

# **Foreseeing the Future of Higher Education in the Internet of Things Context**

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### Abstract

This study aims to investigate how the Internet of Things (IoT) will impact higher education in the future. It employs a descriptive methodology, the Delphi method, and three rounds of application of the questionnaire tool to a sample of 18 experts.

After the third round, the study's experts came to agree on the potential benefits of the Internet of Things platforms for higher education, the most significant of which is the emergence of the Internet of Things applications for the educational sectors. The experts also agreed on future opportunities associated with content delivery techniques, the most significant of which is a high degree of diversity in digital information sources. The development of new assessment strategies that are suited for education through the Internet of Things is most significant, in addition to the agreement of experts on future opportunities associated with mechanisms for evaluating learning outcomes. Furthermore, the most important requirement for integrating the Internet of Things into higher education is the introduction of academic programs in the field of using the Internet of Things in education.

**Keywords:** internet of things, higher education, foreseeing, universities, educational technology.

## استشراف مستقبل التعليم العالي في ضوء إنترنت الأشياء

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### الملخص

هدفت الدراسة إلى استشراف مستقبل التعليم العالي في ضوء إنترنت الأشياء (IoT)، واعتمدت على المنهج الوصفي، فقد استخدمت أسلوب دلفاي Delphi، وطبقت أداة الاستبانة في ثلاث جولات على عينة من الخبراء بلغت (18) خبيراً.

بعد الجولة الثالثة، توصل خبراء الدراسة إلى اتفاق بشأن الفرص المرتبطة بمنصات إنترنت الأشياء في التعليم العالي، وأهمها ظهور تطبيقات لإنترنت الأشياء خاصة بالمجالات التعليمية. كما اتفق الخبراء على الفرص المستقبلية المرتبطة بآليات تقديم المحتوى، وأهمها درجة عالية من التنوع في مصادر المعلومات الرقمية. بالإضافة إلى اتفاق الخبراء على الفرص المستقبلية المرتبطة بآليات تقييم نتائج التعلم، حيث كان أهمها تطوير استراتيجيات تقييم جديدة مناسبة للتعليم من خلال إنترنت الأشياء علاوة على ذلك، فإن أهم مطلب لدمج إنترنت الأشياء في التعليم العالي هو تقديم برامج أكاديمية في مجال استخدام إنترنت الأشياء في التعليم.

الكلمات المفتاحية: إنترنت الأشياء، التعليم العالي، استشراف، الجامعات، تكنولوجيا التعليم.

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### Introduction

The current era is characterized by rapid technological development, for which there is no doubt that this development has an impact on all aspects of life, particularly education. Universities and those who are interested in education must therefore develop their human capabilities and educational environments to keep up with the current and future rapid technological developments to accommodate the spread and development of modern technologies. With the development of their tools and their continued advancement, internet technologies are at the forefront of those that will shape a new type of education in the future.

Notably, one of the most advanced areas of internet technology is the Internet of Things, defined by El-Dahshan (2019) as devices that communicate with each other to transmit and receive data to perform various specific functions and be controlled via the Internet.

By providing rich, flexible platforms and extremely intelligent environments, as well as interacting, sharing documents, and making changes in real-time via the Internet, the Internet of Things makes learning possible anytime, anywhere.

One benefit of the Internet of Things (IoT) is that it connects items through a unique identification, enabling the remote control of successful learning management, contributing to a strengthened relationship between the teachers and students by enabling them to communicate with one another through the IoT applications without having to conduct an in-person interview (Alaklabi, 2019).

The most significant benefit of using IoT technology in university education, according to Meacham et al. (2018), is that it creates a more personalized e-learning environment by using the data gathered sensor devices to tailor educational content to students' preferences, readiness, learning style, and individual differences. It also contributes to raising the standard of education by transforming it from a knowledge transfer model to one of active self-cooperation. Teachers are also able to use it to create an interactive learning environment and compile reports on student performance. According to Mircea et al. (2021), Internet of Things technology also increases opportunities for students to engage in educational tasks and activities, allowing them to track their academic progress, and offering lifelong learning opportunities.

