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Quantifying the usage of creative technology to improve the quality assurance in developing countries' higher education institutions

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Abstract: The significance of quality assurance in universities is a top priority, with advancements in technology composed to revolutionize global educational standards. Enhanced student-teacher communication and independent learning capabilities are among the direct benefits anticipated from technological progress. This research paper investigates how Jordanian universities primarily employ cutting-edge technology to sustain educational excellence. Employing the innovation spread concept, field research was conducted at five different universities in Jordan to identify the specific technological factors that might impact quality assurance in higher education, and involving sixteen semi-structured interviews with key figures in higher education. Participants included academic leaders such as deans, department chairs, and IT managers, with interviews employing triangulation and an interpretive paradigm. In addition, student surveys and focus groups were utilized for deeper insights.

Keywords: Technological innovation; Quality assurance; Higher education institutions; Jordan.

1 Introduction

Researching the ways in which information and communication technology (ICT) might be used to provide assistance to educational institutions is a subject that has been around for quite some time. But there is a paucity of data about the use of information and communications technology in higher education institutions in less developed countries, specifically in universities in Jordan. The primary purpose of this study is to determine the key requirements that will make it possible for Jordanian Higher Education Institutions (JHEIs) to make use of new technologies in order to enhance the quality of education that they provide to their students. There are a number of measures that illustrate the ineffectiveness of higher education under Jordan, as stated in [1]. These indicators include the high rate of unemployment among graduates and the low rate of return on investment in higher education. The failure of higher education institutions to incorporate cutting-edge information technology into their curriculum is a crucial factor that adds to the problems and challenges that have been discussed.

Incorporating state-of-the-art technologies into higher education offers several potential advantages, such as introducing innovative instructional methods that may complement or even replace traditional ones. Furthermore, it might enhance your flexibility in terms of accessing papers at any time and place of your convenience. More than that, it may help students learn outside of class by encouraging them to work together and share what they've learned [2]. However, it has been observed that educational methodologies in Jordanian institutions have mostly not changed from the past. The unwillingness of JHEIs to adopt new technologies new technologies can pose a problem. Therefore, more research into the factors that impact the adoption of new technology in JHEIs is required and presents an opportunity to promote its use. One of the many challenges associated with the term "quality assurance" is its difficulty in defining and quantifying quality, as well as in accounting for the direct and indirect effects of variables such as state-of-the-art technology. The researchers were already aware of a problem that prompted the investigation: there were gaps and restrictions in the use of new technology to improve the standard of higher education. Due to the constraints associated with introducing new

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technologies to JHEI, studies on the following subjects are required:

1. What is the significance of Jordanian institutions obtaining state-of-the-art technology?
2. What are the primary factors that lead JHEIs to adopt state-of-the-art technology?
3. What is the influence of external factors on quality assurance in higher education institutions?

This research study is aiming to shed the light into the challenges and opportunities facing JHEIs into incorporating state-of-the-art technologies as they evolve to shape a landscape of new educational technology: The main contribution of this paper:

1. Explore the main impact of incorporating state-of-the-art technologies on educational standards and quality assurance at JHEIs
2. Identify the primary factors influencing JUHIs from incorporating the state-of-the-art technologies.
3. Highlight the positive impact of incorporating the state-of-the-art educational technologies into the JUHIs.

The remaining part of the paper is organized as follows: Section 2 discusses the role of quality assurance in higher education settings. On the other hand, Section 3 explores the evolution of Information Technology's role in shaping universities. Furthermore, Section 4 presents the theoretical foundation of the study, while the DOI Theory's Main Stages are listed in Section 5. The adopter categories are identified in Section 6, and the research methodology is discussed in Section 7. The main results of the research are presented in Section 8. Finally, Section 9 concludes the paper.

