

## **Internet of Things in Education: Teachers' Perspectives, Practices and Challenges**

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*Abstract:* - The current study aims to detect the level of challenges facing teachers in applying the Internet of Things (IoT) in the educational process. It also investigates the teachers' perceptions regarding the importance of using IoT in the educational process. This study adopts a quantitative approach to analyze the use of IoT amongst Saudi secondary school teachers. The study recruited (142) teachers in schools in the Riyadh region. A questionnaire with (26) Likert Scale items was distributed electronically to the participants. Results indicated that Saudi teachers still face high challenges in applying IoT in teaching and learning, they also report a high importance of using IoT. Results also showed that specialization, year of service, and the training technical

programs played a significant role in the perceptions of Saudi teachers. Specifically, computer science teachers have less challenge in applying IoT when compared to teachers from other specializations. Furthermore, the study showed that teachers with less experience had higher means, indicating their enthusiasm for utilizing modern technological tools in education. Finally, the study showed that teachers who had completed more technical training programs had less difficulty in applying IoT. The study recommends integrating IoT technologies into the educational system. It also proposes conducting research to standardize IoT applications for different teaching materials and all levels of schooling.

*Key-Words:* - Challenges, Communications Network, Education, Importance, Internet of Things, Practices, Computing Systems, Importance of IoT.

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## 1 Introduction

We are currently witnessing a substantial revolution in information and technology that has deeply influenced our daily lives. The technological revolution has transformed various fields. It brings up new opportunities for development. Beginning with the era of computing and personal computers in the 1980s and 1990s, and evolving into the mobile era with the launch of the iPhone in 2007, computing has entered a new phase. Internet technology has progressed, making communication and interaction among individuals easier, [1], [2]. The rapid evolution of internet usage has opened up new chances for incorporating the internet into our daily lives, making smart devices interact more easily with each other. The main goal is to create an improved reality where individuals can communicate and interact with devices and tools based on their preferences and needs, without the constraints of physical presence in a specific time or location, [3].

Upon initial examination, it is evident that the concept of internet-connected devices or things has given rise to a new iteration of the internet, leading to a greater dependence on it. This allows anything to be connected to the internet and imbued with intelligence. Connected devices are capable of communication, information sharing, exchange, processing, and even decision-making. This concept is known as the Internet of Things (henceforth, IoT), which is seen as the imminent major technological frontier that will pave the way for a revolution in various areas of our lives, [4].

IoT refers to the emerging and evolving new generation of information and communication technologies that enhance the ability of physical objects and machines to connect and exchange data

through internet connectivity, [5], [6]. This development provides high-quality systems and technologies that increase productivity, create modern business, industrial, and educational models, generate new sources of income, and represent the most significant features of the Fourth Industrial Revolution. The IoT has great potential to integrate all aspects of natural and digital life in fields such as commerce, industry, medicine, agriculture, and education, which has had a profound impact on changing the current lifestyle. Similar to the previous three industrial revolutions, the IoT is changing the pattern of human life, [7], [8].

The benefits of employing IoT in education include personalized learning experiences, improved classroom management, and increased efficiency in administrative tasks. The Intentional Conference on IoT proposes the incorporation of IoT into learning institutions as such integration develops learning outcomes and equips students with skills required for the digital future. Nevertheless, such integration is not without potential challenges, including privacy concerns, security as well as the necessity for adequate infrastructure and educator training, [9]. In Arab countries, including Saudi Arabia, there is a growing interest in using IoT in education, but there are still obstacles that hinder its widespread adoption. Overall, the use of IoT in education has the potential to improve learning outcomes and the quality of the educational process by providing real-time data and personalized support for learners.

Based on the recommendations of the World IoT Conference held in Saudi Arabia in December 2019, which focused on the significance of employing IoT in the educational process, and due to the rapid progress in the information and technological revolution in the field of education. Furthermore, the

lack of studies that have examined the importance of using IoT in education in Arab countries in general, and Saudi Arabia in particular. Still, the urgent need to update the skills, experiences, and orientations of students to enable them to deal with the information and technological revolution in education. All these factors urged the researcher to bridge such a gap by detecting the level of importance and challenges that Saudi teachers have while utilizing IoT and using it in different educational environments significantly contributes to the quality of the educational process and improves learning outcomes. Therefore, this study is important to answer the questions:

- RQ1.** What is the level of challenges facing Saudi teachers in applying IoT in the educational process?
- RQ2.** To what extent do Saudi teachers perceive the significance of using IoT in the educational process?
- RQ3.** Are there statistically significant differences in teachers' perspectives about the significance of using IoT and the challenges they face attributed to specialization, years of service, and technical training programs?.