The Internet of Things, as explained by Pai et al. (2017), can support the growth of the educational process through a variety of cutting-edge and updated applications, the most significant of which are smart classroom management and the provision of feedback. According to Mershad & Wakim (2018), the Internet of Things technology will offer creative and innovative teaching methods to explain the various concepts to students by connecting the IoT units with the desired reality to be simulated, making it easier for the student to comprehend the various concepts and topics.

IoT technology also helps to the creation of a high-quality learning environment, which helps to improve education by making it more open, coordinated, and interactive, which will allow students and teachers to perceive a wider range of teaching resources (Shang & Qin, 2022).

IoT offers numerous facilities and benefits to reduce the effort and workload of educational administrators, students, and faculty members, as well as for educational institution management, of educational institutions, which will aid in the quick adoption of IoT technology.

Aside from these benefits of IoT technology, universities, and other educational institutions must prepare for a variety of issues, including the rising costs of infrastructure and smart systems; and the ability to provide and maintain security, reliability, and privacy. A rise in big data will also be facilitated by IoT (Al-Hamami, & Al-Hakim, 2017).

To develop digital teaching skills, the capacity to integrate technological tools into the educational process, and the ability to anticipate the future as well as technological acceptance of IoT. Abdulhamid's (2021) study placed a strong emphasis on the need for teacher preparation programs to be developed in education colleges. Additionally, it was suggested to create academic programs to teach students how to use learning environments based on IoT (Ahmed et al., 2021).

According to Aldowah et al. (2017), IoT will significantly alter how universities operate and improve student learning across a wide range of disciplines. They also confirmed that to ensure the successful implementation of IoT in the proper way, universities must work on developing infrastructure, systems, smart devices, and services.

In addition to increasing interactions with applications, a study by Ibrahim and Alkhabra (2022) at the University of Hail in the Kingdom of Saudi Arabia sought to develop a vision for the university's learning environment development and management of knowledge by enhancing the physical objects that surround university users in the learning space from the perspective of the Internet of Things. The most significant obstacles to the Internet of Things' inclusion in academic settings were recognised as well as its concepts, development, and overall structural framework. These were also addressed in order to create a vision for using this technology to advance knowledge management. worldwide organisations. The findings indicated that, in addition to the faculty and experts' conviction of its potential and capabilities in enhancing the educational setting in universities, and offering distinctive research by tying together an infrastructure of research laboratories, a requirement exists to create an approach for the growth of its infrastructure, as well as to offer additional tools and implementations to handle higher levels of data and analyse it for decision-making.

It was determined that the Internet of Things is the best technical solution for academia in a study by Banica et al. (2017) that sought to demonstrate the significance of introducing the Internet of Things in higher education by identifying IoT feature integration in academia, particularly in the areas of teaching and learning improvements to access the smart university model.

According to Xu's (2022) findings, IoT applications will continue to advance technology, which will result in the emergence of several new applications, particularly in the field of education. These applications will help educators better understand the educational needs of their students and incorporate a variety of methods for presenting fresh new teaching concepts.

In order to increase students' enthusiasm to use IoT-based equipment, which is the primary necessity for an IoT enabled campus, Alenizi (2022) undertook studies as a first step to evaluate the fundamental IoT training for students. Since universities in Saudi Arabia strive to introduce IoT programmes in their various departments, a T-test was undertaken to determine the efficiency of training. Universities in Saudi Arabia are also motivated to conduct training to get their teaching staff and students ready for IoT-based courses.

The study by Abed et al. (2020) suggests carrying out a literature review to show how the Internet of Things has affected the educational setting. By utilising the Technology Acceptance Model, which encourages users to adopt this technology, it also attempts to assess Saudi universities and educational institutions' user acceptance of this technology within S. Overall, the findings show that the IoT has had a favourable influence on university campuses and the educational process. Also, there is broad agreement among study participants about how the Internet of Things will develop in Saudi Arabia in terms of perceived utility and usability.

Alblaihed et al. (2022) conducted a study to assess Saudi universities' capability to include the IoT in organizational learning and identify the problems associated with its implementation. The findings revealed that, in addition to the faculty and specialists' conviction in its opportunities to develop universities' teaching and learning environments and offering innovative research by interconnecting the network of laboratories and research and training laboratories, a strategic plan associated with the creation of infrastructure and the availability of equipment and applications to deal with and analyse big data is required.