2 The Role of Quality in the Setting of Higher Learning

This section seeks to clarify the authors' meaning of the word "quality" as it pertains to the domain of education by analyzing their definition of quality [3]. The efficacy, precision, thoroughness, suitability, utility, and cost-effectiveness of educational technology services are considered alongside the outcomes that institutions attain. Table I displays the results of an investigation of the components that may be inferred from this specification. Each of them will be studied in relation to cutting-edge innovation that is being created at JHEIs. The term "first" in the context of state-of-the-art technology denotes the dominance of technical services and the attainment of fundamental benchmarks in this domain. Raising the bar for all of higher education is the overarching goal of this undertaking. The second crucial component is the ability to avoid anticipated restrictions, such as service disruptions and sluggish reaction times, and the effectiveness of technical innovation. The third component that has to be assessed is the service's cost-effectiveness. This part comprises weighing the benefits of a service in terms of raising the bar for student and educator learning against the expenses of delivering that service. The university evaluates the efficacy of its state-of-the-art technical services by considering how well they perform their intended function. In terms of the third criteria, we can see how seriously we take the assessment of the college's role in preparing students for the workforce.

Table 1: Quality metrics

Quality	Definition	Key Concepts
Excellence	Typically defined as very high levels of accomplishment.	Exclusivity means surpassing high standards or meeting the minimal requirements.
Perfection	Emphasizes procedures and establishes criteria it intends to achieve.	Striving for perfection via a quality-focused culture that prioritizes doing things right on the first attempt.
Value for Money	Evaluates quality based on return on investment or spending.	Accountability via performance metrics
Fitness for Purpose	Judges' quality is evaluated based on how well items or services fulfill their intended functions.	Meeting consumer specifications or meeting an institution's objective.
Higher education institution outcomes	The disparity between the universities' results and the demands of the labor market, influenced by the educational process and achievements.	Empowering students by using modern technologies to enhance their learning.

3 Study A Synopsis of the Evolution of Information Technology's Role within Universities

The capacity of technology to enhance educational standards is well-established. The computer was an electrical device that was developed in 1946 at the University of Pennsylvania. The purpose of creating the Electronic Numerical Integrator and Computer (ENIC) was to enable concurrent data input by several individuals, followed by the generation of written output on paper [4]. The use of ENIC significantly lowered the whole processing time, including the entry of the program using punch cards, waiting for the process to complete, and obtaining the results, which were previously considerably slower.

Mainframe computers were created throughout the 1950s and 1960s with the purpose of advancing the field of computer science at prominent research institutes [4].

However, the use of main-frame computers was limited due to their exorbitant cost, the substantial physical area they demanded, and the shortage of qualified instructors and pupils. The notion that IT may enhance the performance of schools is not new. In 1946, Penn developed the first electric computer in the United States. The Electronic Numerical Integrator and Computer (ENIC) was developed to enable concurrent data entry, do calculations, and provide a printed output of the findings [4]. By using ENIC, the duration of the procedure, which included inputting data into the computer using punch cards, waiting for its completion, and retrieving the results, was significantly reduced. During the 1950s and 1960s, mainframe computers were only available to use in big research institutions [4]. Mainframe computers were limited in their functionality due to issues such as their exorbitant cost, the need for large hosting rooms, and the scarcity of professors and students who were skilled in operating them.

The debut of IBM's personal computer in 1981, followed by Apple's Macintosh Personal Computer in 1984. Personal computers, offering equivalent capability to mainframe computers but at a more affordable cost, have empowered people to simplify the intricate computing process. Serveral graphical user interface technologies were introduced during a significant transformation in the educational field [4]. Westera [5] states that schools and universities worldwide played a crucial role in advancing IT and were leaders in using IT to improve the quality of education [6]. Ensminger and Lewis [7] argue that technology innovations have profoundly transformed higher education, giving students almost limitless access to knowledge and motivating institutions of higher education to cultivate a forward-thinking educational environment. Technology enhances pupils' research skills and fosters their overall development.

Forest and Kinser [4] state that politicians saw technology as a solution to several challenges in higher education (HE), such as improving quality, cutting expenses, increasing innovation and productivity, and promoting research cooperation. In the 21st century, the availability of smartphones, mobile phones, tablets, online information communications, and new educational tools has led to an increase in the sharing of research and access to resources among students, researchers, and learners [8].