## 2 Literature Review

The IoT has been defined variously among researchers and experts. For instance, [10], defined it as an interactive internet connection between computers, smart devices, and many other objects, enabling them to transmit and receive data, [11], Viewed IoT as the active connection of many everyday items and objects to the internet, such as alarms, mirrors, rain umbrellas, shoes, and others, to create a better living environment and accomplish easier tasks. Meanwhile, IoT was perceived as the communication and control of objects equipped with suitable sensors through a network connection to accomplish specific tasks, [12], [13].

In the context of the IoT, the term "Things" refers to the objects that can be identified and connected to the internet using established internet protocols. These objects communicate and share with each other over the internet without direct human interaction, utilizing a common language of communication. Each of these objects is assigned its own unique internet protocol (IP). Interestingly, even humans can be considered as "Things" if they are attached to a specific IP address, such as through wearable devices like glasses, watches, bracelets, or

electronic clothing. These connected "Things" are equipped with advanced capabilities in understanding, analyzing, and processing information. They respond to commands, analyze data, generate insights, and can issue commands or perform actions based on their high-level technological skills, [14].

In this study, IoT is procedurally defined as a group of updated devices, software, and connected remote sensors via the Internet, making them capable of sending and receiving data and interacting with them by humans. Furthermore, the challenges of implementing IoT are seen as a set of difficulties and obstacles facing teachers, both male and female, during the application of the IoT, which prevent the optimal use of it in teaching.

IoT has led to the emergence of smart environments that include various household appliances, security systems, building entrances, air conditioning systems, and commercial goods. This technology has revolutionized several settings, including homes, companies, factories, farms, universities, hospitals, and laboratories, [15]. IoT consists of three main elements: things, which refer to everything that can be connected to the internet through a small data chip without human interaction, such as household appliances, cars, transportation, energy, food, and even the human or animal body. The second element is communication networks that connect these things, and the last element is computing systems that process the data sent and received by the things, [16], [17]. Figure 1 illustrates these components.

IoT is a means of communication between interconnected devices through sensors, actuators, and various artificial intelligence tools. It operates within the advancements in data transmission generation like 5G, satellite software development, and remote sensing. Operating IoT requires establishing a set of rules that govern device communication, along with defining cloud storage points and developing web-based platforms to provide advanced systems and technologies for enhanced productivity, [18], [19].

Therefore, IoT is an important modern technology that has brought about a significant revolution in the tech world. It can be used to enhance the teaching process by providing a variety of applications that can greatly improve the attainment of educational objectives and boost the performance of both students and teachers, [20], [21].

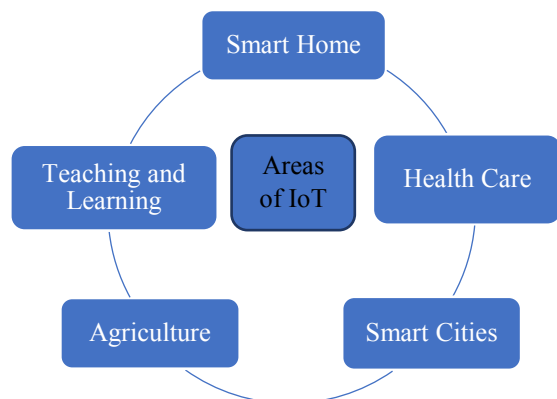


Fig. 1: Components of IoT

The proliferation of internet-connected devices is rapidly increasing, leading many experts research institutions, and analysts to predict the IoT future and its pivotal impact on internet networks. Juniper Research Group in 2015 revealed that there were an estimated 13.4 billion devices linked to the internet; this exceeds the world population at the study time. According to Gartner's statistics for 2021, the new devices which link the internet amount to 21.8 billion. As per Gartner's 2021 statistics, approximately 21.8 billion new devices were connected to the internet. Additionally, a Machine Research study in 2023 projected that the number of internet-connected devices would exceed 28 billion. Furthermore, a study by Machine Research in 2023 predicted that 28 billion devices would be linked to the internet, [22]. Experts such as, [10], [17], have highlighted the vast potential of IoT perceiving it as a field that encompasses billions of connected devices. IoT uses both hardware and software components to exchange data through a variety of communication protocols. The applications of IoT span across various domains including medical, industrial, agricultural, economic, and educational fields. Human creativity fuels the boundless potential for applying IoT in many sectors, such as healthcare, smart homes, agriculture, smart cities, and education as seen in Figure 2.

