International Journal of Data and Network Science 8 (2024) 1451–1462

Contents lists available at GrowingScience

International Journal of Data and Network Science

homepage: www.GrowingScience.com/ijds

Individual, technological, organizational, and environmental factors impact of the internet of things on e-learning adoption in higher education institutions in Jordan

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C H R O N I C L E

Article history:
Received: November 21, 2023
Received in revised format: January 12, 2024
Accepted: March 28, 2024
Available online: March 28, 2024

Keywords:
e-learning
IoT
Awareness
Attitude
Behavior
Jordanian

A B S T R A C T

The world of the Internet of Things (IoT), even though it is continuously morphing as a fresh paradigm at the intersection of technology and education, is still struggling with several difficulties that prevent its absorption into the e-learning platforms of higher education institutions (HEIs). The breadth of Internet of Things implementation in developing countries, particularly Jordan, Malaysia, Iran, Saudi Arabia, Iraq, and Bangladesh, remains behind, even though industrialized nations have made significant advancements in their utilization of IoT, with the United Kingdom, the United States of America, China, and Japan acting as prominent examples. In the realm of research that focuses on the progression of the IOT integration into the e-learning systems of economically challenged countries, there is a substantial disparity. In particular, the focus of this research is on Jordan to shed light on the primary variables that are either facilitating or hindering the adoption of the IoT within the e-learning sector of Jordan's HEIs. A comprehensive analysis of previous research has been undertaken as a first stage in this investigation. The goal of this analysis is to identify important factors that are involved in the process of IOT adoption. Following that, we used an inferential technique, collecting data from 306 respondents who were enrolled in Jordanian higher education institutions. During our investigation, we discovered that the rate of the IOT integration was significantly influenced by factors such as accessibility, usability, technical assistance, and individual capabilities. In addition, our findings suggest that factors such as attitude, behavior, financial preparedness, dependability, and training have a substantial impact on the adoption of the IOT. On the other hand, the study seemed to indicate that characteristics such as class capacity, awareness, system resources, and course design had a minor influence on the adoption rates inside HEIs. In conclusion, this study provides tangible suggestions to strengthen the integration of the IoT inside Jordanian HEIs. These recommendations provide significant insights that can be used by policy architects, government entities, and higher education institutions to overcome the challenges that relate to the deployment of IoT in the higher learning sector.

1. Introduction

In today's digital age, higher education institutions (HEIs) have seen significant changes in their teaching methods. This is mainly due to the complex mix of knowledge-focused individuals within these institutions, namely teachers and learners (Beyene et al., 2023; So et al., 2022). HEIs significantly influence several aspects of an individual's educational identity, including improving skills, developing competencies, enhancing personality, teaching abilities, self-learning abilities, and

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ISSN 2561-8156 (Online) - ISSN 2561-8148 (Print)

doi: 10.5267/j.ijdns.2024.3.020

acquiring communication skills. The addition of technology into these institutes results in a synergistic, dynamic, and self-regulating educational model. Technological advances have transformed the field of education, providing interactive learning experiences and the ability to create educational content (Dogan et al., 2023; Najmi et al., 2023). As a result, seven main types of strategies, technology, and tools have emerged: recognition technologies, internet technologies, digital tools, educational technologies, visualization technologies, and social media-related technologies (Najmi et al., 2023; Zhao et al., 2023). The Internet of Things (IoT) is an important participant in the ongoing digital revolution. It introduces the era of large-scale connectivity, enabling continuous, instantaneous, location-independent communications, without the need for setup or intervention (Rehman et al., 2023; George & Ravindran, 2020). In addition to this, the Internet of Things increases support for online learning and sales, it also provides HEIs with more control and increased scalability of infrastructure (Awan et al., 2019; George et al., 2021). In addition, it promotes resilience (Awan et al., 2019; George et al., 2021) and resilience.

IoT provides interactive features in education, improving communication between teachers and students, facilitating understanding, and seamlessly integrating online and offline academic materials (Bhandarkar et al., 2023). The integration of IoT devices into classrooms has significantly increased the focus on "smart learning", resulting in significant benefits for learners (Cassano et al., 2022). As a result, with the widespread use of online teaching by higher education institutions (HEIs), there has been an increasing demand to evaluate the usefulness of IoT technology. This has aroused the interest of scientists and researchers alike. Jordan's Ministry of Higher Education has developed a strategic plan for that ministry for the years 2020–2024 that emphasizes the importance of developing, enhancing, and aligning outstanding teaching, training, and research within the sector (Symaco & Bustos, 2022; Nagappan & Mukherjee, 2022). The IoT is positioned to achieve this goal and address related obstacles, providing a distinct alternative to traditional learning systems (Kale et al., 2022; Singh et al., 2023). However, it is important to note that nations that are still developing, such as Jordan, have not completely embraced the IOTs in their educational systems. In addition, there are technologies such as e-learning, mobile learning (Naddi et al., 2023), ubiquitous learning (Ramirez et al., 2023), and virtual teaching/learning methods (Botero-Gomez et al., 2023) did not have the transformational effect that was anticipated in the field of higher education. The aim of this research is to build a healthy approach to improving the addition of the Internet of Things into higher education institutions (HEIs), with a particular focus on developing countries.