Recent studies [9, 10, 11] indicate that when presented with the option of using either conventional or technology-enhanced learning methods, students tend to choose for the latter. Therefore, the expansion of technology in education cannot be disregarded, especially in less developed countries. Universities and colleges should possess knowledge of the most efficient methodologies for integrating and synchronizing educational technology. Employing suitable technology in a well-planned way is thus a vital method of improving the quality of higher education [12]. Hence, it is crucial for developing nations to acquire more knowledge and expertise in the realm of educational technology, since doing so would facilitate their economic advancement and improve the caliber of their higher education initiatives.

However, the quality of creative technology in higher education institutions could be mathematically presented as follows:

Creating equations to model the quality of creative technology in higher education institutions involves defining variables that represent different factors affecting quality. These factors can include infrastructure, faculty expertise, student engagement, industry collaboration, and curriculum relevance. Here's a set of equations that could represent this complex relationship:

1. Quality of Creative Technology:

(QCT) $QCT = \alpha \cdot INF + \beta \cdot FAC + \gamma \cdot STU + \delta \cdot IND + \epsilon \cdot CUR$ $QCT=\alpha \cdot INF+\beta \cdot FAC + \gamma \cdot STU+ \delta \cdot IND+\epsilon \cdot CUR$

Where:

- QCT is the overall quality of creative technology education.
- INF represents the quality of infrastructure (e.g., labs, software, hardware).
- FAC represents faculty expertise and engagement.
- STU represents student engagement and performance.
- IND represents industry collaboration and partnerships.
- CUR represents the relevance and innovation of the curriculum.
- $\alpha,\beta,\gamma,\delta,\epsilon$ are coefficients representing the weight of each factor.

2. Infrastructure Quality (INF)

$$INF = \theta_1 \cdot TECH+ \theta_2 \cdot FACIL+ \theta_3 \cdot MAINT$$

Where:

- TECH represents the availability and quality of technology.
- FACIL represents the quality of physical facilities.
- MAINT represents the quality and frequency of maintenance and upgrades.
- $\theta 1,\theta 2,\theta 3$ are coefficients representing the weight of each sub-factor.

3. Faculty Expertise (FAC)

$$FAC= \phi_1 \cdot QUAL + \phi_2 \cdot EXP+ \phi_3 \cdot ENG$$

Where:

- QUAL represents the academic and professional qualifications of faculty.
- EXP represents the practical experience of faculty in the creative technology field.
- ENG represents faculty engagement with students and ongoing professional development.
- $\phi 1, \phi 2, \phi 3$ are coefficients representing the weight of each sub-factor.

4. Student Engagement (STU)

$$STU = \psi_1 \cdot SAT + \psi_2 \cdot PERF + \psi_3 \cdot PART$$

Where:

- SAT represents student satisfaction.
- PERF represents student academic performance.
- PART represents student participation in extracurricular and creative activities.
- $\psi 1, \psi 2, \psi 3$ are coefficients representing the weight of each sub-factor.

These equations create a comprehensive model for evaluating and understanding the quality of creative technology education in higher education institutions. The coefficients can be determined through empirical research and data analysis specific to the institutions being studied.

4 Theoretical Foundation

In the context of adoption, an innovation is described as an idea, action, or thing that is seen as novel or distinctive by a person or another organization. There is a lack of certainty on the verifiability of the innovation, which may vary from person to person or institution to institution. Regardless of whether or not the notion in question is really original, it is nonetheless considered an innovation [13,14,15]. The techniques by which humans generate and disseminate information are referred to as "communication channels," and the phrase "communication channels" This process is referred to as "the diffusion process," and it is explained by Rogers [16, page 18]. It is the act of one person passing on their knowledge to another person.

The DOI hypothesis states that time is crucial for three main reasons. The five-step innovation-choice process starts with the individual's first encounter with the invention and ends with their endorsement or rejection of the concept. This is the first stage of that process. A person's "innovativeness" might be defined as the ease with which they incorporate new ideas into preexisting systems. Thirdly, there's the innovation rate, which is the percentage of the public that has a favorable reaction to the idea within a certain time frame [16]. An interconnected web of entities that overcomes challenges and accomplishes a common goal is one way to characterize a social system [16, p. 23]. Units like this could consist of individuals, communities, organizations, or even individual systems. One or more individuals might make them up as well. That is to say, how quickly innovations spread depends on a number of factors, including the nature and structure of the social system and the extent to which its members work together to solve problems and accomplish common objectives. The reason for this is because many units within a social system could not act in the same way [21-24].

