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The Impact of Digital Teaching Technologies (DTTs) in Saudi and Egyptian Universities on Institutional Sustainability: The Mediating Role of Change Management and the Moderating Role of Culture, Technology, and Economics

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Abstract: Purpose: This research aims to assess the extent to which universities in Saudi Arabia and Egypt have institutionalized digital teaching technologies (DTTs) to enhance institutional sustainability. It focuses on the mediating role of change management strategies and the moderating effects of cultural norms, technological infrastructure, and economic factors on this relationship, specifically examining their impact on institutional sustainability. **Design/methodology/approach**: This study uses a mixed-methods approach with a comparative case study strategy. Data were collected via questionnaires and interviews with university staff, with partial least squares structural equation modeling (PLS-SEM) being used to analyze the relationships among the variables, including DTT characteristics and other mediating/moderating factors. **Findings**: The findings support H1, H2, H6, and H8, confirming that the perceived characteristics of DTTs—**relative advantage, complexity, observability, trialability, and compatibility**—significantly impact institutional sustainability, with change management strategies mediating this relationship. Cultural norms and economic factors also have a direct influence on sustainability. However, H3 and H5, suggesting moderating effects of cultural norms and economic factors, were not supported, and H4 and H7 were excluded due to multicollinearity issues with technological infrastructure, which has already been adopted within DTT components. **Originality/value**: This study adds to the literature by highlighting the role of cultural and economic factors in the adoption of DTTs and introduces the novel concept of how change management strategies mediate the relationship between DTT characteristics and institutional sustainability. It provides practical insights for decision-makers in Saudi and Egyptian institutions, emphasizing culturally and economically aligned strategies for integrating DTT, fostering educational innovation, and enhancing sustainability.

Keywords: digital teaching technologies; institutional sustainability; staff resistance; change management; educational outcomes; culture norms; financial sustainability; technological infrastructure; economic factors; higher education in Saudi Arabia; higher education in Egypt

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1. Introduction

There is no doubt that a greater number of channels are available for the deepening of learning experiences and more opportunities for administration to be more efficient, as suggested in the literature [1,2], and that digital teaching technologies have introduced new teaching formats. This has resulted in the presentation of compelling arguments in favor of using DTT and its redefinition as an integral pillar of the educational landscape and its impact on how the staff at universities across Saudi Arabia and Egypt have resisted its implementation. Resistance refers to multiple dimensions and ways in which resistance to change happens when DTT is being integrated into teaching practices [3,4].

However, to implement DTT successfully, it is essential to address the root causes of resistance, which are often shaped by cultural and economic considerations [5,6]. While the literature highlights the effectiveness of change management strategies in mitigating resistance, their success depends significantly on aligning with the institution's specific economic and cultural contexts [3,7]. Beyond these mediating and moderating factors, other critical characteristics of DTT—such as perceived ease of use, compatibility with existing systems, and observable benefits—are also very important in terms of fostering sustainability. Knowing how these elements interact together to influence adoption is crucial to formulating holistic strategies for successful integration.

This research opts to explain how the change management strategies are affecting staff resistance and how they can contribute to the enhancement of the educational, cultural, and financial sustainability of universities in both Saudi Arabia and Egypt. DTT enhances learning outcomes, reduces operation costs, and advances long-term institutional objectives; therefore, it is a vital enabler of sustainability in higher education [8,9]. This has shown how the integration of DTT standardizes accessible, inclusive, and quality education for everyone, including environmental and financial sustainability, in line with the United Nations' Sustainable Development Goals (UN SDG 4). The following points were deduced as guiding questions:

- Do perceived characteristics of DTT substantially impact institutional sustainability in Saudi and Egyptian universities?
- Do change management techniques mediate the relation between perceived characteristics of DTT and institutional sustainability in Saudi and Egyptian universities?
- Do culture norms moderate the relation between perceived characteristics of DTT and institutional sustainability in Saudi and Egyptian universities?
- Does technological infrastructure moderate the relation between perceived characteristics of DTT and institutional sustainability in Saudi and Egyptian universities?
- Do economic factors, such as budget constraints, funding availability, and institutional financial policies, moderate the relationship between perceived characteristics of DTT and institutional sustainability in Saudi and Egyptian universities?
- Do cultural norms significantly affect the institutional sustainability in Saudi and Egyptian universities?
- Does technological infrastructure significantly affect the institutional sustainability in Saudi and Egyptian universities?
- Do economic factors significantly affect the institutional sustainability in Saudi and Egyptian universities?

The literature review for this research will shed light on the theoretical lens dealing with cultural and economic dimensions. Two case studies have been compared, where the survey data and exploratory interviews come from the two selected universities in Saudi Arabia and Egypt. By incorporating cultural, technological, and economic contextual factors into established technology adoption models, as in the case of the Technology Acceptance Model (TAM) [10] and the Unified Theory of Acceptance and Use of Technology

(UTAUT) [11], this study seeks to examine the moderating role of these factors in relation to the mediating effects of change management strategies. This approach extends TAM and UTAUT, elucidating further Digital Teaching Technology adoption in Saudi Arabian and Egyptian cultural contexts.

The analysis is based on a twofold methodological approach: First, data were gathered through a questionnaire survey sent to private and public universities in Saudi Arabia and Egypt, with 427 questionnaires returned. The survey aimed to investigate DTTs and their potential impact on institutional sustainability, along with three dependent factors: educational outcomes, staff resistance, and financial feasibility. Moreover, the current analysis added three moderation factors, namely cultural norms, economic considerations, and technological infrastructure, and one mediation factor, namely change in management strategies. Second, data collected were analyzed using SEM with SmartPLS 4 to verify inter-relationships among the characteristics of DTT and the mediation and moderation factors with institutional sustainability. Resistance-reducing strategies for sustainability enhancement from the change management portfolio were critically evaluated, and their comparative findings were benchmarked to reveal similarities and differences between the two contexts.

Ultimately, this research study aims to present concrete recommendations for the effective navigation of the problem of staff resistance to DTT. The research gap pinpoints the importance of effective change management techniques in inducing sustainable strategies, which will countervail staff resistance to implementing DDT in teaching and assessments. This research's key takeaways are oriented toward policy and strategy formulators and specialists in education at the university level, with a special focus on Saudi Arabia and Egypt. Therefore, it will help inform strategies that enhance the likelihood of successful integration of DTT in universities in Saudi Arabia and Egypt by enriching the understanding of how the interaction among cultural context, change management strategy, and economic factors drives educational advancement and institutional sustainability. Further, many studies have reported the need to understand the point of view of the university faculties with administrative roles [12–14], which will be done in our study.