In the modern world, when everything has been converted into digital form, the educational system has not yet included the most recent technologies that are associated with the IoT. There have been numerous phases of modernization that have occurred within the education system. These stages include transitioning from conventional learning techniques to the use of smart learning technology, which includes e-learning. The IoT is becoming an essential component of online education at HEIs. Students may participate in e-learning that is based on the IoT in an effective manner, while professors can easily assist their learning, creating an experience that is analogous to that of conventional education. Students will have simple access to all of the technology that is associated with the course, in addition to an intuitive user interface. Using this interface, they will be able to do their quizzes and exams online, and the system will immediately assess them. Additionally, the system will record evidence of their existence. Following the COVID-19 epidemic, e-learning that is built on the Internet of Things has the potential to provide a suitable educational system for future generations, which is of the utmost importance. We conduct an exhaustive investigation, evaluation, and comparison of several previously conducted research on the use of the IoT in online education to accomplish this objective. In addition, it places an emphasis on the facilities that are required and outlines the significant issues that need to be overcome to establish a successful e-learning system that is based on the IoT at HEIs. The study analyzes IoT-based e-learning adoption in higher education institutions, focusing on key issues and system functions. It proposes using an e-learning model based on IoT, categorizing factors into human, organizational, environmental, and technical. The adoption of IoT in higher education is influenced by four distinct groups: human, organizational, environmental, and technical. The study aims to identify which factors should be given the most attention for successful implementation.

There is a strong global push to establish and maintain a harmonious balance between the need for high standards, equity, and financial support in student enrollment amid rapid growth. However, research agrees that large class sizes have an impact on educational quality related to the study of the environment. Therefore, higher education institutions are always seeking habits to efficiently increase the number of students and convey high-quality information. To address the above-mentioned problem, the Internet of Things has been documented to resolve the occurrence of associated problems. The IoT offers a new and innovative online platform for teaching and learning that includes many elements of distance learning. This is a significant improvement over the previous e-learning system. The Internet of Things has been widely industrialized in highly industrialized countries, including the USA, Japan, China, and the UK. However, this research reveals a lack of IoT integration in education systems in emerging countries such as Jordan, Malaysia, Pakistan, Bangladesh, etc. The integration of virtual teaching, technology, and learning methods, such as e-learning, mobile learning, and immersive education, has had little impact on higher education institutions in terms of the changes they have experienced (Razzaq & Hamdan, 2020). Current scientific research indicates that there is a lack of use of IoT technology in HEIs for the purpose of e-learning in nations still to be developed. This research study indicates the paucity of research on the use of IoT for e-learning in higher education institutions in underdeveloped countries. However, studies indicate that the integration of IoT into higher education is now at an early stage, with only a few scientific papers dedicated to the topic. Moreover, there is a lack of evaluation of the impact of human, organizational, technical, and environmental factors on the adoption of IoT for e-learning in HEIs in both developed and developing nations. "What are the determining factors for IoT adoption in HEIs for e-learning?"

2. Literature Review

This study provides a comprehensive synthesis of the latest research findings on the use of IoT technologies in the context of online education within higher education institutions. In this section, we will begin by providing a summary of the research conducted on the IOT and e-learning in advanced education. Next, we will analyze the current body of literature related to these subjects. New studies have confirmed the effectiveness of some Internet of Things technologies in the field of e-learning. As an example, it has been shown that smart communication whiteboards have the capacity to improve student appointments and achieve higher levels of learning outcomes in virtual classrooms. When it comes to enhancing administrative processes in online learning settings, automated attendance systems, which are a sort of IoT application, have been shown to be of great use. In this part, the groundwork is laid for the IoT implementation plan that is being suggested for e-learning in higher education. To do this, it highlights significant results from the literature study and identifies areas that need more investigation.

2.1. The Internet of Things and E-Learning

IoT integration in higher education (Singh et al., 2023) is gaining popularity because it may improve educational procedures. Using IoT in e-learning may enhance outcomes and accommodate individual learning styles (Özbey & Kayri, 2023; Razzaque & Hamdan, 2020). Different individuals' study and remember information using different learning techniques. They greatly affect how students learn and engage with course content (Salhab & Daher, 2023; Chakabwata, 2023). The VARK model and Kolb's Learning Style Inventory categorize learning styles (Qaffas et al., 2023). Teachers may better accommodate students' learning styles by considering these models when creating lesson plans and course material. When incorporating IoT technology into classrooms, researchers recommend considering students' preferences (Troussas et al., 2023; Yeh, 2023). Recognizing and accommodating learning styles may help individuals accept the IoT (Opoku et al., 2023). E-learning project-based teaching methods (Opoku et al., 2023) may assist students in improving critical thinking, collaboration, and problem-solving abilities. However, cost, security, and infrastructure affect IoT adoption for e-learning in underdeveloped nations (Madni et al., 2022). The IoT can evaluate learning and deliver real-time feedback for personalized learning (Jasim et al., 2021). However, an analysis of current patterns, obstacles, and prospects for learning management systems in higher education institutions shows that LMSs face resistance to change, a lack of customization capability, and a lack of support. User reviews are analyzed using various categorization methods in intelligent e-learning systems (Wang et al., 2023), which may increase performance and user experience (Khamparia et al., 2020).