### 2.1 IoT in Education

Education has been revolutionized using technology. It innovatively provides ways to engage students in the learning process. IoT was widely adopted and extended its impact on various areas of life where education is one aspect. This motivates many individual and institutional research efforts to

propping the significance of such efforts. Scientific events and blogs extensively discuss the potential of IoT in education. The focus pinpoints the advantages of IoT as well as areas of further investigation, [13]. IoT potentially participates in developing the system of education in its various stages. Not only students but also teachers and institutions felt the privilege of IoT due to the shift it results while ceasing traditional teaching and encouraging high tech-based teaching. It also helps in improving the infrastructures of schooling worldwide. To sum up, IoT shapes the ways in which we as teachers teach as well as the ways how our students learn, [22].

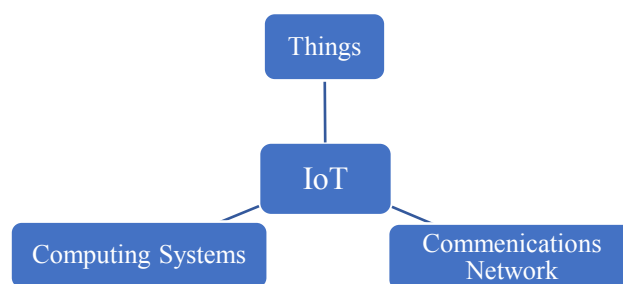


Fig. 2: Areas of IoT

### 2.2 Advantages of Using IoT in Education

IoT has been found to have numerous advantages in the field of education. In education, IoT has been reported to have various benefits. It encourages virtual learning which enables students to learn at a time and place suitable for them according to some studies. Students' engagement is prestigious in this teaching mode. Thus, students can check their progress due to the feedback they immediately receive from their teachers, [20], [23]. Furthermore, IoT celebrates lifelong learning. Students can enroll in online programs and receive their degrees. They can participate in online learning to enhance their qualification. Teachers still make use of the IoT features. They can get access to various learning/teaching materials related to their curriculum. They can also design their course contents using various applications. Teachers can contact their students at any time. Monitors can also easily attend virtual classrooms to evaluation the teaching/learning process, [20], [21]. IoT is possibly incorporated in the process of education, [24]. Teachers can facilitate students retrieving the learning materials virtually using the instructional plan.

Collaborative learning is an interesting environment that teachers can utilize by leveraging interactive applications. Teaching materials based on three dimensions can be created via IoT which enables both teachers and students to surf the internet electronically. IoT applications can be incorporated to save students' privacy and risk that they may encounter in physical classrooms. These applications are voice communication tools, 3D location tracking technologies, wireless watches, and smart cameras. Furthermore, [25], [26], studied the privilege of using IoT technology to develop the system of education. They found that IoT can participate in creating a motivational learning environment; it can also develop education services virtually for students and instructors. New opportunities for improving the learning/teaching process can be sought due to the incorporation of IoT in academia.

### 2.3 Challenges in Using IoT in Education

Nevertheless, IoT is not without defects. A very high percentage amounted to 75% of IoT-based projects fail. The majority of these projects fail at the application stages according to Cisco Networking Academy. A primitive challenge stems from the inability to produce IoT devices with low or considerable prices. IoT spread is contingent on the affordance of learning institutions to establish communication devices that enable interacting surrounds via actuators and sensors, [27]. Energy consumption is another challenge for installing IoT devices. Still, a third source of challenge results from the available big data where IoT acts. These huge data deprive IoT from participating effectively in improving education, [28].

