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Quantifying the Managerial and Practical Benefits of Cloud Computing on Information Security in Higher Education Institutions

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Abstract: The emergence of cloud computing has completely transformed the management of IT and communication networks. Cloud computing is a modern approach to storing and accessing data and applications through a shared network, typically the Internet. There are several concerns associated with cloud computing, such as privacy and security issues, dependence on external providers, and the allocation of resources in shared environments. This study aimed to determine the crucial factors of cloud computing that Jordanian universities and colleges need to consider when deciding to adopt it. In this paper authors want to ensure that these institutions have a comprehensive understanding of cloud computing. This study developed a framework for adopting cloud computing in middle and high schools by incorporating a range of ideas and frameworks. This research utilized various frameworks such as Technology, Organization, and Environment, the Technological Acceptance Model, and the Diffusion of Innovation hypothesis. A framework called the Technology-Organisation-Environment-Quality of Cloud Computing Adoption by developed by the authors using relevant theories and concepts. Exploring the factors that affect the integration of cloud computing in JHEIs can greatly enhance one's knowledge in this field. There were eleven different groups in Jordan, both public and private, that participated in this study. To ensure the accuracy of our findings, enhance data visualization, and optimize our research process, we utilized NVivo. Tables, pies, bars, and columns were utilized to create visual representations of statistical and frequency data. Additionally, the Visio and Business Intelligence programs created by Microsoft were utilized.

Keywords: Cloud Computing, Higher Education, Quality of secure information, Mathematical cloud effect, Security.

1 Introduction

Science has long debated the pros and downsides of using ICT in classrooms. Unfortunately, institutions with third nations like Jordan have not been the subject of much study about the possible use of cloud computing. Finding solutions to the problems that prevent JHEIs from using cloud computing more widely is the main goal of this study. The aim was successfully accomplished by applying a conceptual framework for cloud computing technology.

Investigating the core elements that affect JHEIs' using of cloud technology is critical, as is developing a quality-focused conceptual framework based on these traits. For the sake of (JHEIs), I'm hoping this will lead to a plan for making the most of cloud computing. Finding out what kinds of advantages cloud computing may provide to schools and colleges was the driving force for this research. Transferring to cloud systems and how it might improve educational results are topics of ongoing research. The main objective of this study is to analyze how educational institutions in Jordan have revised their pedagogical approaches in response to the advent of new forms of information and communication technology, particularly cloud computing. Among the many indicators that JHE is ineffective are the high unemployment rate among recent grads and the poor ROI. The inefficiency of Jordan's university programs is plain to see. One of the several reasons for these deficiencies is the academic establishment's unwillingness to accept and use sophisticated types of ICT in the classroom. There are a lot more.

2 Research Problem

A country's ability to adapt to changing social and economic circumstances depends on improving the quality

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of its education [2-4]. The capacity of higher education institutions to make an education that is up to par with international standards is being questioned by certain industry professionals [5-9]. Because of this might fall behind in the global knowledge economy and struggle to address future social and developmental demands. The educational system in Jordan, however, continues to use a variety of antiquated practices. Without cloud computing, small institutions run the danger of being left behind their rivals. The elements that influence acceptance need to be further studied in order to develop the process that promotes the usage of new technology in middle and high school. Jordanian higher education institutions (JHEIs) may streamline and improve their computer operations by switching to a cloud-based architecture.

3 Study Theoretical Foundation

After settling on a central research topic and perusing pertinent prior literature, this study project came into being. Colleges in Jordan may gain from a fresh approach that zeroes in on the main drivers of cloud technology expansive adoption. Remote services that are hosted by other parties. Cloud computing allows for the storage, sharing, and management of data on distant computers via the use of applications and services [10]. A plethora of computer resources, including distributed and grid computing, massive storage capacity, and rapid processing, are available via cloud computing. Capacity is another topic of continuing controversy [11]. Distributed computing systems may be set up by integrating different components such software, hardware, networks, and storage. This setup makes it possible to provide apps and services over the internet. [12-14].