2. Literature Review

2.1. Introduction to Digital Teaching Technologies

Digital teaching technologies encompass all tools and platforms that utilize digital advancements to facilitate learning and improve its results. They transitioned from the initial, fundamental computer-based training programs to more intricate learning environments that were frequently interactive, immersive, and engaging. Thus, the development has been characterized by the integration of artificial intelligence, mobile computing, and internet connectivity. These three elements are integrated to create more flexible and customized learning experiences. These elements formulate Learning Management Systems (LMSs) and Massive Open Online Courses (MOOCs), virtual classrooms, and other educational applications that are applicable to both synchronous and asynchronous learning modalities [15].

The significance of digital technologies in the higher education sector cannot be overstated in the context of the contemporary world. An educational institution will be able to provide a broader range of educational materials and accommodate a wide range of learning styles and requirements through the implementation of digital technologies [16,17]. Ultimately, an integrated approach to digital technologies in practice will result in improved student satisfaction and results as well as more engaging interactive content [18]. Furthermore, the adaptability of a digital platform facilitated lifelong learning and continued professional development in the current high-speed and dynamic labor market [19]. As

indicated in [20], the utilization of DTT has increased significantly worldwide, resulting in a relatively divergent trend across different regions. For example, the Middle East has experienced accelerated growth in the number of virtual classrooms and e-learning platforms. It was the outcome of government initiatives and sector investments in the region, such as Saudi Arabia's Vision 2030, which significantly advanced e-learning infrastructure and increased the adoption of virtual classrooms, leading to improved access to education and enhanced digital literacy among students [21]. This plainly demonstrates the dedication toward modernization in the educational sector and the endeavor to equate students with skills in the digital economy of the future.

2.2. Theoretical Frameworks on Technology Adoption

In this regard, it will be essential to consult a variety of theoretical frameworks regarding the DTTs that have been implemented in higher education [10]. The *"Technology Acceptance Model"* (TAM) is considered one of the most influential models in this field. TAM posits that technology adoption is influenced by only two primary factors: perceived ease of use and perceived utility. Users will integrate technologies into their routines if they perceive task benefits and simplicity of use, as per the model. It has been applied in various studies regarding the acceptance of newly introduced digital tools and platforms among instructors and students in educational settings [22–24].

Another influential model includes the "*Unified Theory of Acceptance and Use of Technology*" [11,25]. Essentially, UTAUT will consider several models, including TAM, for a more comprehensive explanation of the adoption of technologies [26]. This encapsulates fundamental constructs under performance expectancy, effort attainment, social influence, and facilitating conditions. Again, these are moderated by factors such as age, gender, experience, and voluntariness of use. UTAUT has benefited higher education in general and, in a more specific sense, in relation to the interaction of demographic groups with the instruments, which are the DTTs [25].

Finally, ref. [27] observes that Rogers' (1962) theory of the "*diffusion of innovations*" provides a more comprehensive explanation of the process by which innovations disseminate within a social system. It depicts the adoption process as being influenced by the characteristics of innovation, communication channels, time, and social systems that are involved in the process. In this theory, adopters are classified into five categories: innovators, early adopters, early majority, late majority, and laggards. This theory examines DTT and endeavors to determine the mechanisms and reasons behind the diffusion of specific technologies in an educational environment and the factors that could influence their widespread adoption. Researchers and practitioners are better equipped to strategize on how to implement and promote digital teaching tools to enhance educational outcomes when they comprehend these theoretical frameworks [28].

2.3. Perceived Characteristics of DDT

The characteristics of a technology significantly influence its diffusion process and play a crucial role in its adoption. Research indicates that attributes such as relative advantage, compatibility, complexity, trialability, and observability, as perceived by individuals, impact the adoption rate [29]. Also, ref. [29] emphasizes that understanding how new innovations are perceived is essential, as these perceptions strongly affect predictions about the future adoption of specific innovations. Grasping educators' views on innovation is critical for successfully integrating technology into education, which, according to [30], represents a particular type of instructional innovation [31]. Additionally, ref. [32] highlights that when teachers incorporate digital teaching technologies (DTTs) into their practice, they act as innovators. Several recent studies have explored these aspects, including research on

students' attitudes toward educational technology in higher education [33], the views of pre-service teachers, perceptions of asynchronous discussion boards [34], teachers' perspectives on learning technologies [22,35] and the predictive power of perceived attributes of the internet on its adoption as a learning tool [36]. These studies found that observability and trialability were the most influential factors.

Moreover, ref. [31] suggests that the characteristics of DTTs themselves can influence the rate of their diffusion. Examining educators' perceptions of DTT across the five attribute dimensions—relative advantage, complexity, compatibility, observability, and trialability—can offer valuable insights into how these characteristics are perceived and whether they facilitate or hinder the adoption of DTT. The characteristics can be defined as follows: (1) Relative advantage refers to the perceived superiority of digital education transformation compared to traditional education. (2) Compatibility measures how well digital education transformation aligns with existing educational systems, concepts, and values while meeting societal needs. (3) Complexity assesses the difficulty of understanding and implementing digital education transformation. (4) Trialability considers whether digital education transformation can be tested and experienced in a controlled setting. (5) Observability examines whether the outcomes of digital education transformation are visible to potential adopters [31]. Higher levels of relative advantage, compatibility, trialability, and observability typically accelerate the diffusion process, whereas greater complexity tends to slow it down.

2.4. Institutional Sustainability

Institutional sustainability is a comprehensive concept that reflects an institution's ability to maintain its operations, achieve long-term goals, and adapt to changes in the educational environment. One of the key variables affecting sustainability is staff resistance, which can significantly influence the success of new initiatives and innovations. High levels of staff resistance can disrupt the implementation of critical changes, reducing the institution's capacity to grow and evolve [37–39]. Thus, managing staff resistance is essential to fostering a flexible and sustainable institutional culture.

Another critical factor in institutional sustainability is financial sustainability, which ensures that the institution has adequate resources to continue functioning effectively. Institutions with sound financial strategies are better equipped to invest in infrastructure, support academic programs, and respond to economic challenges [40,41]. Financial stability allows institutions to allocate resources where needed, ensuring they can meet both immediate operational needs and future growth goals, which is crucial for long-term sustainability.

Educational outcomes are also a vital component of institutional sustainability, as they directly reflect the institution's success in fulfilling its academic mission. High-quality educational outcomes, such as improved student performance and graduation rates, not only enhance the institution's reputation but also attract prospective students and funding opportunities [42,43]. Strong educational results demonstrate the institution's effectiveness and its capacity to sustain itself and thrive in an increasingly competitive academic landscape.