An interactive learning environment based on the Internet of things was designed as part of a study of the impact of interactive teaching, conducted by Moreir et al. (2017). The study's findings demonstrated that students were able to access content and materials quickly, improving their grades which were noticeably higher in comparison to the conventional educational teaching system. Additionally, concurrently, the proposed system has a very high level of internal consistency reliability, fully demonstrating its effectiveness. In addition, a study conducted by Sultana & Tamanna (2022) to evaluate the potential benefits and challenges of employing Io T in education revealed that the most significant potential benefits are time savings, while the most significant potential challenge are increasing social communication from a distance and decreasing face-to-face contact. El-Dahshan (2019) stressed the significance of amending intellectual property and privacy laws to include and offer protection for students who use IoT.

According to Alaklabi's (2019) study results, the lack of infrastructure readiness, the absence of regulatory legislation for IoT applications, and growing concerns about user data privacy violations are the three biggest obstacles to using IoT in education. The study also highlighted the key characteristics and advantages of the Internet of Things in the context of education, including its potential to significantly advance the services provided by educational institutions and advance scientific inquiry. This study recommends conducting further studies on the relationship between educational institutions' services and work, and IoT applications, working to raise awareness about the importance of IoT in education development and researching any concerns which threaten IoT application investment in education.

To analyze recent advancements in the usage of IoT applications in education, and provide various opportunities and challenges for future experiences, Al-Emran et al. (2020) conducted a study. The study specifically looked at wearable technology, medical training, and vocational education adoption possibilities for IoT in education and learning. The study concluded that the uptake of the internet and its applications in developing nations is still in its infancy, and it made recommendations for

additional studies in the area.

According to the results of a study by Liu et al. (2021), in which they designed a smart classroom structure based on IoT technology that connects to traditional network facilities via an IoT portal, the learning platform can effectively control the classroom's use and have high productivity, fast latency, with minimal effort.

The study also found that IoT-based smart classes enhanced the teaching environment as well as contributed to carrying out other tasks, such as investigating exam results and tracking absence and attendance.

In study conducted by Chen & Huang (2021), an educational system based on IoT technology was created to evaluate the quality of teaching based on this system. The results proved a significant improvement in grades compared to the traditional teaching system, in addition to the advantage of students being able to access educational materials and content in a shorter period. It was also proven that the reliability of the system's consistency is very high. The research also made the case for the necessity of selecting proper teaching and assessment methods for IoT educational systems.

### Research Problem

It has become increasingly necessary for educational institutions to improve teaching environment intelligence, and to invest in modern and advanced technologies to improve educational environments, especially given rapid technological growth. One of the most important modern technologies that education in the current era requires attention to employ in the educational process is IOT technology (Fragou & Mavroudi, 2020).

The use of IoT technology in education is a new trend because it offers fresh, cutting-edge, innovative approaches and resources that improve the educational process, raising education quality, and produce specific learning outcomes that meet the requirements of the digital age (Abdulhamid, 2021). As a result, numerous studies (Hazinji, 2022; Al-Emran et al. 2020; Alaklabi, 2019; Banica et al., 2017) have supported the need for adopting and utilizing IoT technology in educational fields and suggested further research in this area. A study by Abed et al. (2020) showed that colleges

can use IoT to develop a smart and complex environment for their learners and staff members.

On the other hand, Kassab et al. (2020) indicated that although many contributions have been produced regarding IoT inclusion in education, there is still a shortage of knowledge of future trends in this area. It is crucial to be aware of these trends and learn how to better integrate IoT into educational fields, as well as the future of education and its new patterns considering IoT technology. This makes it essential for anyone interested in education generally, and particularly in universities, to explore this topic to be ready for any repercussions of the digital age's developments, and keep up with and invest in modern technologies, such as IoT, most effectively.

This necessitates researching appropriate IoT applications and platforms for educational fields, as well as and suitable teaching and assessment policies for those applications, to produce high-quality educational products, as well as to analyze the requirements for integrating IoT in universities.