Public, private, shared, and hybrid cloud models are among the many varieties of this technology. Public cloud services provided by major IT businesses may be accessed for free or at a small cost, according to Chou [15]. “This method has several applications, says Chou. Although public cloud services are inexpensive and convenient, they have a bad reputation for security reasons [13]. Users have restricted physical capacity and processing speed in the common pool of resources unless they have a premium promotion. This holds true irrespective of whether consumers choose to pay for the advertisement or not. Here we have a citation for an article. Customers using a public cloud service may provide a direct access to the hardware that runs their systems. A corporation runs the danger of having its customers' personal information leaked if they share physical servers with other businesses.

Customers have more leeway to lease or purchase the hardware offered by cloud service provider in private cloud deployments, which gives them more control over their gear. When compared to those who depend on public cloud services, users of private clouds have clear advantages. Providers take care of service management on a client-by-client basis [18]. Compared to public cloud services, private cloud services often have a higher monthly cost. By combining public and private cloud computing in a hybrid model, you may reap the advantages of both without sacrificing any of their specific features. Investigating the possibility of combining several types of cloud providers [11]. Last but not least, businesses that share objectives, rules, and demands might pool their cloud resources via community cloud architecture. One big perk is this.

Organizations and businesses [19] that are among the last to use cloud computing are sometimes known as "late adopters." The situation is different in the medical field and the public sector compared to the educational system. Institutions may have slower-than-expected cloud computing implementations owing to certain organizational considerations. This research has laid up a thorough plan for the adoption of cloud computing in Jordanian institutions and uncovered the most important aspects influencing this shift. With this research, we hoped to pave the way for other institutions in Jordan to use cloud computing. A preexisting framework and two hypotheses were combined to form the one used in this investigation.

In order to better comprehend the challenges encountered by universities and colleges in their pursuit of ICT integration and the prevalent approaches used to accomplish this goal, the researcher opted to do a literature review.

Before rejecting any of the possibilities, the researcher gave careful consideration to all of the alternatives. Individuals' seeming illogical conduct and the lightning-fast spread of new technologies are both left unexplained by this theory. People attending universities in Jordan may be worried about how cloud computing would affect their personal information and safety since it is still a relatively new concept. But keep in mind that these worries may not be justified. To address the shortcomings of TRA theory, TAM considers how people's distinct habits influence their adoption of new technology.

Adopting a kid is a four-step procedure. Level 0 businesses communicate by email but do not have a website that is associated with their services. Level 1 universities have their websites developed while the sites are live. In the second tier, you'll find news organizations that report on breaking stories, innovative technologies, and other major events. The pinnacle of business integration is the creation of a frictionless digital connection between the bank and its esteemed clients [46-47].

Yet universities' information technology (IT) infrastructure, including their networks, storage devices, and systems, is completely ignored by the Web Adoption Model. Perhaps too complex for high and perhaps colleges and universities, the Web Adoption Theory puts an unnecessary focus on assessing websites. In light of the recent shift towards cloud computing, this study aimed to provide guidance to JHEIs.

4 Mathematical and Computational Process

Theoretical Foundation

To produce miasmatical framework based on cloud computing technology we may Let *F* be the framework, which consists of components *Ci* (where ii ranges from 1 to 7). Each component CiCi has elements *Eij* (where *jj* ranges from 1 to the number of elements in each component).

$$F = \{C_1, C_2, C_3, C_4, C_5, C_6, C_7\} \quad 1$$

For each component C_i, we can define the elements as follows:

$$C_1 = \{E_{11}, E_{12}, E_{12}, E_{14}\} \quad 2$$

$$C_2 = \{E_{21}, E_{22}, E_{23}, E_{24}\} \quad 3$$

$$C_3 = \{E_{31}, E_{32}, E_{33}, E_{34}\} \quad 4$$

$$C_4 = \{E_{41}, E_{42}, E_{43}, E_{44}\} \quad 5$$

$$C_5 = \{E_{51}, E_{52}, E_{53}, E_{54}\} \quad 6$$

$$C_6 = \{E_{61}, E_{62}, E_{63}, E_{64}\} \quad 7$$

$$C_7 = \{E_{71}, E_{72}, E_{73}, E_{74}\} \quad 8$$

List the elements for each component:

- C1= {Encryption, Data Masking, Access Controls, Data Loss Prevention (DLP)}
- C2= {Firewall Protection, Intrusion Detection and Prevention Systems (IDPS), Virtual Private Networks (VPN), Secure Network Architectures}
- C3= {Secure Software Development Lifecycle (SDLC), Application Vulnerability Testing, Patch Management, Secure APIs}
- C4= {Regulatory Compliance (e.g., FERPA, HIPAA), Security Policies and Procedures, Risk Management, Audit and Monitoring}
- C5= {Security Training Programs, Phishing Simulations, Cybersecurity Awareness Campaigns, User Access Reviews}
- C6= {Incident Response Planning, Forensic Analysis, Breach Notification Procedures, Disaster Recovery}
- C7= {Service Level Agreements (SLAs), Vendor Risk Management, Cloud Security Posture Management (CSPM), Cost Management and Optimization}

The framework for secure information technology in higher education using cloud computing technology is composed of several key components, each with specific elements designed to ensure comprehensive security. Component 1 (C1) focuses on Data Security and includes elements such as Encryption, Data Masking, Access Controls, and Data Loss Prevention (DLP). Component 2 (C2) emphasizes Infrastructure Security with elements like Firewall Protection, Intrusion Detection and Prevention Systems (IDPS), Virtual Private Networks (VPN), and Secure Network Architectures. Component 3 (C3) addresses Application Security, incorporating Secure Software Development Lifecycle (SDLC), Application Vulnerability Testing, Patch Management, and Secure APIs. Component 4 (C4) covers Compliance and Governance, ensuring Regulatory Compliance (e.g., FERPA, HIPAA), Security Policies and Procedures, Risk Management, and Audit and Monitoring. Component 5 (C5) is dedicated to User Education and Awareness, including Security Training Programs, Phishing Simulations, Cybersecurity Awareness Campaigns, and User Access Reviews. Component 6 (C6) focuses on Incident Response, with elements such as Incident Response Planning, Forensic Analysis, Breach Notification Procedures, and Disaster Recovery. Lastly, Component 7 (C7) deals with Cloud Service Management, encompassing Service Level Agreements (SLAs), Vendor Risk Management, Cloud Security Posture Management (CSPM), and Cost Management and Optimization. This comprehensive framework ensures a robust approach to securing information technology in higher education through cloud computing. Table 1 represents the mathematical notation.

Table 1: One-Level Table with Mathematical Notation

Component (C_i)	Elements (E_{ij})
C_1 Data Security	E_{11} Encryption, E_{12} Data Masking, E_{13} Access Controls, E_{14} Data Loss Prevention (DLP)
C_2 Infrastructure Security	E_{21} Firewall Protection, E_{22} Intrusion Detection and Prevention Systems (IDPS), E_{23} Virtual Private Networks (VPN), E_{24} Secure Network Architectures
C_3 Application Security	E_{31} Secure Software Development Lifecycle (SDLC), E_{32} Application Vulnerability Testing, E_{33} Patch Management, E_{34} Secure APIs
C_4 Compliance and Governance	E_{41} Regulatory Compliance (e.g., FERPA, HIPAA), E_{42} Security Policies and Procedures, E_{43} Risk Management, E_{44} Audit and Monitoring
C_5 User Education and Awareness	E_{51} Security Training Programs, E_{52} Phishing Simulations, E_{53} Cybersecurity Awareness Campaigns, E_{54} User Access Reviews
C_6 Incident Response	E_{61} Incident Response Planning, E_{62} Forensic Analysis, E_{63} Breach Notification Procedures, E_{64} Disaster Recovery
C_7 Cloud Service Management	E_{71} Service Level Agreements (SLAs), E_{72} Vendor Risk Management, E_{73} Cloud Security Posture Management (CSPM), E_{74} Cost Management and Optimization

4.1 Aggregate Metrics

To derive aggregate metrics from these four-level arrays, we use summations or averages across all levels:

Aggregate Risk Reduction

$$\overline{\Delta R} = \frac{1}{mpqr} \sum_{i=1}^{m} \sum_{j=1}^{p} \sum_{k=1}^{q} \sum_{l=1}^{r} \Delta R_{ijkl}$$