2.2. Internet of Things Adoption in Education

IoT studies in academia are frequent. Several studies have studied the effects of students' classroom IoT use (Negm, 2023). This section addresses education, IoT adoption studies, and methods. Negm (2023) analyzes how digital fluency affects college students' distant education IoT goals. Alhasan et al. (2023) used a case study to examine undergraduate students' IoT service consumption in smart classrooms. Shaqrah and Almars (2022) found that the unified theory of acceptance and technology helps schools deploy IoT devices. Sultana and Tamanna (2022) examined IoT applications' pros and cons in Bangladesh's school system during the COVID-19 pandemic. Others have also conducted research on IoT integration in e-government. Lubinga et al. (2023) address what South African higher education institutions face while embracing the fourth industrial revolution. In their study on IoT-based smart campuses, Sneesl et al. (2022) examined technological adoption factors. Kumar and Al-Besher (2022) wrote about cloud computing and IoT in education. Additionally, Rico-Bautista et al. (2022) suggested a preliminary set of critical technology adoption metrics for smart universities to promote IoT use in education. These studies illuminate the IoT's potential advantages and drawbacks in education and its adoption determinants. IoT has substantially affected smart education (Rico-Bautista et al., 2022). Higher education and student engagement are supported by IoT-enabled learning systems (Kumar et al., 2023). Smart campuses employ the IoT to control energy, security, and transportation (Sneesl et al., 2022). In 2020, Romero-Rodrguez et al. surveyed many Spanish institutions to get their perspectives on the use of IoT in education. The quantitative analysis of academic data demonstrated that the IoT might increase information availability, teaching quality, and student learning. Scholars and instructors contemplating IoT use in higher education should read the paper. IoT is a fast-growing area that has entered education. There are several ways the IoT may benefit education and student learning. However, IoT integration in education faces hurdles. Innovation, ICT proficiency, and other factors have been explored for IoT acceptance in education (Sneesl et al., 2022; Gökçearslan et al., 2022; Ahmetoglu et al., 2022). Classroom IoT usage has proved problematic. IoT installation is difficult (Gupta and Alam, 2022). ICT infrastructure, data security, and privacy are further issues (Alhazmi et al., 2022). A new IoT design to smoothly incorporate the IoT into university systems addresses these issues (Altwoyan & Alsukayti, 2022). Besides regular schooling, IoT integration has helped vocational education. A block chain- and internet-powered vocational education platform connects classroom learning to real practice (Li et al., 2022).

2.3. E-Learning

Due to technology in the classroom, HEIs have created e-learning systems. E-learning uses electronic media and ICT to teach. Students who cannot attend conventional classrooms may nevertheless get a high-quality education via e-learning (Kundi and Nawaz, 2014). COVID-19 has accelerated the shift from classroom to online learning at postsecondary institutions. When integrating e-learning technologies, HEIs encounter challenges such as infrastructure, staff training, and student digital literacy. Evaluating HEIs' e-learning readiness and identifying factors that affect e-learning system adoption and effectiveness are crucial. E-learning perceptions by HEI stakeholders should also be examined. Online education and pedagogical innovation organizational strategies are needed for HEIs to construct and operate e-learning systems (Salmon, 2005). This literature review examines the present state of e-learning in HEIs, its potential and problems, and stakeholders' views and attitudes toward e-learning systems. Several studies have examined the usefulness of e-learning systems in postsecondary institutions, focusing on student pleasure. Research has identified simplicity, system quality, service quality, and information quality as key determinants of student satisfaction with e-learning systems. E-learning systems include downsides such as lack of instructor and peer interaction, difficult course material, and poor feedback. Over the last decade, universities and colleges have offered more online courses. "E-learning" refers to the distribution of educational resources and activities over the web, cellphones, and tablets. Higher education institutions (HEIs) use e-learning to enhance quality, extend alternatives, cut costs, and boost access (Embi et al., 2011). Despite its benefits, HEIs have struggled to use e-learning technology. Insufficient teacher and student training, technological infrastructure, and regulations and standards for e-learning implementation have hindered its adoption in HEIs (Nawaz et al. 2012). Thus, HEIs require a uniform methodology to build and distribute e-learning programs. HEIs' adoption and use of e-learning have been investigated in relation to faculty and student trust, attitudes, and viewpoints. Research has also examined student e-learning satisfaction factors. Other research has built e-learning benchmarking models, investigated adoption barriers and facilitators, etc. Cloud computing may be able to address HEIs' e-learning deployment and usage problems. Scalability, cost-effectiveness, adaptability, and dependability are benefits of cloud-based e-learning systems (Najmi et al., 2023). Thus, cloud-based e-learning technologies must be investigated, and HEIs must establish frameworks and criteria for their use.

3. Theoretical Framework

This section describes the study's research methods. Following a thorough analysis of current studies, others identified the HEI IoT for E-Learning adoption criteria. The research approach needs publications from Web of Science, Taylor & Francis, Springer, Scopus, Science Direct, Google Scholar, IEEE Explore, and the ACM Digital Library. This research builds on 2016–2024 investigations. The search key phrases that provide the most relevant connected research papers are ("E-Learning" + "Internet of Things" + "IoT" + "Higher Educational Institutes" + "HEIs") and ("E-Learning" AND "Internet of Things" OR "IoT" OR "Higher Educational Institutes" OR "HEIs"). First, duplicate studies are deleted during screening. The title, abstract, and body of the study publication were then used to apply exclusion criteria. The inclusion and exclusion criteria were also based on the study's emphasis on e-learning technology adoption, written in English, and published in reputable journals and conferences. A thorough list of e-learning elements for IoT adoption in HEIs has been created after content analysis categorizes the influencing factors. The IoT is a new paradigm for technology innovation and educational applications that might enhance HEI e-learning. Despite developed nations' IoT adoption, emerging nations like Jordan have not. Our investigation took learning styles into account. We utilized VARK-based survey questions to learn about students' learning styles during data collection. This information helped us determine how learners' choices affect IoT tool adoption in virtual classrooms.

It is therefore plausible to hypothesize that:

H_1: *The impact of the Internet of Things on e-learning adoption in higher education institutions in Jordan is heavily impacted by accessibility, usability, user expertise, and technical support.*

3.1 E-learning Factors Influencing IoT Adoption at HEIs

Adoption of the Internet of Things is essential for successful e-learning. When it comes to learning, individuals and organizations are required to operate within a technological environment that requires them to adhere to certain procedures to achieve success and efficiency. eLearning elements that influence the Internet of Things adoption model in higher education institutions are categorized into four categories for this purpose, as illustrated in Fig. 1. These groups include people, organizations, technological advancements, and the environment. Attitude and behavior are the foundations upon which individuals are built; institutions and universities are the foundations upon which organizations are built; technology is built upon gadgets and tools; and the environment is built upon communities and houses.