Additionally, it is important to highlight the researcher's background as a member of the university faculty and a representative of the Deanship of E-Learning and Distance Learning, which is tasked with incorporating modern technology into academic teaching and learning environments, where he felt the need to anticipate the future of higher education in light of IoT, knowing the anticipated opportunities for IoT applications and platforms in higher education, and the anticipated opportunities to provide content and evaluate learning outcomes in the context of IoT, as well as identify the prerequisites for integrating IoT in higher education.

Based on the aforementioned it is possible to identify the study's problem, as follows:

What is the future of higher education in the IoT context?

## Research Questions

The study aims to answer the following questions:

**Question 1:** What future opportunities are associated with IoT platforms in higher education?

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**Question 2:** What future opportunities are associated with the mechanisms for providing content in higher education in the context of the Internet of Things?

**Question 3:** What future opportunities are associated with mechanisms for evaluating learning outcomes in higher education in the context of the Internet of Things?

**Question 4:** What are the requirements for integrating the Internet of Things into higher education?

### **Research Importance**

The research is significant because it emphasizes the importance of investing in current advanced technological capabilities, including IoT technology, in facilitating and improving educational processes, as well as providing a conceptual and theoretical framework for IoT use in higher education for researchers and others interested in education technology.

The research also aids in providing educational decision-makers with an idea of what the future of higher education could look like in the context of IoT, allowing them to develop and implement appropriate plans, programs, and regulations in light of rapid technological advancement.

### **Research Methodology**

Employing the Delphi technique, the research depends on a descriptive approach, carried out in 2022, with the research taking three months to implement, with the goal of researching a specialist agreement on the future of higher education in the context of IoT. The Delphi method is based on experts' experience in specific fields, as they are asked to provide predictions on specific topics, with much indirect interaction between them (Amer, 2006).

### **Research Community and Sample**

The researcher specifically chose a sample of 18 experts from various international universities based on the study's nature and the requirements necessary for using the Delphi method. Experts from universities in Saudi Arabia, Egypt, Jordan, the United States, the United Kingdom, and

Australia were included in the sample. This number of participants falls within the acceptable sample number of experts when applying the Delphi method, which according to Avella (2016), should not be less than (10) and not more than (100). The study sample was selected according to the following conditions:

- Specialization should be in the subject area of study - ICT in Higher Education
- To have an interest in and scientific contributions to the study's subject
- University academic rank to be Associate Professor or above
- University work experience to be no less than five years
- Willingness to cooperate with the researcher in all areas of the study

### Research Tool

achieve the research objectives, a questionnaire was used to collect the data under the following research stages:

The first stage utilized the open questionnaire, which was put together by referring to the theoretical framework as well as previous studies relating to the study's subject. The questionnaire consisted of two parts: the first includes general information about each expert (name, academic rank, university, and years of higher education experience). The second includes four questions that represent the research questions on the future of Io T in higher education. As this is the stage for generating ideas, the experts were instructed to respond to the questions with phrases containing each independent point.

The second stage utilized a closed questionnaire, which was constructed from the ideas and visions generated by the first stage's experts. The second stage questionnaire included the following sections:

Section 1 discusses future opportunities associated with IoT platforms in higher education, which contains seven (7) statements.

Section 2 discusses future opportunities relating to mechanisms to deliver content in higher education in the IoT context, which contains nine (9) statements.

Section 3 discusses future opportunities relating to mechanisms for assessing student learning outcomes in higher education in the IoT

context, with seven statements (7) statements.

Section 4 contains ten (10) statements and discusses the requirements for incorporating IoT into higher education.

Experts were also allowed to add statements under each section. The response was given on a triple scale of “Yes”, “To some extent”, or “no”. The following scale was used to clarify the level of agreement between the experts, based on the division of categories and the average value, as follows:

- From 3 to 2.34 - representing a high degree of approval score
- From 2.33 to 1.67 - representing a medium approval score
- From 1.66 to 1 - representing a low approval score

The third stage was prepared according to the second stage results, where the approval rate was high, ranging between 90 - 100%. There were six statements suggested by experts added in the second stage - The emergence of e-learning management systems compatible with IoT in the section of future opportunities relating to IoT platforms, the statement - Education is highly learner-centered added in the section of future opportunities related to the mechanisms of content delivery, while two phrases were added in the section of future opportunities relating to the evaluation of learning outcomes, the statement - Automatically provide feedback to the learner based on an automated diagnosis of his learning level, and the statement - Automatic assessment of the student's participation level), as well as two statements added to the section of requirements for integrating IoT into higher education - Spreading awareness of educational cloud computing applications, and Building positive attitudes among educational leaders towards the IoT use in education.