5 DOI Theory's Main Stages

The acceptance or rejection of innovation within a social system is influenced by five major steps: knowledge, interest, preparation, action, and assessment [16]. Individuals vary in their decision-making approaches as it pertains to novel and inventive concepts. The duration of transitioning from acquiring knowledge and discussing an idea to its practical use varies across individuals. To get a concise understanding of the procedures associated with approving or declining a proposal.

6 Adopters Categories

The Rogers' Diffusion of inventions hypothesis classifies individuals into several categories according to their inclination to embrace new inventions. The following categories are:

1. Innovators: These people are the first adopters of an idea. They possess a strong inclination for adventure, are willing to take risks, and have a profound curiosity for novel concepts. They often possess elevated social standing, enabling them to exert influence over others.

2. Early Adopters: Early adopters are those who closely follow inventors and promptly embrace novel concepts. These individuals are esteemed influencers within their communities and are open to taking chances, albeit they exercise greater caution compared to innovators.

3. The Early Majority: This group has a greater level of intentionality when it comes to embracing new technologies. They exhibit pragmatism and have a tendency to embrace new concepts somewhat ahead of the normal individual. They carefully analyze the experiences of innovators and early adopters before reaching a judgment.

4. The Late Majority: The late majority, similar to the early majority, embraces innovations after the average individual. They exhibit skepticism towards change and often embrace new concepts as a result of peer influence or economic compulsion.

5. Laggards: Laggards are the last individuals to embrace a new idea. They adhere to traditional values and exhibit a strong aversion to change. They often depend on

conventional approaches and exhibit reluctance towards embracing new technology or concepts.

These categories elucidate the process of adopting innovations within a population, delineating the several steps individuals undergo while embracing or dismissing a novel concept, product, or technology.

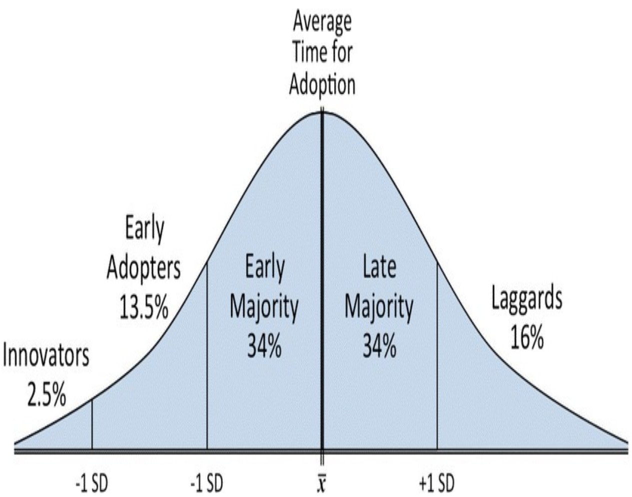

Figure 1: Adopters' classification of innovation over time [20].

The Rogers' Diffusion of Innovations hypothesis can be represented mathematically by dividing the total population into five categories, each corresponding to a different rate of adoption. Let *PP* represent the total population, and *p1,p2,p3,p4,p5p1,p2,p3,p4,p5* represent the proportions of Innovators, Early Adopters, Early Majority, Late Majority, and Laggards, respectively. The following equations describe the distribution of these categories:

- **Interaction between groups**: How one group's adoption influences another group's adoption.
- **Temporal dynamics**: How adoption rates change over time based on a differential equation model.
- **External influences**: Incorporating external factors like marketing efforts or societal changes.

To make the mathematical representation more complex, we can introduce several additional factors, such as:

Variables and Arrays

- A(*t,g,c)A(t,g,c)*: The number of individuals in group gg at time *tt* in category cc.
- *βg1,g2(c1,c2)βg1,g2(c1,c2)*: The influence factor, representing how the adoption in group *g1g1* and category c1c1affects the adoption in group *g2g2* and category *c2c2*.
- *λc(t,g)λc(t,g)*: The adoption rate for category cc in group gg at time *tt*.
- *γc(t)γc(t)*: The external influence factor for category cc at time *tt*.
- *f(g,c)f(g,c)*: A function representing the baseline inclination of group gg to adopt category cc.