2.4.1. Staff Resistance

Understanding the staff's resistance to DTT is crucial for their successful implementation within an educational setting. A simple definition of resistance would be any negative or reluctant attitude to adopt new technologies; it manifests in both active and passive ways [44]. Active resistance involves open actions or acts of resistance in the form of vocal objection to the technology, refusal to use new tools, or even attempts at undermining the

implementation efforts [45]. The latter is more subtle and can take the form of reluctance to train, slowness to adapt, or complying with a minimum dosage without really adopting [46]. Both forms of resistance can significantly hinder digital technology integration in the educational setting, affecting, in general, the overall impact of technology-driven initiatives [47].

Several dynamics appear to produce resistance to staff in educational settings: lack of familiarity and comfort with new technologies, perceived threats to job security, increased workload, and insufficient training and support [48]. In this respect, a high role can be attributed to cultural and organizational factors like resistance to change, rigid hierarchies, and lack of incentives. It thus becomes essential to understand these factors for the development of strategies aimed at mitigating resistance and creating a more supportive environment for technology adoption [49–51].

Moreover, it is elaborated further by empirical studies and case studies conducted across universities in Saudi Arabia and Egypt. In one such case at King Saud University, the lack of technical skills and fear of change have been claimed as the primary reasons for resistance [52,53]. In another case at Cairo University, inadequate training and support, coupled with cultural barriers, emerged as major contributors to resistance [54,55]. Common resistances across these studies revolve around issues related to digital tools' effectiveness, loss of control over the teaching process, and fears about the impact on traditional teaching roles [56].

Measuring resistance is a necessary step toward dealing with it. Hence, it can, in most cases, be done through a survey and in-depth interviews to determine the extent and nature of the staff's resistance. While questionnaires provide data regarding the prevalence and intensity of resistance in quantitative terms, the interviews conducted offer more in-depth insights in qualitative terms into the reasons and emotional responses. These tools contribute to noticing problems and developing interventions to help staff move on to DTT [57–59].

2.4.2. Educational Outcomes

Educational outcomes refer to the measurable achievements and impacts of educational processes on students' knowledge, skills, attitudes, and behaviors. These have usually been assessed by various metrics, such as academic performance, retention rates, and student satisfaction surveys. Hence, in the broader context of digital teaching technologies, the effectiveness of technology for better learning experiences, engagement, and overall satisfaction of both students and faculty members is incorporated into educational outcomes. Such outcomes are typically measured through a combination of quantitative data, in the form of grades and test scores, and qualitative feedback in the form of surveys and interviews [60–62].

Digital technologies impact students much. Such technologies provide an interactive and engaging environment that draws the attention of the learners and ensures active participation. The use of multimedia presentations, virtual simulations, and gamification learning modules are some of the techniques through which the education system can be made more vibrant, hence engaging and stimulating interest in the concepts being taught [63]. Moreover, as instant feedback and individual learning trajectories are possible, students can trace their progress and be more deeply involved in the subject matter [64]. Additionally, research showed that students working with digital tools for learning are much more active during classroom discussions and while working on group projects, which improves their overall learning process [65].

DTTs influence learning effectiveness and, correspondingly, academic performance. It is fundamental that these means can enhance understanding and retentiveness in the

course material by providing various and flexible learning modalities suitable for different learning styles [66]. For instance, students can combine online and face-to-face instruction in blended learning environments. These digitalized learning tools improve their academic performance, as students in such learning contexts have a better opportunity to establish a learning pace for themselves and take up review of such when needed [61,67]. Moreover, by leveraging education technology with the power of data analytics, educators can understand where students may struggle in class and hence provide targeted interventions that help in improving the overall outcome in terms of student learning outcomes [68,69].

Another critical outcome that is influenced is the satisfaction with the educational experience. In fact, students enjoy more flexibility and convenience due to the digital teaching technologies, which help them balance their academic responsibilities with other personal commitments. These technologies make learning more enjoyable and satisfying due to their interactive and engaging characteristics, and more satisfied students drop out less frequently [31]. From the faculty perspective, there was also a view that digital technologies might make administrative tasks easier, provide far greater efficiency in teaching, and eventually create opportunities for professional development. Nevertheless, faculty satisfaction also rests on adequate training and support, coupled with the commitment of the institution to effectively integrate such technologies [70]. Generally, DTT easily engages students, enhances learning and academic performance, increases the satisfaction of students and faculty, and leads to better educational outcomes.

2.4.3. Financial Sustainability

The adoption of DTT in educational institutions has huge economic repercussions and requires careful resource allocation to be financially sustainable. Before technological integration begins, costs include hardware, software, staff training, and technological foundation upkeep. These are considered enormous expenses, especially in low-budget institutions. Over time, enhanced learning outcomes, student motivation in learning, and organizational efficiencies may offset the initial cost [71]. If so, then institutions should evaluate such economic consequences of their actions and implement appropriate systems for cost management to achieve maximum benefit from digital instructional technology.

Therefore, finance and budgeting play an essential role in integrating technology. Most universities regularly receive government support, grants, contributions, and tuition fees. A certain percentage of this technology integration budget guarantees adequate funds for equipment, digital content, technical assistance, and training [72]. Funding can also be provided through collaborations or grants from technological businesses. Technology companies participate in education to market their products, infiltrate markets, and find skilled labor. Partnerships can finance the acquisition of digital tools, staff training, and technological infrastructure maintenance. Hence, strategic budgeting needs to address short- and long-term technology adoption issues.

Assessments of ROI and cost-effectiveness are essential in the strategy of financing technology integration. An institution should be able to calculate the return on investment by comparing the implementation cost to the prospective rewards, such as improved student performance, better retention rates, or reputation. Cost-effectiveness through open-source technology, scalable solutions, and optimizing resources is possible, according to [73]. In addition, finance is limited, initial investment costs are considered very high, and upkeep is continuous, so institutions need to develop robust sustainability strategies. These may include phase-by-phase adoption of digital tools, adoption of high-impact technologies, and constant evaluation of the effectiveness toward the goals of education as well as infrastructure and resource allocation and hence are considered key factors for successful adoption of digital teaching technologies [74]. First, digital learning technology

must be adopted at the institution, which incorporates a safe network, proper hardware, and good internet. Second, institutions need to make judicious resource allocations for infrastructure development, staff training, and technical support. The economic stability of an institution determines the technological advancement of educational institutions [75,76]. According to [77], stable institutions are better at investing in long-term technology projects and supporting digital efforts.