Individual Factors

Instructors and students need IoT-based e-learning abilities to succeed. People should be self-motivated by learning a lot from IoT-based e-learning and having computer skills. Everyone must be moral and careful in their acts and attitudes. Interactive learning sessions between students and teachers improves learning. Students may provide instructors with comments on how they're studying and if they need clarification. Instructors may automatically store attendance using the IoT-based e-learning sign-in record (Agrawal et al., 2020). Subsections discuss individual factors: Attitude is how you feel about goals, events, and assumptions. E-learning helps instructors provide online lessons, feel secure, and encourage distant learning. Positive sentiments regarding e-learning increase students' interactive desire to utilize IoT or smart gadgets. Students anticipate instructors using high-tech IoT-based e-learning settings to help and advise them (Madni et al., 2022). Behavior is how you behave or do something. Behavior affects everything, including IoT-based e-learning uptake. E-learning requires a goal, motivation, synchronous feedback, and learner autonomy. Student learning habits significantly affect all roster students' development and successes. When a student disrupts class, certain teaching plans may be ruined. Instructors must help students complete online learning activities behaviorally. It is therefore plausible to hypothesize that:

H$_2$: *Individual factors (attitude and behavior) significantly impacted the Internet of Things on e-learning adoption in higher education institutions in Jordan.*

Technological Factors

Implementing IoT-based e-learning requires technical equipment or tools. Instructors and students must be able to use IoT devices and platforms easily. IoT-based e-learning systems require a stable structure and easy content addition. They also need enough IoT resources to utilize it effectively. For people to trust the system, it should have adequate network and data security. To handle user difficulties, the technical support system may be built up for each kind of query (Razzaque & Hamdan, 2020a; Madni et al., 2022). The following subsections cover technological aspects. Awareness means understanding IoT-based e-learning uptake and implementation. Students and teachers are ignorant of the advantages of IoT, or smart devices, in HEIs. E-learning awareness seminars and briefings should be part of the academic curriculum to overcome this. Educational institutions must create policies and processes for e-learning. Users should be instructed on how to utilize the IoT-based e-learning system when they log in to prevent unethical behavior (Kumar, 2018; Madni et al., 2022). Learning systems with efficient structures maximize productivity. Virtual classrooms and e-learning systems may have very few or many students without influencing cost. IoT-based e-learning improves learning and student engagement. According to Srivastava (2019) and Madni et al. (2022), IoT-based e-learning saves students travel and material expenses and enhances performance. Reliability indicates constant and trustworthy performance. Reliable and trustworthy user-e-learning system linkages help students learn efficiently. A reliable technological infrastructure makes IoT-based e-learning courses more interactive between teachers and students. Also, good dependability increases user acceptance of the system (Madni et al., 2022). IoT smart devices, networks, virtual classrooms, virtual exam halls, e-invigilators, conference rooms, course materials, and more are elements of IoT-based e-learning systems that enhance their performance. Computer programs provide straightforward, easy-to-execute learning resources. E-learning technologies improve HEI students' performance by teaching them (Madni et al., 2022). It is therefore plausible to hypothesize that:

H$_3$: *Technological Factors (Awareness, Efficient Structure, Reliability, and System Resources) significantly impacted the Internet of Things on e-learning adoption in higher education institutions in Jordan.*

Organizational Factors

Organizations include universities and institutions. However, organizations must develop the course before posting and make the website user-friendly. They should also consider if they can afford to produce a course and satisfy future obligations. The website should be infrastructure-ready, so an online exam, test, or quiz may be taken and monitored to see if everything goes well.

The following subsections discuss organizational factors.

IoT, or smart gadgets, may improve academic quality, course evaluation, and learning methods. Motivation for student performance depends on the learning material. HEIs should have clear rules for IoT-based e-learning course strategies. IoT-based eLearning course design should include design, operational planning, and development assistance for teachers. The education board offers e-learning solutions to highlight comprehensive, customizable, and adaptable IoT packages or smart device costs for HEIs to fulfill their individual demands and goals utilizing e-learning technology. IoT smart gadgets and technologies cost more than traditional learning systems. Due to its high-tech nature, e-learning has substantial development and maintenance expenses. Higher education institutions invest <25% of their money in e-learning technology and apps. Online exams are questionnaires or e-exams. Students may take virtual tests worldwide. Lack of computer and Internet abilities, fear of technology, and cheating in tests as there are no supervisors to invigilate and supervise the exam flow are the primary challenges to online e-learning exams. Online exams are straightforward to administer since the automated timer lets students finish in the allotted time and saves and closes the test interface. The e-proctor needs a fingerprint scanner and an eye tracker with a camera to verify a student's identity, but instructors in the virtual hall can easily design, monitor, mark, and set the online exam's time. Training is teaching someone a skill or technique. Due to a dearth of qualified computer teachers, smart or IoT-based e-learning systems need instructor training. Corporate training packages tailored to a particular educational institution are the most effective teacher training and reorientation in the smart learning environment. Lack of disciplined and efficient learning is the major reason HEIs lack appropriately qualified workers (Liu et al., 2018). It is therefore plausible to hypothesize that:

H$_4$: *Organizational factors (course design, financial readiness, and training) significantly impacted the Internet of Things on e-learning adoption in higher education institutions in Jordan.*

Environment Factors

Learning takes place in schools and homes. To fully grasp the IoT-based e-learning system, students and instructors should be taught before posting the course. Privacy and ethics should be addressed while running an online classroom. The conference room, class size, and internet speed must also be considered. The faculty should also help the class use the IoT-based e-learning system. The following subsections discuss environmental influences. IoT-based e-learning offers infinite class capacity. There is no limit on the number of virtual classroom attendees. Participants get an e-link to join the class. The room hosts real-time virtual lectures by instructors. Online instructors may post limitless course materials for students. Students may download course materials anytime, anywhere. It is therefore plausible to hypothesize that:

H_5: *Environment Factors (Class Capacity) significantly impacted the Internet of Things on e-learning adoption in higher education institutions in Jordan.*

4. The Methods and Procedures for the Collection of Data

In the methodology that was presented, the techniques and processes for collecting data comprised several phases that were designed to guarantee the correctness and dependability of the data. To begin, we carried out pilot research to modify the data gathering instrument in accordance with the findings that were gathered. In the next step, a list of educational establishments of a higher level was gathered from the website of the Jordanian Ministry of Education. From the websites of these organizations, we were able to collect the contact information of individuals who might be interested in responding. A total of 420 individuals were selected at random and asked to take part in the data-gathering operation using several avenues of communication, including email and other social media platforms. Between the months of December 2023 and January 2024, data were collected. In all, there were 338 responses; however, throughout the process of filtering the data, we had to exclude 32 of them since they were either inconsistent or lacked information. In the end, to conduct a statistical analysis, 306 responses were retained. To ensure that the responses would be reliable and accurate, we invested a significant amount of work in the technique of data collection. This was done to ensure that the samples would be representative of the population.

4.1 Sample Selection and Characteristics

This research involved a total of 306 people who were selected for sampling. Participants came from Jordanian universities and were chosen at random from among those institutions. Participants were required to meet the entrance requirements, which included being a Jordanian citizen and being enrolled in a university at the time of the competition. An equal number of males and females made up the sample, with 62% of the participants being male and 38% being female. The ages of the participants varied from 18 to 30, with 22 being the average age. Most participants were undergraduates, accounting for 78% of the total, while the remaining 22% were graduate students. Participants came from a wide range of fields, including engineering, commerce, the humanities, and science, among others. Seventy-nine percent of the participants were full-time students, while twenty-one percent were part-time students.

4.2 Data Analysis

The suggested method makes use of SmartPLS4, a piece of software that is designed to do incomplete examination of structural least squares (PLS-SEM4) prototypes about this investigation.

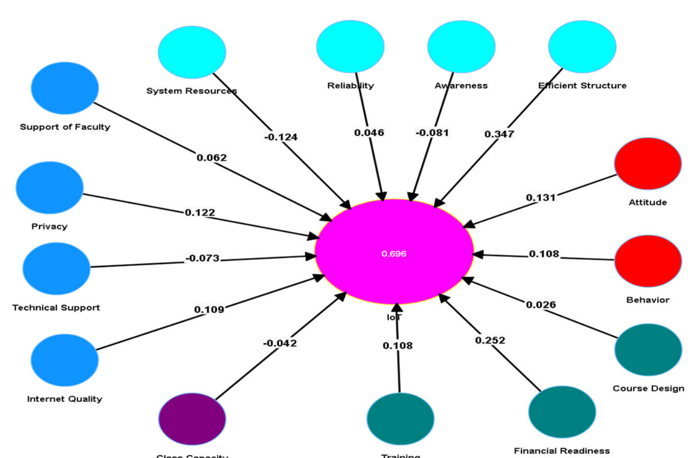

Fig. 1. The proposed Internet of Things adoption model for e-learning in SmartPLS4 testing

Fig. 1 is an illustration of the execution of the suggested technique in SmartPLS4 as well as the results of the data relevant to the approach. For the last several years, PLS-SEM4 has gained popularity as a statistical tool for studying complex connections between factors in enormous datasets. This is shown by the fact that it has been increasingly widely used. Applications of this program may be found in the social sciences, such as economics and management, where it is often used for the purpose of analyzing the correlations that exist between latent variables. Users can do PLS-SEM studies, which include model formulation, estimate, and assessment, with the help of SmartPLS4, which is a complete program that is well-known for its user-friendliness, versatility, and scalability. Researchers can concentrate on their study issues rather than their software skills since the program offers an accessible interface that makes the demonstrating process easier to understand. In addition, the application has several different methods for evaluating models, such as bootstrapping, which will make it possible for researchers to evaluate the statistical significance of their results. During this investigation, the suggested method makes use of SmartPLS4 to do data analysis and put research hypotheses to the test. Table 2 illustrates the several stages that are involved in the analysis process. These stages include the specification of the model, the assessment of the measurement model, the evaluation of the structural model, and the analysis of the brokerage. Researchers can adjust their analysis to their research topic and the properties of their data, which are depicted in Table 3. SmartPLS4 provides a choice of alternatives for these processes, enabling them to do so.

Table 2
Measurements of the Internet of Things Adoption Model for E-Learning in SmartPLS4

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Attitude	0.6	0.664	0.783	0.551
Behavior	0.672	0.735	0.816	0.6
Class Capacity	0.638	0.643	0.846	0.733
Course Design	0.521	0.523	0.806	0.676
Efficient Structure	0.54	0.625	0.804	0.675
Financial Readiness	0.693	0.693	0.867	0.765
Internet Quality	0.509	0.518	0.802	0.67
Privacy	0.776	0.788	0.868	0.688
Support of Faculty	0.831	0.838	0.898	0.747
System Resources	0.831	0.852	0.898	0.746
Technical Support	0.748	0.748	0.888	0.799
Training	0.798	0.798	0.881	0.712

Table 3
A Structural Internet of Things Adoption Model for E-Learning in SmartPLS4