## **Validity of the Tool**

### **1.1 Reviewers validity**

The reviewers verified the tool's validity by putting it through the Reviewers validity process.

The tool was presented to the experts during each of its three stages and was then modified based on the reviewers' observations, including deletions, additions, and modifications.

## 1.2 Validity of the study tool's internal consistency

According to the Pearson Correlation in both the second and third stages, there is a positive and statistically significant correlation between the scores on individual items and the tool's overall score at the level of (0.01).

## Reliability of the Tool

To determine the tool's reliability, the Alpha-Cronbach coefficient was calculated in the second and third stages. It was calculated in the second stage as (0.91), and reached (0.93) in the third stage, which indicates a high level of reliability.

## Research Procedures

The researcher performed the following procedures to implement the research:

- 1- A group of experts was identified according to the conditions set by the research.
- 2- An open questionnaire for the first round of the Delphi method was built electronically.
- 3- The questionnaire was emailed to the experts to obtain their points of view.
- 4- The expert's answers were analyzed in the first stage and based on the results of the analysis, a closed questionnaire was built electronically for the second stage.
- 5- The questionnaire was presented to a group of reviewers to ensure the tool's validity.
- 6- The closed questionnaire for the second stage was sent emailed to participating experts to complete.
- 7- After the experts completed the questionnaire, it was analyzed statistically by calculating the arithmetic averages, standard deviations, and percentages of approval for the statements of each section.
- 8- A closed electronic questionnaire was built for the third stage based on the questionnaire's results in the second stage, where approval rates were high, ranging between 90 to 100%. Six statements were added as

suggested by the experts.

- 9- The third stage's closed questionnaire was emailed to experts to complete, which included the second stage's results for which to express their views.
- 10- After completing the third stage's questionnaire, anything agreed by 90% or more was approved as approval for all experts, and after analyzing the questionnaire statistically; all statements in each of the four sections were approved, as the approval percentage exceeded the specified percentage of 90%, which ranged between 94% - 100%.

### **Difficulties encountered by the researcher when applying the Delphi method**

- 1- It is difficult to determine the group of experts who meet the conditions participating in the study.
- 2- Difficulties obtaining some of the experts' approval.
- 3- Late responses to the questionnaire during each of the study's stages.

### **Statistical methods**

The study's data were analyzed using the statistical package for the social sciences (SPSS), which used arithmetic means, standard deviation, relative percentage, as well as Pearson's correlation coefficient and Cronbach's alpha coefficient.

### **Results and Discussion**

The researcher used arithmetic means, standard deviations, and relative percentages to answer the research questions. A presentation and discussion of the results of the third (last) stage are set out below.

**Question 1:** What future opportunities are associated with IoT platforms in higher education?

The table below sets out the answer to this question:

**Table (1)**  
**Expert responses on future opportunities associated**  
**with IoT platforms in higher education**

| Order | N. | Statement                                                                                      | Mean | SD   | Percent |
|-------|----|------------------------------------------------------------------------------------------------|------|------|---------|
| 8     | 1  | The emergence of software to ensure control of inputs, processes, and outputs                  | 2.82 | 0.59 | 94%     |
| 5a    | 2  | The emergence of new applications of artificial intelligence, especially in educational fields | 2.91 | 0.29 | 97%     |
| 5b    | 3  | Integration between IoT and other electronic platforms                                         | 2.91 | 0.29 | 97%     |
| 1a    | 4  | The emergence of applications for IoT for educational fields                                   | 3.00 | 0.00 | 100%    |
| 1b    | 5  | The emergence of highly capable software to provide advanced communication tools between users | 3.00 | 0.00 | 100%    |
| 1c    | 6  | The emergence of new features in web technologies that support IoT                             | 3.00 | 0.00 | 100%    |
| 1d    | 7  | The emergence of electronic platforms for IoT                                                  | 3.00 | 0.00 | 100%    |
| 5c    | 8  | The emergence of e-learning management systems compatible with IoT                             | 2.91 | 0.29 | 97%     |
|       |    |                                                                                                | 2.94 | 0.18 | 98%     |

Table (1) clearly shows that the general mean was (2.94), indicating that experts have a high level of approval for the future opportunities associated with IoT platforms in higher education. All the claims in this section also received approval rates of more than 90%. For example, it was in the first place.