Aggregate ROI

$$\overline{ROI} = \frac{1}{mpqr} \sum_{i=1}^{m} \sum_{j=1}^{p} \sum_{k=1}^{q} \sum_{l=1}^{r} ROI_{ijkl}$$

Aggregate Efficiency Improvement

$$\overline{\Delta E} = \frac{1}{mpqr} \sum_{i=1}^{m} \sum_{j=1}^{p} \sum_{k=1}^{q} \sum_{l=1}^{r} \Delta E_{ijkl}$$

Aggregate Security Incident Reduction Rate

$$\overline{SIRR} = \frac{1}{mpqr} \sum_{i=1}^{m} \sum_{j=1}^{p} \sum_{k=1}^{q} \sum_{l=1}^{r} SIRR_{ijkl}$$

Aggregate User Satisfaction Improvement

$$\overline{\Delta U} = \frac{1}{mpqr} \sum_{i=1}^{m} \sum_{j=1}^{p} \sum_{k=1}^{q} \sum_{l=1}^{r} \Delta U_{ijkl}$$

Aggregate Compliance Improvement

$$\overline{CI} = \frac{1}{mpqr} \sum_{i=1}^{m} \sum_{j=1}^{p} \sum_{k=1}^{q} \sum_{l=1}^{r} CI_{ijkl}$$

Aggregate Operational Flexibility

$$\overline{OF} = \frac{1}{mpqr} \sum_{i=1}^{m} \sum_{j=1}^{p} \sum_{k=1}^{q} \sum_{l=1}^{r} OF_{ijkl}$$

These aggregate metrics provide a detailed and comprehensive view of the overall impact of cloud computing on information security across different dimensions within higher education institutions.

5 Research Methodology and Main Results

Using a triangulation technique and an interpretative paradigm, 27 semi-structured interviews were conducted with important individuals in educational systems. Members of the group included department chairs, deans, IT managers, VPs, and cloud computing and IT experts from around the university. A hundred surveys were delivered to students in Jordan, and the researcher there ran three focus groups. Information was given through the Ministry of Higher Education in Jordan. The analysis was carried out using NVivo and consisted of three steps [34]: data streamlining, data presentation, and conclusion derivation and confirmation. New Findings in the Realm The researchers that worked on this study used a theory called the Theory of Elements (TOE) [31] to classify all the possible problems that may arise when JHEIs try to use cloud computing. Criteria developed via data analysis and fieldwork were supplemented by the TOE framework throughout the inquiry.

During a knowledge exchange, someone suggested adding quality to the TOE framework (Figure 1), which already included factors like cost effectiveness and employment rate, and which suggests a model with factors for cloud computing in higher education.

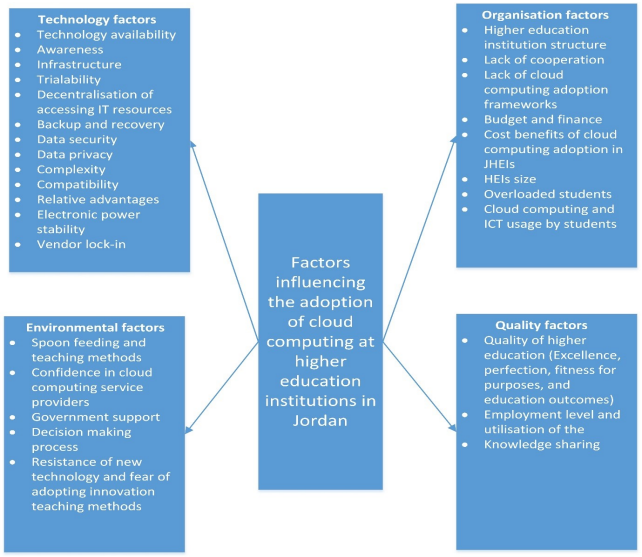

Fig. 1: Factors influencing the adoption of Cloud Computing Technology

(ICT) is widely utilized by educational institutions in Jordan, both in the public and private sectors.