In addition, personnel pay and incentives are crucial for financial sustainability. Competitive compensation and incentives will attract and retain qualified staff who can effectively deploy and support digital instructional technology. Thus, providing staff with professional development opportunities and acknowledging their achievements would boost motivation and dedication to institutional goals [78]. Financial sustainability and effective resource allocation enable educational institutions to utilize digital instructional technology.

2.5. The Impact of DTT on Institutional Sustainability

Higher education institutions (HEIs) go the extra mile to support SDGs by implementing various key initiatives that promote SD. First, higher learning institutions should inspire a culture of sustainability by infusing sustainability principles into their curriculum, education, and research programs. They offer resources and expertise on sustainability matters as crucial centers for local knowledge. Thirdly, by incorporating sustainability into strategic planning and management, higher education institutions set a clear example to transform sustainability into a core institutional value. This is because HEIs actively contribute to the societal transformation toward sustainability in view of its effect on (a) generating knowledge and (b) disseminating it within the wider community, and training future leaders through these actions. Hence, HEIs are significantly striving to attain the SDGs while simultaneously benefiting from their involvement with these global goals [79].

However, the integration of DTT frameworks is crucial for any realistic attainment of the SDGs. DTT refers to competence development in software functionality, systems integration, and computing. Effective DTT in education combines digital literacy and a focus on applied technologies and infrastructure that is foundational to teaching curricula. DTT can also meaningfully contribute to accelerating progress toward each SDG and solving fundamental environmental challenges. In addition, DTT offers direct tools and technologies to support Egypt and the KSA 2030 Agenda and to enable better access to knowledge on sustainability. These have made learning an active and dynamic process, with much greater effectiveness and the spread of education globally [9,80].

Technology-enhanced education for sustainability makes applying Green IT principles in people's daily and professional lives possible. That would raise awareness of specific meaningful ways in which sustainable technology is performed. Competencies for DTT professionals must be developed to enable a digitally enhanced future, integrate sustainability within university programs, and incentivize faculty and students to contribute toward sustainability [64].

2.6. Change Management Techniques

Implementing DTT in an educational institution requires strong change management strategies to ensure smooth transitions with minimal resistance. Conceptually, a framework pertaining to change management in an educational setting encompasses the understanding of these unique cultural, structural, and operational aspects of educational institutions. It considers the preparation of the organization for change, transition management, and the institutionalization of new approaches that sustain such change. Effective change management would, therefore, require a holistic approach: clear communication,

active participation, continuous support, and concern addressing for all stakeholders involved [81,82].

A plethora of principles and models about change management lend support in managing transitions in any area, including training organization. For instance, "*Change Management Model*" entails the stages of unfreezing, changing, and refreezing; it places much emphasis on preparing the organization for the change, the introduction of new practices, and the fixing of these practices until they become a part of the organizational culture [83]. This model is about developing a sense of urgency, breaking current mindsets, and re-emphasizing new behaviors. Another well-known model is the "*Eight-Stage Model*" for change of Kotter, which represents the complete approach of a change in the leadership process. Kotter's model entails creating a sense of urgency, forming a guiding coalition, developing a vision and strategy, communicating the vision, empowering people for broad-based action, generating short-term wins, consolidating the gains to produce more change, and anchoring new approaches in the culture [3,84,85]. Both models emphasize the importance of leadership, communication, and direct involvement by stakeholders in the change process.

Effective change management practices that integrate DTT include several strategic actions: First, they include developing a clear vision and strategy outlining the benefits and aims of integrating the technology [86–89]. The communication process is vital in keeping everybody on board, open to what is taking place, and dispelling any misapprehensions that might have cropped up. Further, providing detailed training and ongoing support to staff enhances their competence and confidence in using new technologies. It encourages participation and feedback from staff and students since it induces in them a sense of ownership and commitment to the process of change. Moreover, short-term successes, if noted and celebrated, serve as a means of building momentum and reinforcing positive messages about the impact of digital technologies on the process of change [90]. Drawing upon these principles and practices, an educational setting would be capable of surmounting many of the complexities of change and transforming itself in such a manner that it integrates DTT with a focus on better educational outcomes.

2.6.1. The Impact of DTT on Change Management Techniques

Change management embraces all aspects of changes taking place in the modern economy and global society. Indeed, today, change has become all-present, turning into a mandatory constituent of both organizational and social life. Organizations should take proactive measures to ensure efficiency, profitability, and sustainability as contemporary society urges incessant adjustment. Organizations often fail to pursue a strategy for strategic change management approach, as they view change as a discrete event instead of a process. It does not account for the fact that such change should be addressed from a systemic point of view at all possible levels. This landscape is highly influenced by the changes that have been happening in technologies. It is, in fact, a very broad field that is gradually targeting the education sector [91].

This change is predominantly taking place in the place of this transformation: educational institutions themselves. For the modern educator, adaptations to digital methodologies and effective technology integrations to enhance learning are becoming key challenges. A junction of DTT and change management would provide an avenue for bringing improvement in the quality of education with updated technology and curriculum development [92]. Commercial, political, and cultural changes are witnessed in organizations as a result of dynamic forces characterizing the modern economy. Traditional businesses need to orient their current activities toward new technologies so that they can survive in a modern economy. Basically, in the current environment, success requires intelligence, ideas,

and information. Organizational change has generally been categorized into one of two types: a change made to improve the organization proactively, and circumstantial-reactive change. Change management systems provide ways for organizations to proactively plan and manage change, rather than reacting to change [93]. Effective change management strategies ensure that institutions embrace DTT with least resistance; hence, a workforce is created that can deliver both current and future expectations within a fast-changing economy [91,94].

2.6.2. The Impact of Change Management Techniques on Institutional Sustainability

During the last decade, the term 'transformations toward sustainability' has become a fashion in international research and policy discourse on sustainability. However, from the organizational change management perspective, advocating for sustainability is extremely problematic for three reasons: It is vague. One path forward is obscure due to several different stakeholders with different interests; transition pathways to sustainability are inherently complex. A scientific approach is thus needed if these additional barriers are to be overcome. Although the sustainability transformation of organizations is a comparatively new discipline, several lessons could be transferred from established research on the management of organizational change with respect to sustainable transitions. Sustainability is simply not a key focus of most organizations at their establishment [95].