Differential Equations for Adoption Rates

The rate of change in the number of adopters in group gg at time *tt* for category cc is influenced by internal dynamics within the group, interactions with other groups, and external influences.

1. **Rate of Change in Innovators:**

$$\frac{dA(t,g,1)}{dt} = \lambda_1(t,g)\cdot\left(f(g,1)+\sum_{g=1}^{G}\sum_{i=1}^{5}\beta_r g_r(c^i,1)\cdot A(t,g,c^i)\right)+\eta_1(t)\cdot P(t,g)$$

2. **Rate of Change in Early Adopters:**

$$\frac{dA(t,g,2)}{dt} = \lambda_2(t,g)\cdot\left(f(g,2)+\sum_{g'=1}^{G}\sum_{c'=1}^{5}\beta_{g',g}(c',2)\cdot A(t,g',c')\right)+\gamma_2(t)\cdot P(t,g)$$

3. **Rate of Change in Early Majority**

$$\frac{dA(t,g,3)}{dt} = \lambda_3(t,g)\cdot\left(f(g,3)+\sum_{g'=1}^{G}\sum_{c'=1}^{5}\beta_{g',g}(c',3)\cdot A(t,g',c')\right)+\gamma_3(t)\cdot P(t,g)$$

4. **Rate of Change in Laggards**

$$\frac{dA(t,g,4)}{dt} = \lambda_4(t,g)\cdot\left(f(g,4)+\sum_{g'=1}^{G}\sum_{c'=1}^{5}\beta_{g',g}(c',4)\cdot A(t,g',c')\right)+\gamma_4(t)\cdot P(t,g)$$

5. **Rate of Change in Laggards**

$$\frac{dA(t,g,5)}{dt} = \lambda_5(t,g)\cdot\left(f(g,5)+\sum_{g'=1}^{G}\sum_{c'=1}^{5}\beta_{g',g}(c',5)\cdot A(t,g',c')\right)+\gamma_5(t)\cdot P(t,g)$$

7 Research Methodology

There were four universities in Jordan that contributed to the material. As was mentioned previously, the researchers carried out sixteen semi-structured interviews with important officials at Jordanian institutions. These individuals included, but were not limited to, senior vice provosts, managers, department chairmen, and deans in the field of information technology. In addition, as part of the experiment, researchers conducted a survey with 232 Jordanian students and performed two focus groups simultaneously. In accordance with the procedures described by Miles and Huberman [17], we used NVivo to decrease the amount of data, improve the visualization of the data, and validate our findings. Statistical data, including averages, as well as frequency counts, were shown with the help of Microsoft Excel. A number of different drawing tools, such as tables, diagrams, and graphs, are used in the process of creating charts.

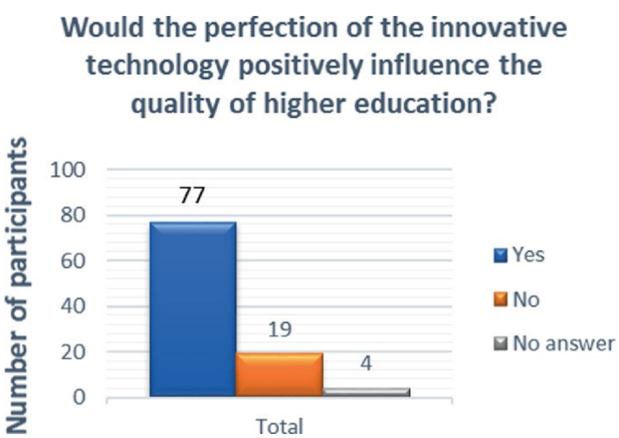

Figure 2: The perfection of innovative technologies has a significant influence on the quality of higher education.