When asked about their experiences with ICT at Jordanian institutions, most respondents were unhappy with the use of the technology. They felt that the present level of information and communication technology at universities was insufficient to achieve the desired educational outcomes. In Figure 2, this is shown.

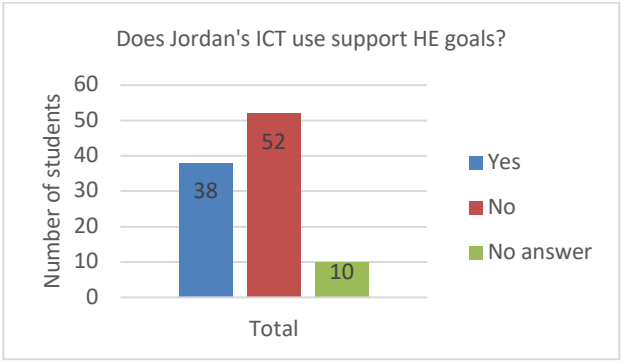

Fig. 2: The level of information technology usage in Jordanian higher educational institutions

The senior professor (P17) in the management information systems department questioned the prevailing notion that information and communications technology (ICT) is not fully utilized. They argued that advanced technology like cloud computing is easily accessible and that service providers are always prepared to help institutions with its implementation. However, understanding and learning about cloud technology may present a major obstacle to its widespread acceptance. P17:

The technology that powers cloud computing is available to everyone, at no cost, and with no limitations. How can we encourage employees to make the most of the resources at their disposal? Ensuring that all staff are up to date with the latest technology and actively incorporating it into their work is a key focus for management.

An instructor from the school of computer science (P10) provided evidence to back up her claim that the technology currently utilized by the majority of Jordanian institutions is outdated. She stated that her assertion is backed by the evidence that:

I have had mostly negative experiences with ICT. The technology we use in class is quite outdated, making it quite frustrating to perform basic tasks such as connecting to the internet or even powering it on. Some PCs are still using outdated versions of Microsoft software, like Windows XP, which are no longer supported. Transitioning to Office 365 would streamline the utilization of cloud-based services such as Google Drive.

The usage of cloud computing technology

Research reveals that there is a notable level of dissatisfaction among students and teachers in Jordanian universities regarding the current state of ICT integration. It is evident that the potential of ICT and cloud computing is

not fully utilized in JHEIs. Although progress has been made in Jordan's efforts to incorporate ICT into the classroom, there is still potential for further enhancement. Based on our observations in the field, it is evident that the necessary tools are not easily accessible or being utilized to their full potential. This poses a challenge for JHEIs in meeting the demand for skilled workers in Jordan's economy.

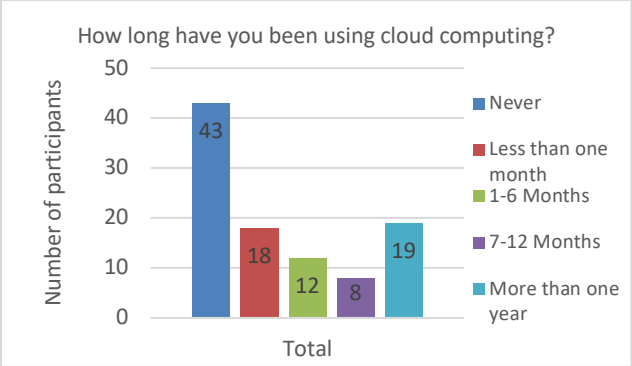

Fig. 3: Cloud computing usage

Nevertheless, the data indicates a significant level of Internet usage among students. As a result, individuals can utilize cloud computing services that primarily require internet connectivity. According to Figure 4, a large majority of students, more than 92%, used the Internet every day. However, the use of cloud computing was not very common among them. None of the participants in the qualitative poll have prior experience with the Internet.