Sustainable institutional building requires a robust implementation mechanism, active involvement of employees, thorough stakeholder involvement down the value chain, and evident commitment from leadership. Whereas it is crystal clear there is a need to generate a sustainable strategy, the way forward seems to be vague. There is also a serious shortage regarding research on sustainability transformation with an emphasis on operationalization processes. The unsustainable practices, instead of highlighting the processes leading to transformation, have gained academic prominence. It should, therefore, follow that a structured framework should be specified to enable the effective implementation of sustainability. It would, therefore, be important for sustainability science and change management to be integrated to provide a structured approach for sustainability transformation that will guide the institutions concerning the need for sustainable development. This offers steps that are actionable in enhancing institutional sustainability, and it can be applied by implementing change management techniques [96,97].

2.6.3. The Mediating Role of Change Management Techniques in the Relationship Between DTT and Institutional Sustainability

Change management techniques are essential for linking the adoption of digital teaching technologies (DTTs) with the realization of institutional sustainability. Effective change management ensures that technological transitions are integrated smoothly, fostering an environment that supports long-term operational resilience and adaptability [4]. Such strategies address both human and procedural aspects, making transitions less disruptive and aligning technology initiatives with institutional goals.

Comprehensive change management approaches, including faculty training, engagement workshops, and adaptive leadership models, enhance the acceptance and utilization of DTT. These approaches mitigate resistance by preparing stakeholders and facilitating a shift toward a culture that embraces technological innovations. According to research on strategic change management, initiatives that incorporate regular feedback and iterative learning practices contribute to continuous improvements and the successful embedding of new technologies within organizational processes [98].

Change management also provides a platform for evaluating existing procedures and ensuring that new technologies are seamlessly integrated without compromising the quality of operations. Such assessments often lead to optimized workflows and resource

allocation, thereby improving overall educational outcomes and supporting sustainability efforts [99]. By embedding change management as a strategic element of their digital initiatives, educational institutions can enhance their resilience and maintain the momentum necessary for future innovations [100].

2.7. Cultural Norms

Cultural norms play a significant role in shaping the adoption and integration of digital teaching technologies (DTTs) within educational institutions. These norms refer to shared values, beliefs, and practices that influence the behavior and attitudes of individuals within a specific cultural context. In educational settings, understanding cultural norms is crucial as they impact how technology is perceived and embraced by faculty, students, and administrators [101].

In high-power-distance societies like Saudi Arabia and Egypt, the acceptance of DTT often hinges on endorsements from top-level authorities and alignment with traditional teaching practices [102]. This hierarchical structure can facilitate technology adoption if leaders actively support it but can also contribute to resistance if faculty members feel that DTT challenges conventional teaching norms [49,103].

On the one hand, collectivist cultures, which emphasize group harmony and collaborative learning, may show greater receptivity to technologies that support cooperative educational models, such as online discussion forums and group-based projects [104]. On the other hand, societies with high uncertainty avoidance may exhibit resistance due to fears of change and a preference for stability [105]. Extensive training, clear communication, and alignment with cultural values are essential for overcoming these barriers [106].

Empirical evidence from universities in both Saudi Arabia and Egypt underscores the necessity of culturally adaptive strategies. For instance, initiatives at King Abdulaziz University involved incorporating local language and religious content into e-learning platforms, increasing acceptance among students and faculty [107]. Similarly, institutions in Egypt that tailored their digital approaches to align with societal norms observed higher rates of technology adoption [108].

The Moderating Role of Cultural Norms in the Relationship Between Digital Teaching Technologies (DTTs) and Institutional Sustainability

Cultural norms significantly influence how DTT impacts institutional sustainability. In both Saudi Arabia and Egypt, cultural values shape staff perceptions and acceptance of DTT, which in turn affects long-term sustainability. Cultural considerations include hierarchical decision-making and traditional teaching preferences, which can either support or hinder the integration of DTT [101,103]. Adaptation to these norms can result in smoother transitions, enhancing sustainability by fostering environments more accepting of technological change [102].

Cultural norms play a moderating role between DTT and institutional sustainability. For example, in high-power-distance cultures like Saudi Arabia, where authority structures are respected, face-to-face teaching is highly valued [53]. In Egypt, similar cultural barriers exist, particularly in conservative academic fields. Recognizing and aligning DTT adoption strategies with cultural expectations can help increasing institutional sustainability [52,108].

2.8. Technological Infrastructure

Technology infrastructure forms the backbone for the effective deployment and integration of digital teaching technologies (DTTs) in educational institutions. It includes reliable high-speed internet, modern hardware, software systems, and secure network environments. The presence of robust technology infrastructure enables the seamless delivery of online and hybrid learning models, facilitates interactive learning environments,

and supports real-time assessments and feedback [94]. Without a strong infrastructure, challenges such as connectivity issues and outdated equipment can hinder the adoption of DTT, affecting both teaching efficacy and student engagement [53].

Investments in technology infrastructure are critical for enhancing institutional sustainability and educational outcomes. Well-developed infrastructure allows institutions to adapt to modern educational demands, promoting efficiency and a better learning experience. For example, continuous updates and maintenance of technological resources ensure minimal disruption and support long-term educational goals [9]. The scalability of infrastructure also plays a crucial role in future-proofing institutions, making them better prepared for advancements in digital learning technologies.

The Moderating Role of Technological Infrastructure in the Relationship Between Digital Teaching Technologies (DTTs) and Institutional Sustainability

Technological infrastructure significantly affects the sustainability of institutions adopting DTT. Robust and reliable infrastructure, including high-speed internet and up-to-date software and hardware, enables successful integration and long-term use of DTT. Weak infrastructure can impede adoption and limit the sustainable benefits of technology, creating operational challenges [72,94]. Therefore, investment in infrastructure is crucial to ensure that DTT positively impacts institutional sustainability.

2.9. Economic Factors

Economic factors significantly influence the adoption and successful implementation of digital teaching technologies (DTTs) in higher education. Financial resources determine the extent to which institutions can invest in the acquisition, maintenance, and upgrading of digital tools and platforms. Universities with substantial budgets can implement comprehensive digital strategies and provide faculty training and support services that facilitate DTT adoption and integration [71]. Conversely, institutions facing financial constraints may struggle with initial investment costs, ongoing operational expenses, and resource allocation, potentially leading to resistance or limited adoption of DTT [109].

The economic landscape also impacts how educational institutions prioritize spending. For institutions in regions with economic challenges, strategic allocation of funds and external support, such as government grants or partnerships with technology firms, become essential for digital transformation [8]. Additionally, evaluating the return on investment (ROI) from adopting DTT can help institutions understand potential long-term benefits such as operational efficiency, enhanced learning outcomes, and expanded enrollment capacity, which may outweigh the initial costs [37]. Economic considerations thus play a pivotal role in shaping strategies for sustainable implementation of digital technologies in education.