Several studies pinpointed the challenges resulting from incorporating IoT, [26], [27], [28]. They listed them in disruptions, privacy violations, data espionage, hacking, and weak internet connection. Another plight to them is the resistances that accompany change resulting from complexities of IoT, technical vulnerabilities, insufficient technological development, high energy consumption, security vulnerabilities, weak infrastructure, and human errors. Furthermore, the social, psychological, and health challenges that students face in using IoT technologies include increased sedentary behavior, leading to health risks like obesity, social isolation, and addiction. An additional concern is the fear of job displacement due to the reliance of most jobs on technology, raising

uncertainties about students' future prospects. Finally, [29], [30], explored the concept of the IoT on campus and the related infrastructure of the university campus. The study concluded that it is important to use new technologies through IoT applications specific to the university campus to achieve the concept of a smart university capable of supporting senior management, educational activities, research activities, increasing needs, and environmental challenges.

### 2.4 IoT in Saudi Arabia

IoT has been examined in Saudi Arabia by a few studies, 30, [31]. However, such studies whether examined higher education facility members, for example, [5], explored the potential benefits and obstacles associated with using the Internet of Things (IoT) in Saudi universities, as seen through the eyes of faculty members from diverse sectors including education and learning, human resources, energy, transportation, public infrastructure, safety and security, and data analysis. The study listed the challenges in applying IoT by weak infrastructure, data breaches and leaks, increased economic costs, and privacy breaches. Another study focused on students, investigated the efficacy of IoT technologies in a personalized learning environment for developing cognitive achievement in linear programming skills in mathematics among female middle school students. The study employed a personalized learning environment and a cognitive achievement test for linear programming skills as research tools. Results indicated that the use of IoT technologies was effective in improving cognitive achievement in linear programming skills in mathematics among the participants, [31].

On the other hand, [32], focused on the important features and benefits of the used of IoT and its contribution to educating and raising awareness among learners about the advantages of using IoT technologies in the learning and teaching process. The study also addressed the major challenges and obstacles that hinder the use of IoT in the learning and teaching process. In other Arabic sittings, like Jordan, [32], investigated the effectiveness of using IoT to develop reading and writing skills among 7th-grade female students. To achieve this, the researchers prepared a test that was administered to 50 students. The study results showed the effects of teaching using IoT technologies. Such studies clarified the IoT in the Saudi context, however, there

is still a crucial need to explore the importance and challenges of adopting IoT amongst Saudi secondary schools in Riyadh as the previous studies were conducted in other Saudi governorates.

### 3 Methodologies

#### 3.1 Research Design

This study adopts an analytical descriptive approach that is suitable for examining the IoT in education. This approach is comprehensive and flexible. It allows for the researchers to analyze and compare the phenomenon with others, while also pinpointing the causes of its emergence, this methodology enables the accurate determination of results and conclusions. This study was conducted in Saudi Arabia, for the academic year 2022/2023.

#### 3.2 Participants

The participants of this study consist of 142 teachers (males and females) in schools in Riyadh Saudi Arabia during the academic year 2022/2023. The sample of the study was selected by using the simple random method, and a questionnaire was distributed electronically to the participants. Participants were introduced to the aim of the study and asked whether they could participate (Table 1, Figure 3, Figure 4 and Figure 5).

Table 1. Study Sample Distribution

Variable	Category	Frequency	Percentage
Specialization	Mathematics	46	32.4%
	Computer	49	34.5%
	Sciences	47	33.1%
Years of Service	Less than 7	59	41.5%
	7 – 15	46	32.5%
	More than 16	37	26%
Technical training programs	Less than 3	35	24.6%
	3 – 6	47	33.1%
	More than 7	62	43.7%

