytical descriptive approach using appropriate statistical analyses for the study.

4. Results, technical challenges and solutions

The data in Table 1 indicates that 65% of the respondents were male respondents compared to 44% of male respondents. The percentage of students from scientific colleges reached 68%, and from humanities colleges, the percentage reached 32%. The students were distributed according to the academic year: 17% of them were first-year students, 23% were second-year students, 24% were third-year students, and 36% were fourth-year and above students.

Table 2 summarizes the responses of male and female students at Al-Zaytoonah University of Jordan regarding the challenges of using IoT in education. In terms of experiencing technical difficulties or limitations when using IoT devices for learning, 88% of male and 81% of female respondents reported no difficulties. Regarding the adequacy of the university's infrastructure to effectively integrate IoT technologies, 92% of male and 82% of female respondents agreed that the infrastructure was sufficient. The percentage of respondents who felt they had received adequate training on using IoT devices was similar for both genders, with 50% of males and 51% of females reporting adequate training. When asked whether IoT technologies enhance the learning experience by providing interactive environments, 86% of male and 83% of female respondents agreed. However, concerns about new IoT connections introducing vulnerabilities to cyber-attacks were higher among male respondents (96%) compared to female respondents (80%). Lastly, challenges related to ensuring the reliability of IoT-based assessments were reported by 93% of male and 88% of female respondents.

Table 1: Demographic profile

Variables	Levels	Frequency	Percentage
Gender	Male	112	56
	Female	88	44
College	Scientific	136	68
	Humanity	64	32
Academic level	First-year	34	17
	Second-year	46	23
	Third year	48	24
	Fourth-year and above	72	36

Table 2: Distribution of the students surveyed about the challenges of using the IoT in education from their point of view according to the gender variable

Paragraph	Male				Female			
	Agree		Disagree		Agree		Disagree	
	F	P	F	P	F	P	F	P
Have you experienced any technical difficulties or limitations while using IoT devices for learning?	13	12%	99	88%	17	19%	71	81%
Do you believe your university has sufficient infrastructure to effectively integrate IoT technologies into the learning environment?	103	92%	9	8%	72	82%	16	18%
Students have received adequate training on how to effectively use IoT devices for educational purposes	55	50%	57	50%	45	51%	43	49%
IoT technologies can enhance university students' learning experiences by providing interactive learning environments	96	86%	16	14%	73	83%	15	17%
New IoT connections introduce new vulnerabilities to potential cyber-attacks	107	96%	5	4%	70	80%	18	20%
Students encounter challenges in ensuring the reliability of IoT-based assessments	104	93%	8	7%	77	88%	11	12%

F: Frequency; P: Percentage

Table 3 presents the responses of students at Al-Zaytoonah University of Jordan regarding the challenges of using IoT in education, based on their college affiliation. Regarding technical difficulties or limitations when using IoT devices for learning, 81% of students from humanities colleges reported difficulties compared to only 3% from scientific colleges. For the adequacy of infrastructure to support IoT integration, 90% of students from scientific colleges and 78% from humanities colleges agreed that the infrastructure was sufficient. In terms of receiving adequate training on using IoT devices, 43% of students from scientific colleges and 16% from humanities colleges reported receiving sufficient training. Regarding the enhancement of learning experiences through interactive environments provided by IoT, 92% of scientific college students and 94% of humanities college students agreed. Concerns about new IoT connections introducing vulnerabilities to cyber-

attacks were reported by 96% of students from scientific colleges and 83% from humanities colleges. Lastly, challenges related to the reliability of IoT-based assessments were noted by 97% of students from scientific colleges and 86% from humanities colleges.