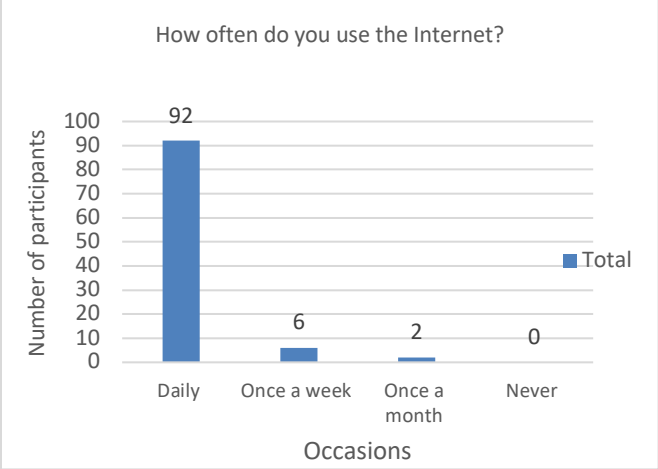

Fig. 4: Internet usage by participants

Figure 5 also presents findings from a qualitative survey that captures students' views on how cloud computing can enhance the quality of JHEIs (Jointly Funded Research Institutions). A total of 110 individuals responded to the survey. A majority of the study's participants expressed optimism about the potential of cloud computing to enhance classroom instruction and improve student outcomes. Cloud computing could enhance the quality of education in Jordan, although there were 9 respondents who expressed doubt and 17 individuals who believed otherwise.

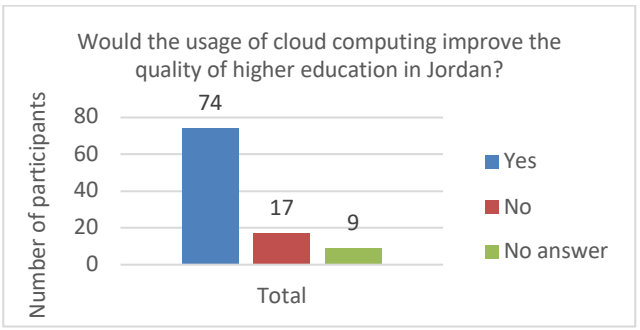

Fig. 5: The perspectives of present and past students on the capacity of cloud computing.

Generalizing about the quality of Jordanian Higher Education schools (JHEIs) may be challenging due to the significant variations in student ability and institutional status among these schools in Jordan. The majority of individuals questioned stated that education at Jordan's universities did not match the demands of the economy. Nearly everyone involved also believed that current information and communication technology may help students catch up and possibly move ahead of the curve.

The dean of MIS at a private Jordanian university has made the following statement

The quality of Jordan's university system is difficult to judge. We are still unsatisfied with the study that was carried out, the caliber of the pupils, and the proficiency of the professors. Every organization in Jordan works toward the same shared goal: translating academic knowledge into practical application for the benefit of the economy. Undoubtedly, there exists a significant disparity between the theoretical ideas imparted in Jordanian classrooms and the demands of the job world.

Concurs about Cloud Computing technology

Customers' levels of confidence in the cloud provider and worries about privacy and security are two aspects that could impact their choice to use cloud computing [37-41]. There is general agreement that cloud service providers should protect their customers' personal information [42]. Findings from the study indicated that decision-makers at JHEI would rather work with global IT service providers than domestic ones. Local enterprises in Jordan may not have what it takes to offer a long-term service and might go out of business at any moment, according to most respondents with decision-making power. "Our company would be devastated if one of the local businesses we were using for cloud computing suddenly disappeared from the market," said the DM3 member who had the last say. Given the current state of affairs, switching cloud providers would not be an easy or straightforward technical process.