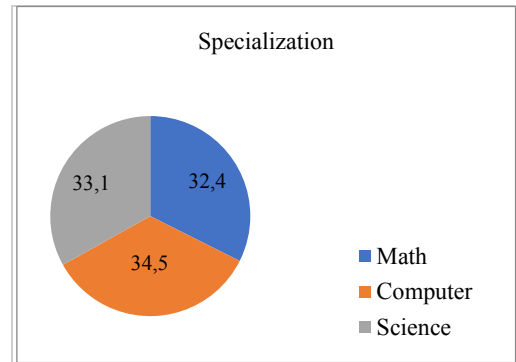


Fig. 3: Participants according to the specialization

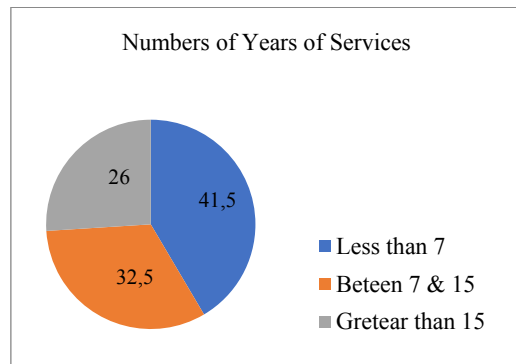


Fig. 4: Participants according to the number of years of services

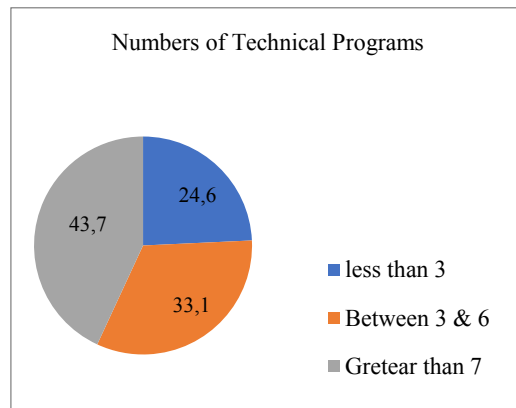


Fig. 5: Participants according to the technical training programs

#### 3.3 Instrument

A questionnaire was developed to measure the IoT, drawing on relevant research studies, [33], [34]. The questionnaire comprised 26 items divided into two domains: (1) The challenges encountered by male and female teachers when implementing the IoT in the educational process, with 12 items, and (2) The significance of utilizing the IoT in the educational process, contained 14 items. The scale was built by a

five-point scale Likert, with each item offering 5 answers: (strongly agree, agree, neutral, disagree, and strongly disagree) and assigned values from five to one, respectively.

The questionnaire validity was ensured by giving feedback from some experts' committees. Their opinions were used to modify certain items of the scale until its final form was achieved. In order to ensure the questionnaire's reliability, the coefficient of Cronbach's alpha was calculated for the overall questionnaire for each domain, and for each individual item. This was done by using an exploratory sample consisting of 24 teachers. The resulting values, ranging (from 0.73 - 0.92), and (0.83, 0.86, 0.89) for the first, second, and for the overall domains, confirm the reliability of the IoT scale for achieving the study's objectives.

### 3.4 Statistical Analysis

The data was entered by using SPSS (Version 27), and the arithmetic means; and standard deviations were calculated for each paragraph of the questionnaire. One-way analysis of variance ANOVA tests were also used to detect significant differences between the means of the study participants' responses, since ANOVA test aimed at comparing means or determining whether there are significant differences among the arithmetic means performances of groups subjected to different treatments, with the aim of identifying factors that cause one mean to differ from others.

## 4 Results

### 4.1 What is the Level of Challenges Facing Saudi Teachers in Applying IoT in the Educational Process?

Table 2 indicates that there is a high challenge ( $M=4.13$ ,  $SD=1.08$ ) facing teachers when applying the IoT in the educational process. The first rank mean is 4.52 for the ninth item, with an SD is 1.19. The second-rank mean is 4.51 for the second item, with SD being 1.31. The third-rank mean is 4.44 for the eighth item, with SD being 1.13. As for the last ranking occupied by item six with mean is: 4.35 and SD is: 0.96. These results show the most important challenges facing mathematics teachers in their use

of IoT technologies were the lack of desire among teachers to develop the educational process resulting from the use of IoT technologies, and that the large burdens placed on them prevent them from using them, in addition to the difficulty of using them by teachers and some students alike.

### 4.2 To What Extent Do Saudi Teachers Perceive the Significance of using IoT?

The study's findings, as shown in Table 3, reveal that Saudi teachers perceive highly the significance of using IoT technologies, with an arithmetic mean of: 3.95 and SD is: 1.10. Notably, item 24 ranked first with an arithmetic mean of: 4.38 and SD of: 1.22. Item 26 ranked second with an arithmetic mean of: 4.22 and an SD of: 1.19. Similarly, item 15 ranked third with an arithmetic mean of: 4.19 and SD of: 1.21. These results underscore the significance of integrating IoT technologies into the educational process to enhance teaching and learning outcomes. By incorporating IoT technologies into the curriculum, students are provided with opportunities to develop critical thinking skills, engage in self-learning, and experience a stimulating and competitive learning environment. Additionally, item 20 received an arithmetic mean of: 3.52 and an SD of: 0.88. In summary, these findings highlight the potential benefits of leveraging IoT technologies in education for improved instructional practices and enhanced student outcomes.