Table 3: Distribution of the students surveyed about the challenges of using the IoT in education from their point of view according to the college variable

Paragraph	Scientific colleges				Humanities colleges			
	Agree		Disagree		Agree		Disagree	
	F	P	F	P	F	P	F	P
Have you experienced any technical difficulties or limitations while using IoT devices for learning	4	3%	132	97%	52	81%	12	19%
Do you believe your university has sufficient infrastructure to effectively integrate IoT technologies into the learning environment?	122	90%	14	10%	50	78%	14	22%
Students have received adequate training on how to effectively use IoT devices for educational purposes	58	43%	78	57%	10	16%	54	84%
IoT technologies can enhance university students' learning experiences by providing interactive learning environments	125	92%	16	8%	60	94%	4	6%
New IoT connections introduce new vulnerabilities to potential cyber-attacks	130	96%	6	4%	53	83%	11	17%
Students encounter challenges in ensuring the reliability of IoT-based assessments	132	97%	4	3%	55	86%	9	14%

The technical challenges can be divided into four main issues: infrastructure limitations, security vulnerabilities, reliability of IoT-based assessments, and insufficient training. A study conducted at Al-Zaytoonah University of Jordan identified that insufficient infrastructure was a major concern for students when integrating IoT technologies. This includes problems such as limited network capacity, poor Wi-Fi coverage, and outdated hardware incompatible with IoT devices. The study also emphasized that new IoT connections create additional risks of cyber-attacks, which were particularly concerning for male students and those in scientific disciplines. Furthermore, students from all groups reported difficulties in ensuring the reliability of IoT-based assessments, such as device malfunctions during exams or worries about data accuracy. Lastly, only about half of the students believed they had received adequate training in using IoT devices for educational purposes.

The proposed solutions are as follows: universities should prioritize upgrading their network infrastructure to handle the increased data traffic from IoT devices. This includes expanding Wi-Fi coverage, increasing bandwidth, and ensuring reliable campus-wide connectivity. Strong cybersecurity measures, such as device authentication, data encryption, and regular security audits, must also be implemented, along with educating users on IoT security best practices. Standardized protocols for IoT-based assessments should be developed to ensure reliability and fairness, including backup systems, clear device-use guidelines during exams, and measures to prevent cheating. Finally, comprehensive training programs for both students and faculty are essential to address the issue of inadequate training in using IoT devices effectively in education.

5. Conclusion

The research results highlight challenges faced by university students at Al-Zaytoonah University of Jordan in using IoT in education, influenced by gender and college affiliation. For gender-based differences, male students reported sufficient infrastructure for IoT integration, concerns about new IoT connections introducing vulnerabilities to cyber-attacks, and challenges in ensuring the reliability of IoT-based assessments. Female students, on the other hand, primarily highlighted challenges in ensuring the reliability of IoT-based assessments, while also noting that IoT technologies enhanced their learning experiences and that the university infrastructure was adequate for IoT integration.

Regarding college affiliation, students from scientific colleges reported sufficient infrastructure for IoT integration, concerns about new vulnerabilities introduced by IoT connections, and challenges with IoT-based assessment reliability. They also reported minimal technical difficulties when using IoT devices for learning. Students from humanities colleges, however, reported higher rates of technical difficulties but also noted that IoT technologies enhanced their learning experiences and faced similar challenges with the reliability of IoT-based assessments.

5.1. Applications and recommendations

The integration of IoT technologies in higher education offers numerous potential applications and benefits but also presents challenges that need to be addressed. Based on the study conducted at Al-Zaytoonah University of Jordan, several recommendations can be made to improve IoT adoption in educational settings. First, universities should invest in robust infrastructure to support IoT integration, as both male and female students identified this as a key factor. Particular attention should be paid to scientific colleges, where infrastructure needs are more pronounced. Second, comprehensive training programs should be developed for both students and faculty on effectively using IoT devices and systems for educational purposes, as the study revealed a significant gap in this area. Third, to address security concerns, especially among male students and those in scientific colleges, universities should implement strong cybersecurity measures and educate users on best practices for safe IoT usage. Fourth, efforts

should be made to enhance the reliability and validity of IoT-based assessments, as this was a common concern across all student groups. Finally, universities should explore ways to leverage IoT technologies to create more interactive and engaging learning environments, as students recognize this potential benefit.

By addressing these areas, higher education institutions can harness the power of IoT to enhance the learning experience, improve educational outcomes, and better prepare students for a technology-driven future. Ongoing evaluation and adaptation of IoT integration strategies will be crucial to ensure their effectiveness and relevance in the rapidly evolving landscape of educational technology.

Compliance with ethical standards

Ethical considerations

Informed consent was obtained from all participants, and their anonymity and data confidentiality were maintained throughout the study.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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