Point 4 in the table – "The emergence of applications for the IoT for educational fields", followed the same order as points 5, 6, and 7 - and their texts – "The emergence of highly capable software to provide advanced communication tools between users", "The emergence of new features in web technologies that support IoT", and "The emergence of electronic platforms for IoT".

This may be attributed to the astounding rate of development and technological advancement, which presents opportunities for the

emergence of cutting-edge web technologies, platforms, and applications in educational settings based on IoT. Additionally, as educational institutions try to keep up with technology and equip it with the best mechanisms, this also presents opportunities for the emergence of cutting-edge communication software at the same time. Whereas Xu (2022) stated that several applications, particularly in the educational fields, will emerge as a result of IoT applications experiencing constant technological advancement. Additionally, according to Pai et al. (2017), IoT can advance the educational process through several cutting-edge and updated applications, the most significant being smart classroom management, and providing feedback. Furthermore, Abed et al. (2020) show that there is substantial agreement among the survey participants on future potential for the Internet of Things in Saudi Arabia in terms of perceived usefulness and simplicity of use.

**Question 2:** What future opportunities are associated with the mechanisms for providing content in higher education in the context of the Internet of Things?

The table below sets out this question's answer:

**Table (2)**  
**Experts' responses to future opportunities related to mechanisms for providing content in higher education in the IoT context**

| Order | N. | Statement                                                                    | Mean | SD   | Percent |
|-------|----|------------------------------------------------------------------------------|------|------|---------|
| 1a    | 1  | Diversity of digital knowledge sources to a high degree                      | 3.00 | 0.00 | 100%    |
| 3a    | 2  | Spread of virtual learning communities                                       | 2.91 | 0.29 | 97%     |
| 1b    | 3  | Expand the use of smart classes                                              | 3.00 | 0.00 | 100%    |
| 8a    | 4  | Expand the use of virtual laboratories                                       | 2.82 | 0.59 | 94%     |
| 3b    | 5  | Investing more in Web 2 tools to provide scientific content                  | 2.91 | 0.29 | 97%     |
| 3c    | 6  | The emergence of new teaching strategies appropriate to IoT use in education | 2.91 | 0.29 | 97%     |

Table (2)

| Order | N. | Statement                                                                  | Mean | SD   | Percent |
|-------|----|----------------------------------------------------------------------------|------|------|---------|
| 8b    | 7  | The growing interest in online teaching design programs                    | 2.82 | 0.39 | 94%     |
| 3d    | 8  | Investing in the internet to implement independent, self-directed learning | 2.91 | 0.29 | 97%     |
| 3e    | 9  | Investing in the internet to develop critical and creative thinking skills | 2.91 | 0.29 | 97%     |
| 8c    | 10 | Education is highly learner-centered                                       | 2.82 | 0.59 | 94%     |
|       |    |                                                                            | 2.90 | 0.21 | 97%     |

Table (2) clearly shows that the general mean was 2.90, which indicates that experts have a high level of approval on future opportunities associated with the mechanisms for providing content in higher education in light of IoT - all of this section's terms obtained an approval rate greater than 90%.

For example, in the first place is Point 1 and its text – "Diversity of digital knowledge sources to a high degree"; and Point 3 has the same rank with its text – "Expand the use of smart classes". In third place are Points 2, 5, 6, 8 and 9, with their text – "Spread of virtual learning communities", "Investing more in Web 2 tools to provide scientific content", "The emergence of new teaching strategies appropriate to IoT use in education", "Investing in the internet to implement independent, self-directed learning", and "Investing in the Internet to develop critical and creative thinking skills".

This could be attributed to the variety and multiplicity of modern technologies as well as the development of technical tools, which offer the chance to greatly diversify digital knowledge sources and will support the spread of smart classes and virtual learning communities and necessitate the use of more Web 2 tools to provide content.