### 4.3 Are There Statistically Significant Differences in Teachers' Perspectives about the Significance of IoT and the Challenges they Face Attributed to Specialization, Years of Service, and Technical Training Programs?

Table 4 shows the mean scores and SD for the participants according to the study variables regarding the importance of using IoT technologies from the teacher's perspective and the challenges, with respect to the study variables.

To detect whether there is a significant differences between the means of Saudi teachers' regarding the importance of using IoT technologies and the challenges, based on the variable of specialization, ANOVA analysis was used.

Table 2. Challenges facing teachers in applying the IoT in the educational process

No	Item	Mean	SD
1	Weak Internet network and outages	4.04	1.31
2	Privacy breaches and data and information spying	4.51	0.91
3	Poor technological development of devices	4.36	1.25
4	Fear of technical glitches	4.12	1.31
5	Lack of desire to develop the educational process	3.75	0.95
6	The school curricula do not include using IoT in teaching and learning	4.35	0.96
7	Lack of training in using IoT technologies and weak technical support	4.06	1.06
8	Dismissal of some educational positions in the future	4.44	1.13
9	The large burden placed on teachers prevents them from using IoT technologies	4.52	1.19
10	High financial cost	3.86	0.97
11	Fear of equipment malfunction	3.82	1.02
12	High power consumption for devices connected to the IoT.	3.82	1.01
<b>Average</b>		<b>4.13</b>	<b>1.08</b>

Table 3. The significance of applying the IoT

No	Item	Mean	SD
13	IoT helps with flexibility in selecting and designing educational material	3.87	1.01
14	IoT allows students' performance to be monitored automatically	3.95	1.13
15	IoT as an educational method facilitates education and develops student performance	4.19	1.21
16	Using IoT in teaching and learning develops the spirit of challenge, competition, and excitement among students	3.82	0.97
17	I provide assistance to students who have little experience in using IoT	4.01	1.26
18	IoT helps students make appropriate educational decisions for them	3.86	0.97
19	IoT saves time and effort in the educational process	3.72	0.92
20	IoT allows monitoring students and tracking attendance and absence	3.52	0.88
21	IoT helps in managing and monitoring students remotely	3.79	1.23
22	The use of IoT takes into account individual differences among students	3.96	1.21
23	The use of IoT helps students in self-learning	4.13	1.19
24	IoT provides appropriate feedback to the teacher	4.23	1.22
25	IoT is considered a guide and facilitator for the student learning process	4.06	1.06
26	Using IoT helps students develop their critical thinking skills	4.22	1.19
<b>Average</b>		<b>3.95</b>	<b>1.10</b>

Table 4. Distribution of participants according to the variables

Variable	Category	Mean	SD
Specialization	Mathematics	58.69	7.95
	Computer	60.27	8.02
	Sciences	58.09	7.92
Years of Service	Less than 7	59.65	7.85
	7 – 15	58.16	7.72
	More than 16	55.57	7.29
Technical Training Programs	Less than 3	59.62	6.95
	3 – 6	60.55	7.12
	More than 7	62.32	7.16



Table 5. ANOVA analysis according to specialization

Domains		S.S.	d.f.	M.S.	F	Sig.
The difficulties of applying the IoT in the educational process	Between-Groups	305.65	2	152.82	0.93	0.045
	Within Groups	22965.63	140	164.04		
	Total	23271.28	142			
The importance of applying the IoT in the educational process	Between Groups	286.36	2	143.18	0.92	0.062
	Within Groups	21589.62	140	154.21		
	Total	21875.98	142			

Table 6. ANOVA analysis according to years of service

Domains		S.S.	d.f.	M.S.	F	Sig.
Difficulties of applying the IoT	Between Groups	235.15	2	117.575	0.78	0.035
	Within Groups	20895.97	140	149.25		
	Total	21131.12	142			
Significance of applying the IoT	Between Groups	206.44	2	103.22	0.70	0.030
	Within Groups	20771.55	140	148.36		
	Total	20977.99	142			