The Moderating Role of Economic Factors in the Relationship Between Digital Teaching Technologies (DTTs) and Institutional Sustainability

Economic factors, such as budget constraints and funding availability, play a critical role in moderating the relationship between DTT and institutional sustainability. Institutions with strong financial resources can invest more readily in DTT, facilitating smoother adoption and maintenance, thereby enhancing sustainability. Conversely, institutions with limited funding may struggle with implementation and maintenance, which can hinder the sustainable integration of technology [8,71].

2.10. The Role of Cultural Norms in Institutional Sustainability

The cultural norms at an institution form the backbone for ensuring sustainability, as they may influence significant aspects related to staff resistance, educational outcomes, and

financial sustainability [110]. Adding to that the ability of institutional mechanisms to adapt and prosper in a dynamic educational and economic environment lays the foundation of sustainability, wherein cultural norms also act as an enabler and a barrier to adaptability. These norms, which encompass shared beliefs, values, and practices within an institution, often dictate the acceptance of new strategies or technologies [111]. On the one hand, hierarchical cultures may resist innovations that challenge traditional authority structures, leading to higher levels of staff resistance and hindering the implementation of transformative initiatives. Similarly, cultural preferences for traditional teaching methods can limit the adoption of innovative pedagogical tools, hence affecting educational outcomes. On the other hand, cultures that place a high value on collaboration, adaptability, and continuous improvements are more likely to create an environment that is supportive of change and thus improves institutional performance [112]. Financial sustainability is also affected by the cultural attitude toward resource allocation and long-term planning [113]. Cultures that emphasize transparency, accountability, and strategic foresight tend to align financial practices with sustainability goals, ensuring the institution's capacity to invest in infrastructure, training, and innovative projects [114]. Furthermore, the integration of cultural norms into institutional strategies can mitigate resistance, foster stakeholder engagement, and align organizational practices with societal values, creating a resilient and sustainable institutional framework. Addressing cultural norms effectively requires tailored approaches that respect and incorporate these underlying values while fostering a progressive organizational culture that supports long-term sustainability goals [115].

2.11. The Role of Technological Infrastructure in Institutional Sustainability

Technological infrastructure is a core of institutional sustainability, for it has great potential to influence staff performance, educational outcomes, and financial resilience. With a strong infrastructure of modern hardware, software reliability, high-speed internet, and security of the networks, one can achieve a base that can easily integrate innovative practices and maintain operational efficiency. Institutions with better-developed technological systems can easily facilitate interactive and flexible learning environments for better student engagement and academic performance [116]. However, where infrastructure is outdated or untrustworthy, it becomes an obstacle, resulting in various hindrances to the success of technological initiatives and the integration by teachers and students of tools that support an innovative approach. Moreover, adequate technological infrastructure helps lower barriers to innovation among staff themselves [117]. Comprehensive systems that are user-friendly and well supported through training and technical assistance build confidence and acceptance from employees, minimizing disruptions when transitioning to new methods or platforms. Financial sustainability also has a close linkage to quality technological infrastructure. Investments in scalable and efficient systems enable institutions to streamline processes, reduce physical resource dependency, and implement cost-effective solutions, such as e-learning platforms and automated administrative functions [118]. Over time, these benefits can offset initial infrastructure costs and contribute to long-term financial stability. Additionally, a strong technological backbone supports institutional adaptability, allowing for quick responses to evolving educational demands and external challenges. This adaptability not only ensures the institution's resilience but also positions it as a competitive leader in the educational sector. Strategic investments in technological infrastructure, coupled with continuous updates and maintenance, are therefore indispensable for achieving institutional sustainability and advancing long-term organizational objectives [94].

2.12. The Role of Economic Factors in Institutional Sustainability

Economic factors are fundamental to institutional sustainability, influencing the ability to achieve long-term operational stability, educational excellence, and innovation [119]. The financial health of an institution determines the extent to which it can invest in critical areas such as infrastructure, staff development, and program expansion. Economic resources enable institutions to adopt and maintain advanced technologies, ensuring they remain competitive and responsive to modern educational demands. It is equally true that budgetary constraints can delay innovation adoption, postpone needed renovations, and increase the staff's resistance to changes due to the lack of proper support and resources. How strategically an institution decides on budget spending determines the institution's sustainability. Hence, institutions that give attention to optimizing resources and spending value will maximize returns on investments accordingly [120]. For example, targeted investments in digital tools and blended learning systems have the potential to reduce long-term operational costs, improve student outcomes, and increase enrollment capacities, thus strengthening financial resilience. In addition, economic factors affect institutional adaptability in response to external challenges such as changes in funding policy or economic downturns. Institutions with diversified income streams, such as government grants, private partnerships, and tuition revenues, are better equipped to weather financial uncertainties and sustain their missions [121]. Furthermore, economic considerations drive institutional decisions on staff compensation and incentives, which are essential for attracting and retaining qualified personnel who align with the institution's goals. By integrating sound economic planning with sustainable practices, institutions can create a stable and adaptive framework that supports educational innovation and long-term growth [122].

From the previous discussion, we can formulate the following hypotheses:

H1. *Perceived characteristics of DTT significantly affect the institutional sustainability in Saudi and Egyptian universities.*

H2. *Change management techniques mediate the relation between perceived characteristics of DTT and the institutional sustainability in Saudi and Egyptian universities.*

H2a. *The perceived characteristics of DTT affect change management techniques in Saudi and Egyptian universities.*

H2b. *Change management techniques affect the institutional sustainability in Saudi and Egyptian universities.*

H3. *Culture norms moderate the relation between perceived characteristics of DTT and the institutional sustainability in Saudi and Egyptian universities.*

H4. *Technological infrastructure moderates the relation between perceived characteristics of DTT and the institutional sustainability in Saudi and Egyptian universities.*

H5. *Economic factors moderate the relation between perceived characteristics of DTT and the institutional sustainability in Saudi and Egyptian universities.*

H6. *Culture norms significantly affect the institutional sustainability in Saudi and Egyptian universities.*

H7. *Technological infrastructure significantly affects the institutional sustainability in Saudi and Egyptian universities.*

H8. *Economic factors significantly affect the institutional sustainability in Saudi and Egyptian universities.*