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Attitude → IoT	0.331	0.126	0.078	11.674	0.004
Awareness → IoT	0.381	-0.077	0.094	6.862	0.009
Behavior → IoT	0.308	0.108	0.075	6.436	0.001
Class Capacity → IoT	0.342	-0.049	0.095	5.441	0.009
Course Design → IoT	0.326	0.025	0.049	5.533	0.004
Efficient Structure → IoT	0.347	0.342	0.059	5.878	**0.078**
Financial Readiness → IoT	0.252	0.248	0.057	4.436	0.002
Internet Quality → IoT	0.309	0.113	0.066	4.658	0.007
Privacy → IoT	0.322	0.124	0.062	4.968	0.009
Reliability → IoT	0.346	0.054	0.098	4.468	0.001
Support of Faculty → IoT	0.362	0.068	0.068	3.912	0.002
System Resources → IoT	0.224	-0.124	0.054	3.304	0.001
Technical Support → IoT	0.373	-0.073	0.103	3.704	0.001
Training → IoT	0.308	0.11	0.104	3.037	0.003

5. Results Analysis

The measurement model was used to investigate the validity and reliability of the research model. The results of this investigation are shown in Table 4, which provides an example of the method. The procedure for measuring the efficacy of the instrument makes use of two metrics: composite dependability and Cronbach's alpha. Both metrics are used to measure the reliability of the instrument. The calculation of a model's discriminant validity and its Average Variance Extracted (AVE) is another method that may be used to assess the dependability of a methodology. The fact that both the Cronbach's alpha and composite dependability values were higher than 0.600 demonstrates that the model satisfies the quality requirements for dependability. Similar to this, the AVE values are more than 0.50. The purpose of this analysis is to determine whether or not the measures used in the research are trustworthy and valid, as well as whether or not they are evaluating the appropriate factors. Within the first column, a list of the several elements that were assessed is shown, including “Attitude” and “Behavior”. Cronbach's alpha, rhoA, and composite reliability are the three separate metrics of reliability that are shown in the next three columns. These metrics, which provide an indication of exactly that degree, allow one to determine the level of internal consistency that exists among the items that evaluate each component. To ensure that there is internal consistency, it is widely believed that a value of 0.7 or above is desirable. The final column, which is referred to as AVE, displays a measure of convergent validity. The acronym is a representation of this metric. The purpose of this strategy is to determine the extent to which the elements that assess each feature are related to each other and not to any other aspects. It is necessary to have a value of 0.5 or above for it to be considered acceptable for convergent validity. A conclusion may be drawn from the information shown in Table 2, which demonstrates that the measurements that were used in the study project are reliable and valid for the components that were investigated. Most of the components have AVE values that are acceptable (in excess of 0.6) and excellent internal consistency measures (in excess of 0.8), which suggests that the measurements are consistent with each other and related to each other in the manner that was intended. The fact that "Course Design" has a lower CA and AVE, on the other hand, is something that should be brought to your attention. This implies that the measurements for this component may be less consistent than those for the other components.

Table 4
Construct Reliability and Validity.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Attitude	0.667	0.664	0.783	0.551
Behavior	0.672	0.735	0.816	0.6
Class Capacity	0.638	0.643	0.846	0.733
Course Design	0.621	0.523	0.806	0.676
Efficient Structure	0770	0.625	0.804	0.675
Financial Readiness	0.693	0.693	0.867	0.765
Internet Quality	0.709	0.518	0.802	0.67
Privacy	0.776	0.788	0.868	0.688
Support of Faculty	0.831	0.838	0.898	0.747
System Resources	0.831	0.852	0.898	0.746
Technical Support	0.748	0.748	0.888	0.799
Training	0.798	0.798	0.881	0.712

Table 5
Fornell–Larcker Discriminant Validity

	Attitude	Behavior	Class Capacity	Course Design	Efficient Structure	Financial Readiness	Internet Quality	Privacy	Support of Faculty	System Resources	Technical Support	Training
Attitude	1											
Behavior	0.602	1										
Class Capacity	0.589	0.637	1									
Course Design	0.544	0.568	0.559	1								
Efficient Structure	0.579	0.581	0.603	0.447	1							
Financial Readiness	0.519	0.531	0.603	0.465	0.558	1						
Internet Quality	0.585	0.641	0.773	0.545	0.577	0.536	1					
Privacy	0.609	0.669	0.68	0.609	0.586	0.535	0.631	1				
Support of Faculty	0.611	0.595	0.654	0.519	0.616	0.58	0.589	0.639	1			
System Resources	0.447	0.436	0.488	0.417	0.566	0.507	0.458	0.444	0.62	1		
Technical Support	0.662	0.694	0.739	0.642	0.701	0.694	0.704	0.787	0.789	0.69	1	
Training	0.625	0.664	0.846	0.555	0.66	0.711	0.645	0.671	0.678	0.535	0.784	1

A correlation matrix is shown in Table 5, which illustrates the links that exist between the many variables that are investigated in a scientific investigation. There is a correlation coefficient between those variables, and the dictionary values indicate that connection. A positive correlation coefficient (one variable increases as the other rises) and a negative correlation coefficient (one variable rises as the other lowers) are the two kinds of correlation coefficients that may be used to describe the relationship between the direction and magnitude of two variables. It may be concluded that there is no connection between the two components if the correlation coefficient is equal to zero. According to this specific plot, there are certain variables that have a strong positive correlation (near to 1) with one another, while there are other variables that have a strong negative correlation (close to -1). For instance, the variables Attitude, Behavior, Class Capacity, Course Design, Efficient Structure, Financial Readiness, Privacy, Technical Support, Support of Faculty, and Training have a positive correlation with one another. On the other hand, the variables System Resources, Internet Quality, and Financial Readiness have a negative correlation with one another. The strength of the correlations varies greatly, with some variables being more tightly related than others. There is a tremendous degree of diversity in the strength of the correlations. In this regard, for instance, efficient structure has relatively significant negative correlations through most additional variables, though attitude has substantial positive connections through class capacity, course design, efficient structure, financial readiness, privacy, technical support, support of faculty, and training. Our assumptions were put to the test by using the structural model, which allowed us to evaluate the route coefficients. In the field of publication, it is generally agreed that a p-value of 0.05 or below is indicative of a statistically significant finding. Self-efficacy, financial limitations, online monitoring, training, technical assistance, interaction, network and data availability, tools, automated attendance, and security are all covered in the Internet of Things Impact-Introduction to Human Language Interface, as shown by the findings. On the other hand, the p-values for accessibility, privacy, usability, effectiveness of structure, and support for faculty admission were not supported.