Table 7. ANOVA analysis according to the technical training programs

Domains		S.S.	d.f.	M.S.	F	Sig.
Difficulties of applying the IoT in the educational process	Between Groups	214.87	2	107.44	0.68	0.042
	Within Groups	21985.62	140	157.04		
	Total	22200.49	142			
The importance of applying the IoT in the educational process	Between Groups	197.21	2	98.60	0.70	0.044
	Within Groups	19584.66	140	139.89		
	Total	21875.98	142			

Table 5 indicates that there are signs differences between the Saudi teachers' perceptions regarding the challenges in using IoT, based on their specialization. Specifically, teachers specializing in computer science scored higher when compared to teachers from other specializations. This suggests that

computer science teachers may have greater skills, knowledge, and experience in utilizing IoT technologies. However, there is no significant difference in the perceptions of Saudi teachers regarding the significance of using IoT for their specialization. This suggests a consensus among

teachers, irrespective of their fields of expertise, regarding the significance of integrating IoT technologies into education. To discern whether there are statistically significant variations in the perceptions of Saudi teachers concerning the importance of utilizing IoT technologies and the obstacles they encounter, based on their years of service, a One-Way ANOVA test was employed, see Table 6.

Table 6 describes that there is a sign differences in Saudi teachers' perceptions of the difficulties they face in applying IoT attributed to the years of service. Interestingly, teachers with less experience had higher means, indicating their enthusiasm for utilizing modern technological tools in education. To investigate whether there is a sig. differences in the perceptions of Saudi teachers regarding the importance of using IoT technologies and the challenges they face, based on the technical training programs, ANOVA analysis was conducted, see Table 7.

Table 7 reveals that there is a sign. the difference for arithmetic means of the Saudi teachers for difficulties in applying IoT according to the technical programs. However, there is no sign. the difference in the perceptions of Saudi teachers regarding the importance of applying the IoT. This suggests that completed high technical training programs tend to have higher means in the first domain.

## 5 Discussions

The results of the current study on the challenges faced by Saudi teachers in applying IoT in the educational process clearly show that there are high levels of challenges that hinder Saudi teachers from the ideal application of IoT. This includes weak internet network and disconnection, fear of device failure, privacy breaches, fear of technical vulnerabilities and espionage on information, reluctance of teachers to develop the educational process, lack of training on using IoT technologies, weak technological development, and lack of experience and training in using these advanced technologies. This is especially true for teachers who have more years of service and are less proficient in using these advanced technologies and have not undergone sufficient technical training courses from various scientific disciplines. They may believe that using this type of high-quality technology requires more time and effort than using traditional methods

they have been following for years during their service, especially since there are many burdens and duties that require them to hold tests, correct them, evaluate students' tools, and prepare daily lessons and administrative work.

The current study showed the high level of connectedness between teachers and IoT technology while incorporating the IoT in the learning/education process. This high connection with technology can be explained by the high skills that teachers master and their knowledge of the up-to-date information affiliated with IoT. However, the missing teaching instructions and roles challenge IoT's future. This technology-based learning creates a new learning environment which teachers should be aware of. These findings are confirmed with [34], [35]. Using modern technology needs high training for participants and users. Such lack of training and insufficient teachers' support set a challenge for teachers in underutilizing IoT in the learning process. Another challenge in addition to what has been mentioned is the low number of trainers and experts in IoT when compared to other fields. To sum up, the success of utilizing IoT in the education process requires the availability of competent expertise in the field. These technical skills and expertise are ensure good investment in technology in education.

The study's findings show a high level of the importance of using IoT technologies in education, regardless of teachers' expertise, years of service, or training. Teachers recognize the value of IoT for flexible material selection, self-learning opportunities, and critical thinking skill development. IoT also teaches basic skills, provides feedback to teachers, and considers individual differences among students. These findings agree with some studies, [3], [28], that affirmed of using modern strategies that rely on IoT to have positive effects for the motivation of students, challenging spirit, excitement, and competition. Incorporating IoT into curricula and utilizing it in teaching improves learning outcomes by providing flexibility in presenting materials, facilitating monitoring of student performance, and tracking attendance. This saves the efforts and time of teachers and develops the quality of learning outputs.