8 Main Results

This research used a qualitative methodology, integrating three sources of information to shed light on the main issues and resolve the core puzzle. To properly handle the research problem, it is necessary to use research procedures, as recommended by Bell [17]. In order to get a deeper understanding of the system being studied, Tellis [18] suggested use a triangulation methodology. The need of triangulation to ensure the study's trustworthiness, a critical ethical concern. Data triangulation, as defined by Adams et al. [19], involves collecting information from many viewpoints in order to validate findings. Potential factors that may determine quality in the context of technical aspects include perfection, value for money, fitness for purpose, and higher education institution outcomes. To ascertain the correlation between these aspects and cutting-edge technology, we have established links between them.

8.1 Achieving Excellence in Cutting-Edge Technological Services

By "improving state-of-the-art technology services," we mean that our deeply rooted culture allows us to reliably complete jobs accurately on the first try. According to the results of the research, getting to zero errors is quite unlikely, particularly when looking at the big picture. Therefore, despite the inevitable occasional failures, HEIs should strive for the greatest feasible standard of quality. According to an interviewee who is an expert in information systems, our objective is to raise the bar for higher education by attaining excellence in information technology. This perspective is in agreement with the comment made before. A number of software and hardware parts of a computer could go down throughout the course of a semester. However, by comparing our failure rate to the whole period, we may anticipate substantial progress and strive for perfection in the next academic years.

The results show that most people think that better technical services would lead to better higher education. Figure 2 displays the figures, and it's evident that 77% of respondents think that perfection improves the quality of higher education. A small percentage of respondents (19%) do not believe that greatness is correlated with perfection, and 4% are unsure

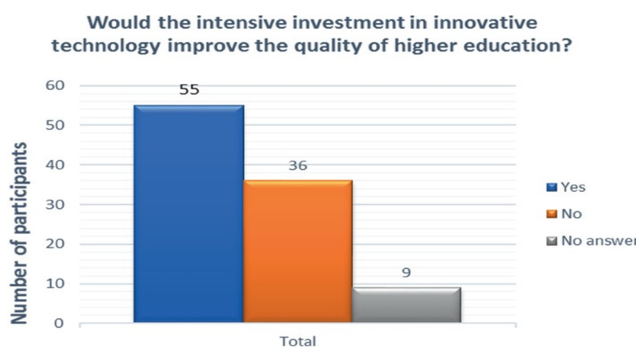

Figure 3: Investment in creative technology.

8.2 Investing in Higher Education for the Purpose of Yielding Returns in the Form of Emerging Technologies and Student Achievement

To what degree has state-of-the-art technology enhanced the standard of higher education is one way to measure its return on investment (ROI). Some people who took the poll think it's a waste of money to put money into cutting-edge equipment because you can't see the results right away. One of the panelists, a dean at a school of computer technology, made the comment that it is difficult to exactly measure the return on investment in technology due to the high initial costs. I believe that it will take at least five to ten years before we can see a return on our investment in technology and how it raises the bar for higher education and helps students develop their abilities. More than half of those who took the poll think it's a good idea to spend money on cutting-edge innovation that will improve universities' teaching and learning. On the other hand, 36% of respondents disagreed, saying that investing in new technologies to enhance universities would be a waste of money. Nine percent were unsure.

8.3. Suitability for Intended Use

In the context of a university, "fitness for purposes" refers to the selection of a technology that is both innovative and of high quality. Given the abundance of available technologies, this study affirms the need of a meticulous selection process to cater to the specific requirements of each institution. The primary challenge is in acquiring the knowledge to choose a technology that aligns with your requirements. A deputy vice chancellor from a private university in Jordan, who was present at the event, said that the technology is freely available and can be utilized without difficulty. The most critical factors to evaluate are the nature and rationale for accepting a certain groundbreaking technology. Our main goal is to improve university instruction. Hence, the objective of every decision should be to augment the quality. Our opinion on this issue has been influenced by both favorable and unfavorable events. From my perspective, the superiority of software or hardware does not always correlate with its price. In order to accomplish our goal of elevating the standard for exceptional instruction, we may discover that a readily accessible resource is more advantageous in some situations. As seen in Figure 4, the productive innovation selection differs. Technological innovations have greatly improved the quality of higher education in recent years.