3. Conceptual Model

Figure 1 illustrates the conceptual model designed by the authors

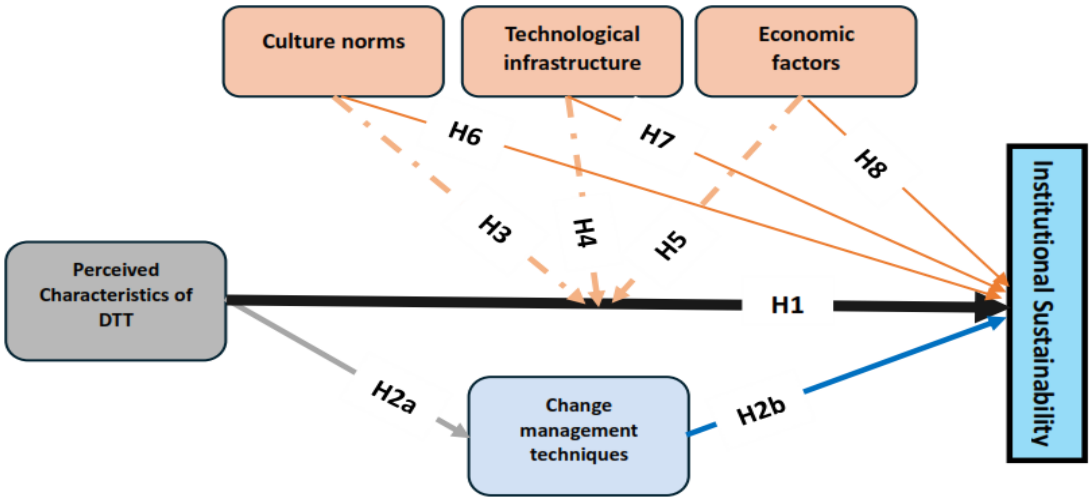

Figure 1. The conceptual model.

4. Methodology

4.1. Qualitative Study (Exploratory Study)

Specifically, this exploratory study intends to determine the overall dynamics and variables that influence how DTT impacts staff resistance, educational outcomes, and the financial sustainability of universities in Saudi Arabia and Egypt. Through the current study, an attempt is made to explore how cultural norms, technological infrastructure, and the economic context moderate the relationship between DTT and staff resistance, educational outcomes, and financial sustainability within these universities. These exploratory research findings will provide actionable recommendations for policymakers and educational leaders in enhancing the successful adoption of DTTs, which would eventually improve educational outcomes and financial sustainability, and of course, overcome staff resistance. For this purpose, the comparative case study approach was used, having both qualitative and quantitative methods drawing on the questionnaires and exploratory interviews directed at university staff with managerial roles in Egyptian and Saudi Universities to cover the main research hypotheses.

4.1.1. Exploratory Research Questions

The fast and invasive power of digital technologies in a variety of sectors, education being one of them, through DTTs, has since reflected itself. However, in the setting of a university, their integration is not without problems. This, therefore, is what this exploratory study seeks to undertake—to understand the complex dynamics that shape the adoption and acceptance of DTT within the university staff. This research has tried to identify key sources of resistance to DTT by examining a range of DTT perceived characteristics, cultural, technological, economic, and infrastructural factors. It also evaluates the moderating effect of change management strategies and ascertains the presence of broader implications of DTT for educational outcomes, financial sustainability, and reducing staff resistance.

Results of the Comparative Analysis of Digital Teaching Technology (DTT) Adoption in Egypt and Saudi Arabia

The adoption of DTT has so far been quite different between universities in Egypt and Saudi Arabia. This would then imply that each of the two countries has different challenges and opportunities regarding how such technologies could be integrated into their higher education systems. In this research study, insights are consolidated from interviews with key stakeholders in private nonprofit and governmental or public universities in Egypt and Saudi Arabia. The stakeholders interviewed in this regard included deans, vice deans, departmental heads, program coordinators, heads of quality units, and leaders of the DTT units. The contribution of these parties offers a general view of cultural, technological, and economic factors affecting the said DTT adoption in both contexts.

1. **Key Sources of Resistance to Digital Teaching Technologies**

Faculty members in both Egypt and Saudi Arabia also shared a similar concern in the adoption of DTT. Among the primary resistive reasons is that it disrupts the traditional ways of teaching. In both countries, faculty members, mainly those in the accounting, economics, and mathematics disciplines, questioned the efficiency of digital tools in communicating such subjects. For instance, instructors in Egypt worry that technology could outsource some of the critical parts of their jobs and hence eliminate them from their jobs. Workload increases, a shortage of training, and inadequate technological support are instances where issues that develop resistance to technology in Saudi Arabia are high.

Cultural preferences to maintain face-to-face interactions also act to deter DTT adoption in enforcement in both nations. This preference is particularly deep-rooted in Saudi Arabia, and most faculty members attest that direct teaching is paramount to ensuring the highest possible educational standards. In Egypt, whereas disciplines such as marketing and international business are becoming more accepting of DTT, more traditional direct lecturing disciplines remain wary about fully embracing these technologies.

2. **Impact of Change Management Strategies**

Change management strategies which are considered significant in both countries for minimizing resistance to DTT were discussed, including the involvement of faculty members in decision-making, provision of customized training programs, and follow-up assistance in Egypt; similarly, clear communication and supportive environments that provide opportunities for faculties to adjust to new teaching technologies were highlighted in the case of Saudi Arabia. Both countries saw value in framing DTT as complementary to, and not a replacement of, the conventional and traditional mode of teaching. Additionally, the participation of staff through workshops and examples of successful integration of DTT is necessary in both contexts to facilitate further general acceptance and reduce skepticism.

3. **Cultural Norms and Staff Attitudes Toward DTT Adoption**

In both Egypt and Saudi Arabia, cultural influences play a significant role in attitudes toward DTT adoption. The hurdle of change from Egyptian organizations is very vertically hierarchical and very adherent to traditional methods, which are upheld especially in fields such as accounting and economics. However, those departments closer to global trends—just like the marketing department—are more open toward DTT adoption.

Similarly, in Saudi Arabia, there is also a very strong culture that supports face-to-face interaction, especially in more technical fields of study. Most faculty teaching in Saudi universities believe that students learn more effectively through in-class teaching and thus resist adopting digital tools. This resistance will definitely be doubled by the organizational culture—that leadership might prefer something, and all the rest follow the institution's approach toward DTT.

4. **Economic Factors Influencing the Uptake of DTT**

The economic aspect is very important in Egypt and Saudi Arabia. On the one hand, private universities in Egypt especially care about the up-front initial costs of acquiring and maintaining digital tools, whereas these costs can be balanced by long-term operational efficiency and improved students' learning outcomes. Governmental universities, however, would need government funding and external grants to attain a greater degree in support of DTT adoption.