Results also revealed signs. differences in the perceptions of Saudi teachers regarding the importance of using IoT technologies in education. Moral differences are reported in the attitudes of Saudi teachers regarding incorporating IoT

technology in education in some variables. Completion of training course, field of experience, and year of service are examples. Results reported that Science teachers with newly hired PCs and who received extensive training have reported high and moral significance in using IoT technology. Due to the high training they received, they construct a reliable plan to incorporate IoT in the teaching process; they also get high access to learning and teaching sources and support they need. The teaching/learning process can be developed due to the availability of applications responsible for developing instructing, bringing challenges to the students, and keeping them enthusiastic. Such findings agreed with, [36], [37], [38], who confirmed the positive impact resulting from leveraging IoT in the learning process.

The significant differences reported by Saudi teachers can be attributed to the widespread of computer technology and the high knowledge of Science teachers when compared with the teachers of other subjects. Science teachers are exposed to a wide range of information during their study for the skills and expertise required for incorporating IoT technology. Yet, this board knowledge helps to organize valid teaching plans and solve any problem they face. Their broad knowledge and high culture of modern technologies may be the reason for their proficiency. Despite the ease of access to these technologies, some educational platforms have provided many technologies and applications that help teachers improve the quality of the teaching process. They also help students learn using modern technologies that develop a challenging spirit, excitement, and competition among students, which promotes self-confidence and contributes to improving the educational process, as some studies have indicated, [22], [23], [32].

Regarding newly hired teachers, it is noticeable that the requirements of the rapidly advancing era we live in have necessitated the acquisition of high experience and skills in using IoT. They have accumulated skills that enable them to perform the required educational competencies and teaching skills more than teachers with longer service. This has enabled them to easily access the latest software and device versions connected to the internet network in order to employ them in the educational process and improve the quality of learning outcomes. Additionally, newly hired teachers have motivation, enthusiasm, and creative ideas on how to manage the

educational process more than teachers with longer service who are accustomed to traditional methods and do not deviate from convention in teaching. This has been indicated in some studies, [35], [36].

Teachers who trained in more than seven training technical courses show a significant positive impact on their ability to effectively utilize IoT technologies in the educational process. The training and preparation they receive equip them with the necessary skills and knowledge to overcome challenges and employ these technologies optimally. This, in turn, leads to improved student performance. The value of training courses in enhancing teaching performance and providing a clear vision for teachers is widely recognized, as supported by previous studies, . In-service training enables teachers to acquire new skills and experiences that positively influence students, reshape their attitudes, boost morale, increase productivity, and align with the demands of modern education. Additionally, teachers' awareness of advancements in IoT fosters a sense of belonging and importance within their educational institutions, further enhancing the development of learning outcomes.

## 6 Conclusions and Recommendations

IoT technologies have become necessary and even essential in contemporary life, especially in the field of education. These technologies require flexible infrastructure and wireless communication networks. On the other hand, we must take into account the challenges facing the employment of IoT and try to overcome them. The study recommends the implementation of IoT technologies and conducting more studies on standardizing and preparing IoT for different educational materials and for all educational levels. It also recommends undertaking more studies that examine the relationship between educational services and IoT technologies, raising awareness of the importance of IoT in developing this process, and developing and processing automated systems for managing education through IoT. The study also recommends the importance of providing a suitable technological environment for IoT in education, providing specialists to provide appropriate technical support, studying the sources of concern that threaten the investment of IoT technologies in the educational process, and trying to find solutions to them by allocating more discussion sessions and specialized seminars on the subject of IoT services to discover

more promising opportunities, deal with difficulties that hinder working with IoT, and benefit from the experiences of advanced countries that have used IoT in the field of education.

## 7 Limitations

- **Human Limitations:** The teachers (male and female) in schools of the KSA affiliated with the Ministry of Education in Riyadh region.
- **Temporal Limitations:** This study was conducted during the school year 2022- 2023.
- **Spatial Limitations:** The government schools in the Kingdom of Saudi Arabia in the city of Riyadh.
- **Subjective Limitations:** This study is focused for the significance of using the Internet of Things in education from teacher's perspective and addressing the challenges during its implementation in the educational process.

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