6. Discussion

The study's e-learning model has four primary components: organization factors, environment factors, individual factors, and technology factors, as shown in Fig. 2. T-statistics for subcomponents indicate the specific variables' important contributions to the general efficacy of the e-learning model. Environmental factors comprise class capacity, with a t-statistic of 3.002, indicating that although class capacity is significant, it may not be the most crucial element in e-learning performance. The strong t-statistic value of 5.232 for class capacity supports Hypothesis H2, indicating its considerable impact on the achievement of e-learning. The strong t-statistic value of 7.001 for training supports Hypothesis H4, indicating its considerable impact on the success of e-learning. Organizational components consist of course design, financial preparedness, and training. The subcomponent with the highest t-statistic worth of 7.001 was training, suggesting its significant impact on the success of e-learning. The t-statistics for course design is 2.234, indicating moderate significance. The financial preparedness, with a t statistic of 6.342, is a substantial obstacle to e-learning adoption.

An understanding of technology, efficient structure, reliability, and system resources are the components that make up technology aspects. In terms of dependability, the t-statistic is 5.232, which indicates that it is quite significant. The resources of the system have a t-statistic of 3.112, which indicates that it is possible that they are not significant. Considering that the t-statistics for awareness and efficient structure are 1.887 and 1.998, respectively, it is possible that these two factors do not have a substantial impact on the success of e-learning experiences. The high t-statistic value of 5.232 for reliability demonstrates that it has a considerable impact on the efficiency of e-learning, which is a confirmation of Hypothesis H3. Attitude and conduct are both included under the personal com. This evidence supports our first hypothesis, H5, which proposed that attitude is a significant determinant for the effective adoption of the Internet of Things in e-learning in Jordanian higher education institutions. It was determined that behavior has a significant impact on the effectiveness of e-learning, as shown by the t-statistic value of 7.002. Given that the attitude t-statistic is 11.22, it is reasonable to assume that it is the most significant element in the success of e-learning.

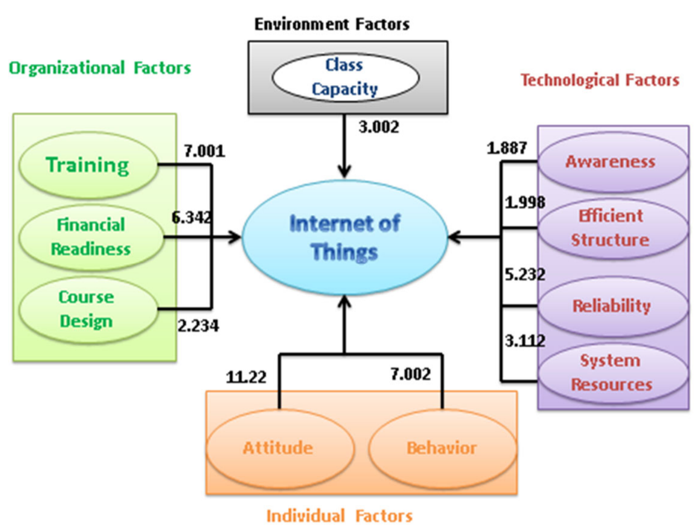

Fig. 2. The final Internet of Things-based e-learning model for higher education institutions

Our results indicate that the e-learning model that has been developed, which is equipped with a variety of aspects including environmental, organizational, technical, and human factors, has the potential to have a substantial influence on the success of an e-learning program. According to the findings of our research, the preferred learning style of students, which may include learning best by seeing, doing, hearing, or reading and writing, has a major impact on the level of engagement and success that they experience using Internet of Things-based e-learning. Students who learn best through seeing and doing displayed better engagement with technologies based on the Internet of Things, according to our findings. This study strengthens our belief that the effective design and implementation of Internet of Things technologies in e-learning must take into account the variety of learning styles displayed by students. According to these results, Internet of Things technology may make it possible to create online classrooms that are more inviting and that can accommodate students who have a range of learning styles. To be more specific, we demonstrate that the most significant sub-components of the model are interaction, training, attitude, behavior, financial preparedness, and dependability. These sub-components have high t-statistics, which indicates that they have a major influence on the effectiveness of e-learning. The t-statistic for behavior was determined to be 7.002, which indicates that it has a significant impact on the achievement of success in e-learning scenarios. That individual competency, which includes elements such as conduct, has a key influence on the adoption of the Internet of Things for e-learning in Jordanian higher education institutions is supported by this evidence, which also lends credence to Hypothesis H2 and Hypothesis H1. According to the findings of a study, these results indicate that well-designed e-learning programs should prioritize the creation of learning environments that are interactive and engaging, as well as the provision of proper training and supervision and the consideration of the budgetary restrictions of learners.