A majority (56%) of participants agreed that the appropriateness for a certain objective has a direct impact on the caliber of tertiary education. While 18% of respondents either did not provide a response or were unsure, 26% acknowledged the existence of a link between fitness for purpose and the quality of a college degree.

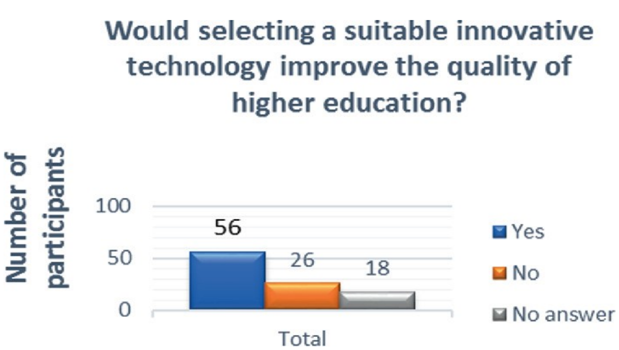

Figure 4: The influence of choosing appropriate cutting-edge technology on the caliber of higher education.

8.4. Results from Academic Institutions

There is no more crucial factor than the quality of the work that HEIs generate, whether it students, papers, reports, or anything else. Unfortunately, there are a lot of sub-factors that make up this component, therefore it's not easy to assess the effect of higher education. Important indicators might include things like the employment rates of graduate students and feedback from companies on the competence of graduates. A large outcome may be the quantity and quality of research publications, with the papers' possible global influence also playing a role. In the opinion of the dean of research school at one of the private institutions that took part in the survey, the results are the most crucial factor in determining the quality of higher education. Success portends good things to come, whereas failure portends bad things to happen.

The nature and assessment of superiority and inferiority may be the primary foci of the inquiry. University rankings are only one of many potential evaluation strategies. Two more indexes used to assess the quality of educational institutions are the Web Metrics University Ranking and the QS World University Ranking. According to the survey's findings, most people think that a college or university's performance is heavily dependent on its academic consequences. Figure 5 shows that 83% of those who took the survey believe that HEI outcomes significantly impact the global standard of higher education. But 9% of those who took the survey felt this factor had no bearing on university quality, and 8% were still undecided.

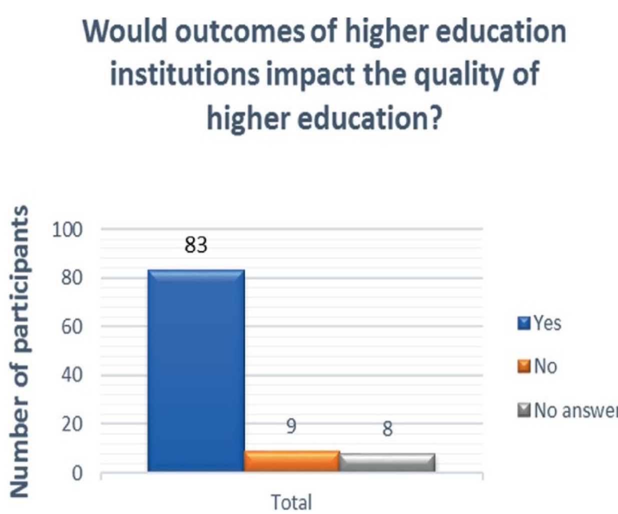

Figure 5: How university performance affects the quality of university education.

9 Conclusion

This research examines the impact of technological infrastructure at Jordanian institutions on student learning outcomes. Semi-structured questionnaires were used to interview professors, IT directors, and lecturers. Furthermore, a total of 232 questionnaires have been distributed, gathered data from, and assessed. The findings suggest that the use of state-of-the-art technology has a positive impact on higher education institutions in the Kingdom of Jordan. Multiple studies have been undertaken on various subjects, such as "suitability," "economic efficiency," "excellence," and the outcomes of educational institutions. Additional research is required to determine the most effective methods for promoting the acceptance and use of emerging technology, especially in less developed areas. Additional study in this field might help institutions improve the quality of their programs.

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