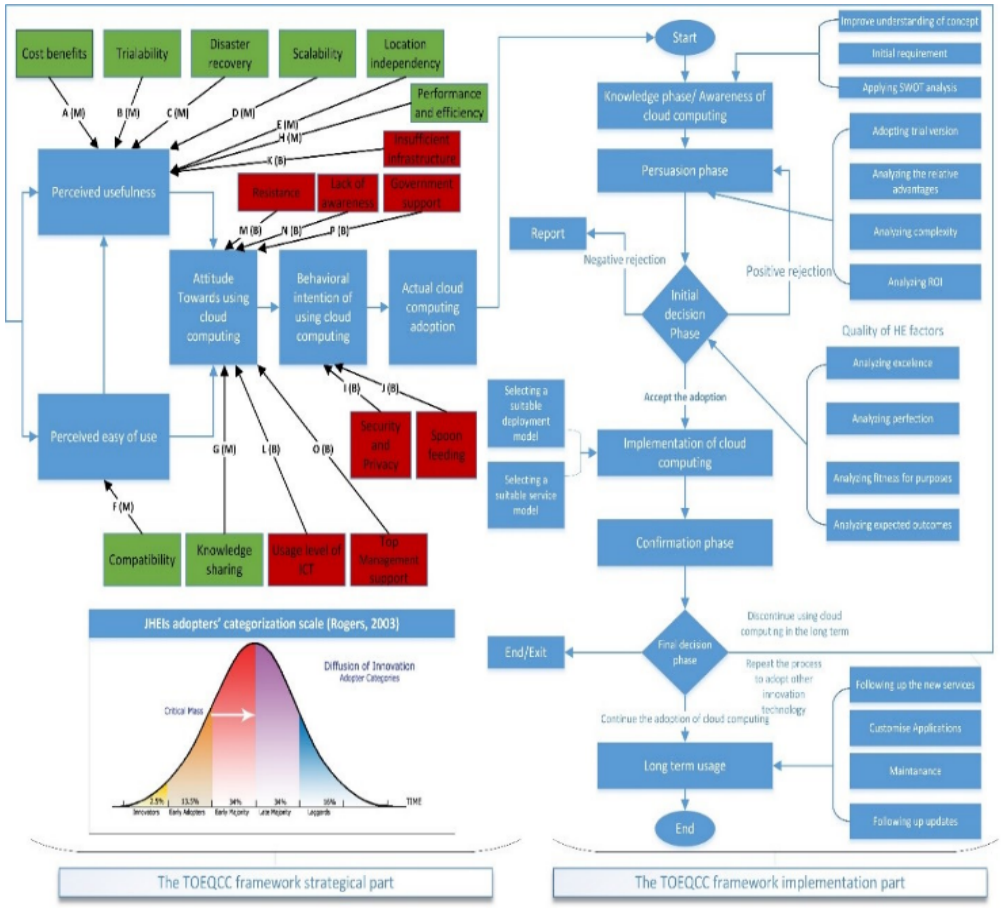

Fig. 6: Proposed Framework

For this technology to be widely used, people must have faith in cloud service providers. According to the findings, decision-makers would rather work with international cloud computing service providers than regional ones. In addition, there are major problems with Jordan's laws on the protection of personal information. Cloud computing may see a decrease in use by Jordanian institutions due to the frequency of these challenges. When it comes to sensitive consumer data, which is to limit who may access it, but the goal of privacy is to control which people can see what [43]. The aforementioned qualitative study, focus groups, and interviews led to the conclusion that JHEIs are hesitant to use cloud computing due to concerns about security and privacy. Perhaps these concerns are of the

most importance to the people who make decisions on Jordan's educational system. Powerful people who aren't familiar with cloud computing have expressed serious concerns about security. People who have used the cloud before and dealt with trustworthy businesses like Amazon, Google, and Microsoft have less worries about the safety of their information.

Government support

To better understand the relationship between public funding and HEIs' efficient use of cloud computing and its influence on students' ability to afford higher education, this part surveys the perspectives of relevant stakeholders. Even if the relative importance of HE varies across different settings (e.g., public vs. private colleges in Jordan), governments should always place a premium on promoting high-quality HE because of the vital role it plays in society's advancement.

Based on the findings, the Jordanian government's support is essential for introducing new technology to the nation. Having said that, a few of participants did concede that the government is just not yet settled on a specific plan for carrying out the program.

However, many delegates feel the Jordanian government isn't doing enough to help, and they want the government to do more to prioritize using cutting-edge technology in schools. One application that fits this description is cloud computing.

6 Proposed framework

This study's stated principles were developed and integrated into the suggested framework by drawing on the theoretical underpinning that served as a foundation for its formation. The theoretical analysis and actual findings were integrated to build the TOEQCC framework. The TOEQCC design

suggested that JHEIs might benefit from cloud computing by using TAM components and DOI theory. This procedure followed a set pattern.