Our results have a wide range of implications, not only for theoretical frameworks but also for actual applications. The results support the relevance of an integrated approach to e-learning that considers technical, organizational, and human factors. When it comes to the creation and implementation of e-learning, this approach places an emphasis on the significance of considering the complex interaction that exists between technology, instructional strategies, and learner characteristics. According to the findings, e-learning programs need to prioritize the development of dynamic and engaging learning environments, the provision of appropriate training and supervision, and the consideration of the budgetary constraints of learners, respectively. A few of the discoveries that emerged from our study questions and hypotheses are as follows:

To proving that accessibility, technical help, individual, and usability competency all had a significant influence on the adoption of the Internet of Things (IoT) for e-learning in Jordanian higher education institutions (HEIs), the results provided support for Hypothesis 1. Therefore, increasing these characteristics could be able to increase the adoption of the internet of things in these establishments. According to the findings of our study, hypothesis 2 (H2) was confirmed by the evidence of a considerable association between the adoption of the Internet of Things (IoT) for e-learning in Jordanian higher education institutions (HEIs) and individual factors such as attitude and behavior. The successful implementation of the Internet of Things demands attention to these concerns. Our research showed that there was a strong link between using the Internet of Things (IoT) for e-learning in Jordanian higher education institutions (HEIs) and technical factors like system resources, dependability, and awareness. This supported the third hypothesis (H3). The successful implementation of the Internet of Things demands attention to these concerns. Our research showed that there was a strong link between using the Internet of Things (IoT) for e-learning in Jordanian higher education institutions (HEIs) and things like course design, financial preparedness, and training. This supported the fourth hypothesis (H4). The successful implementation of the Internet of Things demands attention to these concerns. The findings of our study indicated that Hypothesis 5 (H5) was supported by the evidence of a significant association between the use of the Internet of Things (IoT) for e-learning in Jordanian higher education institutions (HEIs) and environmental parameters, including class capacity. The successful implementation of the Internet of Things demands attention to these concerns. Our findings disproved hypothesis number six, which claimed that several factors including infrastructure preparation, usability, accessibility, privacy, faculty support, and internet quality influenced the rate of Internet of Things adoption for e-learning in Jordanian higher education institutions. Considering this, it is of the utmost importance to reassess these characteristics and determine how they influence the proliferation of the Internet of Things.

To test the hypotheses and answer the research questions, we first determined which features were the most important for the implementation of the Internet of Things (IoT) in e-learning in Jordanian higher education institutions (HEIs), and then we analyzed the significance of these aspects. Based on the findings of our investigation, we provide the following recommendations for enhancing the use of the Internet of Things in Jordanian educational institutions of higher learning (RQ3): Providing user-friendly interfaces and a reliable internet connection are two of the most significant things that can be done to improve usability and accessibility. For people to increase their abilities and their sense of self-confidence, it is essential that they have access to adequate training and technical assistance. There must be a budget that is adequate to allow for the investment in high-quality Internet of Things technologies and infrastructure, even though there are financial obstacles. Additionally, a secure learning environment must be provided, and the privacy of users must be respected. It is possible to achieve this goal by increasing the amount of data and network security measures that are enforced. It is imperative that teachers remain current with the Internet of Things (IoT) and that they incorporate it into their teaching practices.

The limitations of our investigation, like those of any other study, should be acknowledged and taken into consideration. To begin, our poll was carried out in a particular situation, and it is possible that the findings will not be applicable to other environments. These limitations might be addressed in further research by conducting studies in a variety of settings and making use of a wide range of data sources, including observational data and performance measures, among others. Last but not least, the purpose of our research was to determine the relative significance of a number of characteristics that contribute to the success of e-learning; however, we did not investigate the processes that these factors utilize to function. The underlying processes and mechanisms that are responsible for the many aspects that impact the results of e-learning might be investigated in future study, which could help fill this gap. According to the findings of our study, the effectiveness of e-learning is dependent on several factors, including attitude, behavior, financial preparedness, dependability, and training. Because of these characteristics, which provided substantial support for our hypotheses H1, H2, H3, H4, and H5, a complete approach that takes into account these aspects has the potential to dramatically increase the use of the Internet of Things in e-learning. The following are the important elements that influence the adoption of the Internet of Things in Jordanian higher education institutions: attitude, behavior, financial preparedness, dependability, and training. These results are in response to RQ1.

7. Conclusions

A paradigm shift has occurred in the field of e-learning because of the introduction of the IoT, which is exemplified by developments for example teaching tools, automatic attendance systems, and smart gadgets that are enabled by the IoT. Within the context of a digital environment, it has the capability to adapt with the ever-changing requirements of educators and students, hence increasing learning standards, especially in developing countries. This study's research technique consists of an all-encompassing model that has the potential to act as a road map for decision-makers working inside HEIs, therefore directing the planned adoption of the Internet of Things by providing them with direction. One of the most important aspects of incorporating the Internet of Things into online education in HEIs is having a sophisticated grasp of the many learning approaches that students have. The findings of our research highlight the critical need for policymakers and educators to not only be aware of the many learning panaches that exist, but also to actively include these types into the process of designing and implementing Internet of Things-based e-learning solutions from the very beginning. This imperative is echoed by the actual information that we obtained over the course of our investigation. To facilitate the efficient execution and smooth adoption of the Internet of Things in e-learning, the results of our study highpoint the critical role that various element such as attitude, behavior, financial readiness, reliability, and training via IoT-enabled course design, financial readiness, training, and IoT-enabled teaching tools play. Our results imply that elements that are typically assumed to be significant, such as infrastructure adoption, course design, class capacity, awareness, and efficient structure, do not substantially affect the adoption of the Internet of Things (IoT) for e-learning in higher education. This is an interesting hypothesis to investigate. Specifically in the context of the deployment of the internet of things for e-learning, these discoveries have major consequences for policymakers and government agencies, particularly those in the higher education sector. Regarding the first research question, our investigation reveals significant factors that influence the adoption of the Internet of Things in Jordanian higher education institutions. These factors include attitude, behavior, financial preparedness, system resources, dependability, and training. In answer to RQ2, the most important component was the individual's attitude, followed by the individual's conduct, training, willingness to contribute financially, and dependability. These results provide policymakers with key data points that may be used to guide their choices on the deployment of the internet of things.

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