This calls for the emergence of modern teaching strategies suitable for IoT use as well as the growing interest in programs for designing online instruction. Ahmed et al. (2021) suggested creating academic programs to foster the development of IoT-based learning environment design skills. Mershad & Wakim (2018) also mentioned that IoT technology will offer creative teaching methods to help students understand various

concepts. Additionally, Chen & Huang (2021) argued that selecting appropriate teaching methods is essential for IoT-based educational systems. Furthermore, Alenizi (2022) noted that colleges in Saudi Arabia are interested in launching IoT programmes in their various departments, as well as training courses in order to equip their learners and teachers for IoT-based courses.

**Question 3:** What future opportunities are associated with mechanisms for evaluating learning outcomes in higher education in the context of the Internet of Things?

The following table answers this question:

**Table (3)**  
**Experts' responses to future opportunities related to mechanisms for evaluating learning outcomes in higher education in the IoT context**

| Order | N. | Statement                                                                                        | Mean | SD   | Percent |
|-------|----|--------------------------------------------------------------------------------------------------|------|------|---------|
| 1a    | 1  | Develop new assessment strategies appropriate for education through IoT                          | 3.00 | 0.00 | 100%    |
| 1b    | 2  | Automatically diagnose learners' levels                                                          | 3.00 | 0.00 | 100%    |
| 1c    | 3  | Investing in IoT to adjust the tests provided remotely with high accuracy                        | 3.00 | 0.00 | 100%    |
| 1d    | 4  | Automatically monitor learners' progress.                                                        | 3.00 | 0.00 | 100%    |
| 1e    | 5  | The emergence of technical applications for learning process analysis.                           | 3.00 | 0.00 | 100%    |
| 1f    | 6  | Develop software to be more accurate in detecting plagiarism in evaluating students' work        | 3.00 | 0.00 | 100%    |
| 8a    | 7  | Expand electronic activities                                                                     | 2.91 | 0.29 | 97%     |
| 1g    | 8  | Automatically provide feedback to the learner based on the automated diagnosis of learning level | 3.00 | 0.00 | 100%    |
| 8b    | 9  | Automatic assessment of student participation level                                              | 2.91 | 0.29 | 97%     |
|       |    |                                                                                                  | 2.98 | 0.04 | 99%     |

Table (3) clearly shows the general mean was (2.98), meaning the approval of experts on future opportunities associated with mechanisms

for evaluating learning outcomes in higher education in the IoT context is high. All of this section’s terms obtained an approval rate greater than 90%.

For example, in the first place were Points 1, 2, 3, 4, 5, 6, and 8, and their text – "Develop new assessment strategies appropriate for education through IoT", "Automatically diagnose learners’ levels", "Investing in IoT to adjust tests provided remotely with high accuracy", "Automatically monitor learners’ progress", "The emergence of technical applications for learning process analysis", "Develop software to be more accurate in detecting plagiarism in evaluating students' work", and "Automatically provide feedback to the learner based on the automated diagnosis of learning level".

The Internet of Things technology will unavoidably contribute to the emergence of modern technical evaluation tools, which necessitates selecting the appropriate evaluation methods considering these tools, to be invested to the best possible degree, and adjusting the tests. This can be explained by technology's rapid development and progress, and the corresponding development of teaching strategies, leading to appropriate evaluation strategy development. Liu et al. (2021) confirmed that IoT has contributed to various functions, such as exam result inquiries, attendance, and absence monitoring. Additionally, Chen & Huang (2021) argued that for IoT-based educational systems, choosing suitable assessment strategies is essential.