The TQEC framework is designed to integrate Technology, Quality, Education, and Cloud Computing into a cohesive model that enhances educational outcomes through the effective use of modern technological advancements. This framework underscores the interplay between these constructs to create a synergistic effect on educational processes and outcomes.

Figure 6 shows the TOEQCC framework, which was established by Mile and Hubermann; this section gives a brief overview of it. Both the Diffusion of Innovation (DOI) [29,30] and the Technological-Organizational-Environmental (TOE) [31] theories were included into the new framework. The recently developed framework relied heavily on the Technology Acceptance Model (TAM) [32]. The recognized advantages highlighted by TOEQ have led to JHIEs adopting cloud computing. Questionnaires, focus groups, interviews, and document analysis were used to reveal the features of Jordanian HEIs. The TOEQCC letters stand for the drivers (M) and stumbling blocks (B) of cloud computing, as identified by the T-O-E-Q factors framework and TAM (A to P).

"What are the factors that promote or hinder the adoption of cloud computing in JHEIs?" is the third sub-question of the research, and this section's objective is to answer it. Considering the drivers and obstacles associated with TAM is the primary focus of the first component of the framework, which is designed to handle this matter. A process flow diagram showing how JHEI uses cloud computing is the second part of the TOEQCC framework. You may see more quality criteria and steps in this DOI theory diagram.

In order to help universities in Jordan to embrace cloud computing, a new framework has been designed that combines theoretical and practical methods. A growing country is Jordan. If JHEIs reach out to TOEQCC for assistance, they may gain helpful insights on cloud computing. Important factors influencing cloud computing use are also covered, along with implementation methodologies. It might also find application in Middle Eastern countries that are culturally and economically similar, have similar views on cloud computing, are receptive to new technology, and employ information and communication technologies.

7 Study limitations

This study has several limitations, generalizability is constrained due to differences in institutional size and resources, and the data relied upon may lack accuracy and completeness. Rapid technological advancements can quickly render findings outdated, while variability among cloud service providers and differences in implementation practices can affect outcomes. Cost considerations may overlook hidden expenses, and inherent security risks such as data breaches and dependency on third-party providers are not fully addressed. Regulatory and compliance challenges vary by region, and user acceptance and adoption are critical yet underexplored factors. Additionally, the scope of benefits measured may miss qualitative improvements like user experience and operational agility. These limitations suggest the need for cautious interpretation and highlight areas for future research.

8 Conclusion

Finding the best ways to apply cloud computing and increasing JHEIs' comprehension of it were the primary goals of this project. According to theoretical foundations gained from the literature study, the researchers established a new paradigm after researching the main factors that impact the adoption of cloud computing at JHEIs. This survey was taken part in by eleven different universities in Jordan, both public and private. The research drew on interviews with 27 JHEI leaders. Included in the research were three focus groups, student surveys, and direct observation. Several variables influence JHEIs' adoption of cloud computing, according to the study's results. You can see how all these different traits are related in the TOEQCC framework

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Hala Alsabatin's research interests are deeply rooted in the dynamics of educational leadership, curriculum development, and linguistic studies. Her academic work focuses on exploring innovative leadership strategies within educational institutions, aiming to enhance the efficacy of educational administration and policy-making. She is particularly interested in how effective leadership can influence and improve school environments, teacher performance, and student outcomes. In addition to her work in educational leadership, Dr. Alsabatin is passionate about curriculum development. She investigates how curricula can be designed and implemented to better meet the needs of diverse student populations. Her research often examines the intersection of curriculum and cultural context, seeking to develop educational programs that are both culturally relevant and academically rigorous. Her background in linguistics also informs her research, as she explores the role of language in education. *Dr. Alsabatin is interested in how linguistic principles can be applied to teaching methodologies, especially in* multilingual and multicultural classrooms. Her work aims to bridge the gap between linguistic theory and practical teaching strategies, enhancing language acquisition and literacy among students. Overall, Dr. Alsabatin's research is driven by a commitment to improving educational practices and outcomes. By integrating insights from educational leadership, curriculum development, and linguistics, she seeks to create more effective and inclusive educational environments.