**Question 4:** What are the requirements for integrating the Internet of Things into higher education?

The following table sets out the answer to this question:

**Table (4)**  
**Experts' responses to the requirements for integrating**  
**the Internet of Things into higher education**

| Order | N. | Statement                                                                         | Mean | SD   | Percent |
|-------|----|-----------------------------------------------------------------------------------|------|------|---------|
| 1a    | 1  | Introducing academic programs in the field of using IoT in education              | 3.00 | 0.00 | 100%    |
| 7a    | 2  | Developing educational quality standards in the IoT context                       | 2.91 | 0.29 | 97%     |
| 1b    | 3  | Adopting advanced technical systems commensurate with future changes              | 3.00 | 0.00 | 100%    |
| 1c    | 4  | Providing advanced technical support services to support IoT application users    | 3.00 | 0.00 | 100%    |
| 1d    | 5  | Develop infrastructures to provide requirements for IoT use                       | 3.00 | 0.00 | 100%    |
| 1e    | 6  | Increasing budgets allocated to e-learning management systems development         | 3.00 | 0.00 | 100%    |
| 1f    | 7  | Developing faculties' digital skills                                              | 3.00 | 0.00 | 100%    |
| 7b    | 8  | Developing students' digital skills                                               | 2.91 | 0.29 | 97%     |
| 7c    | 9  | Spreading a culture of digital learning                                           | 2.91 | 0.29 | 97%     |
| 7d    | 10 | Spreading a culture of digital citizenship                                        | 2.91 | 0.29 | 97%     |
| 7e    | 11 | Spreading awareness of educational cloud computing applications                   | 2.91 | 0.29 | 97%     |
| 7f    | 12 | Building positive attitudes among educational leaders toward IoT use in education | 2.91 | 0.29 | 97%     |
|       |    |                                                                                   | 2.95 | 0.07 | 98%     |

Table (4) clearly shows the general mean was (2.95), meaning the experts' approval of the requirements for integrating IoT into higher education is high. All of this section's terms obtained an approval rate greater than 90%.

Points 1, 3, 4, 5, 6, and 7 came in the first place, with their text - "Introducing academic programs in the field of using IoT in education", "Adopting advanced technical systems commensurate with future changes", "Providing advanced technical support services to support IoT application users", "Develop infrastructures to provide requirements for IoT use", "Increasing budgets allocated to e-learning management systems

development" and "Develop faculties' digital skills". Points 2, 8, 9, 10, 11, and 12 followed in the same order, and their text – "Developing educational quality standards in the IoT context", "Developing students' digital skills", "Spreading a digital learning culture", "Spreading a digital citizenship culture", "Spreading awareness of educational cloud computing applications" and "Building positive attitudes among educational leaders toward IoT use in education".

This could be a result of the significance and requirement of creating academic programs in the area of IoT use in education and adopting technological systems that are adaptable to future changes, in addition to creating infrastructure and offering the required financial and technical support to ensure successfully integrating IoT into higher education, and suitably investigating this. In addition, it is critical to promote a culture of digital learning and foster positive attitudes toward it while also helping faculty members and students improve their digital skills.

To build teacher preparation programs in colleges of education and to enable the integration of IoT into the educational process, Abdulhamid's 2021 placed a strong emphasis on this requirement. According to Ibrahim and Alkhabra (2022), there is a need to design a strategy for the growth of its infrastructure, as well as to supply equipment and apps to handle large volumes of data and analyse it for decision-making. Aldowah et al's (2017) research further supported the fact that integrating IoT necessitates universities to work on developing infrastructure, systems, smart devices, and services, as well as the need for developing its human components to ensure successful IoT employment in the right way. El-Dahshan (2019) also emphasized the significance of updating privacy and intellectual property laws to include and safeguard students who use IoT.

## Conclusion

It is evident from the above that the experts concurred on future opportunities related to IoT platforms in higher education, as well as future opportunities related to content delivery; the evaluation of learning outcomes mechanisms, and the prerequisites for the integration of IoT into higher education.

## Recommendations

The researcher suggests making plans and getting ready to invest in upcoming prospects associated with learning platforms, content distribution methods, and evaluation techniques in the HE IoT context, based on the study's findings.

The researcher also suggests training faculty members on the use of IoT in the classroom. In addition, he suggests that universities establish the infrastructure, equipment, and systems required for integrating IoT into instruction, as well as academic programmes in the field of IoT application in education and educational quality standards within the IoT context.

In addition, the study suggests fostering positive views towards IoT use in education among educational leaders.

## Limitations

As with any other study, this research has certain limitations. This study was confined to academics from Saudi Arabia, Egypt, Jordan, the USA, the UK, and Australia, as well as to ICT specialists only.

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