Some key disincentives in Saudi Arabia include the high costs related to the upgrading of technological infrastructure and training. Long-term savings are, nonetheless, also achieved by the stakeholders through DTT, since the reliance on physical resources is reduced, along with increasing operational efficiency. The financial constraints constitute a stumbling block for DTT adoption in both countries to the extent that the rate of adoption may be delayed, or its extent limited, even as long-term return on investment remains a factor of motivation.

5. **Technological Infrastructure and Its Impact on DTT Deployment**

Success in deploying DTT in both Egypt and Saudi Arabia is very much dependent upon the technological infrastructure of each university. In Egypt, for instance, stakeholders identified the importance of reliable bandwidth, modern software, and hardware that will ensure DTT integration goes smoothly. Without these resources, even faculty and students are experiencing technical difficulties that impede the adoption of DTT.

The state of the technological challenges is not much different in Saudi Arabia. Faculty members, for instance, spoke about unreliable internet connections and outdated hardware facilities. Economics and MIS programs require digital simulations and data analysis, which might pose a serious obstacle. In this context, improving the technological infrastructure in both countries would go a long way in fostering the wider acceptance of DTT.

6. **Educational Outcomes and the Role of DTT**

DTT is an opportunity to exist in both countries, which would assist in improving educational outcomes. This is because DTT is flexible, interactive, and personalized. Some of the instructional tools in Egypt have involved digital ones like simulations, real-time data analysis, and collaborative platforms, which enhance the students' comprehension and retention of course knowledge. The same potential for increased student engagement exists with DTT in Saudi Arabia, particularly including online assessments and recorded lectures.

However, in both countries, there is an apprehension that students would not take online learning as seriously as traditional methods. Faculty members in both Egypt and Saudi Arabia expressed doubts regarding student engagement, especially in hands-on or creative interactive kinds of subjects.

7. **Long-Term Financial Sustainability Through DTT**

The adoption of DTT for both countries, Egypt and Saudi Arabia, represent a way to achieve some kind of financial sustainability for universities in the long term. Private Egyptian universities, by introducing online and hybrid learning programs, could attract more diverse and international students while reducing operational costs associated with traditional teaching methods. Similarly, Saudi universities would be able to create a strategy related to increasing enrollments while reducing administrative processes and cutting down the number of traditional courses taught. Continuous investment in infrastructure and training will be required for the realization of the otherwise high financial returns of DTT in both these cases.

4.2. Quantitative Study

4.2.1. Data Collection, Sampling, and Questionnaire Design

The data sample was collected through online questionnaires administered to 427 respondents to represent private, governmental, and other universities in Saudi Arabia and Egypt. To ensure the validity and reliability of the questionnaire, a pilot study was conducted, followed by PLS-SEM testing to assess content validity, construct validity, and measurement consistency across universities in both countries.

A snowball non-probability sampling technique was used to target university staff with experience in digital teaching technologies (DTTs). This approach ensures that participants have relevant exposure to DTT integration in higher education. Although this method does not allow for full randomization, efforts were made to enhance sample diversity and representativeness by including faculty members from different institution types, experiences, academic positions, age groups, and genders. The questionnaire was initially distributed within professional circles of university staff and then expanded to reach a broader network of respondents actively engaged with DTT.

To assess the representativeness of the sample, cross-tabulations and descriptive statistics (Tables 1–7) were used to examine the distribution of key demographic variables. The results confirmed a balanced sample composition, with 59% male and 41% female respondents, a predominant age range of 25–45 years, and a mix of professors, associate professors, assistant lecturers, and teaching assistants. These characteristics ensure that the findings reflect a broad and relevant spectrum of university staff involved in DTT adoption.

First, the questionnaire included in Appendix A.1 was designed to fit on average 5 Likert scale statements to measure the independent variable representing the characteristics of applying digital teaching technologies (DTTs): relative advantage, complexity, observability, trialability, and compatibility. Second, the dependent variable comprised 3 general categories measuring the staff's resistance, educational outcomes, and financial feasibility. Each of those categories was covered by at least 5 Likert scale indicators. The mediating variable representing change management techniques was proxied through 5 Likert scale statements, as well as each of the 3 moderators chosen in the first place to represent cultural norms, technological infrastructure, and economic factors.

4.2.2. Main Descriptive Results for Tabulations and Cross-Tabulations

At first glance at the demographic data, Table 2 shows that 59% of respondents were males and 41% were females, and Table 1 for age distribution illustrated that over 80% of the respondents dominated the age bracket of (25–45). As shown in Table 3, over 51% of the sample worked as assistant professors, in contrast to a minority of 19.2% for associate professors and finally 8% for professors. The majority, 51%, of the respondents belonged to private universities, as illustrated in Table 4, benchmarked to 44% from governmental universities. The choice of respondents to be naturally biased toward private universities is expected, as most of them are well funded and equipped with an advanced digital infrastructure to support learning and teaching techniques. Finally, Table 5 refers to a breakdown of around 60% of respondents being of African nationalities; meanwhile, 30% are Asian.

Table 1. Age distribution of respondents.

Age	Freq.	Percent	Cum.
Less than 25 years old	19	4.45	4.45
From 25 to less than 35 years	177	41.45	45.90
From 35 to less than 45 years	167	39.11	85.01

Table 1. *Cont.*

Age	Freq.	Percent	Cum.
45 years and older	64	14.99	100.00
Total	427	100.00	

Table 2. Gender breakdown of respondents.

Gender	Freq.	Percent	Cum.
Male	252	59.02	59.02
Female	175	40.98	100.00
Total	427	100.00	

Table 3. Frequencies of academic titles.

Degree	Freq.	Percent	Cum.
Teaching assistants	39	9.13	9.13
Assistant lecturer	50	11.71	20.84
Assistant professor	222	51.99	72.83
Associate professor	82	19.20	92.04
Professor	34	7.97	100.00
Total	427	100.00	

Table 4. University type.

University Type	Freq.	Percent	Cum.
Private	216	50.59	50.59
Governmental	187	43.79	94.38
Other	24	5.62	100.00
Total	427	100.00	

Table 5. Nationality distribution.

Nationality	Freq.	Percent	Cum.
African	254	59.48	59.48
Asian	112	26.23	85.71
American	41	9.60	95.32
European	20	4.68	100.00
Total	427	100.00	

Table 6 illustrates cross-tabulations between age and the relative advantage of teaching technologies (DTTs) for the characteristics of their delivery, innovative technique, and employability by staff members. As shown in Table 6 (A), the younger the age of respondents (25 to 35), the more the delivery is facilitated via DTT, with 37.7% of this age bracket confirming the effectiveness of delivery will be optimized. Part (B) of Table 6 tends to draw insights regarding the correlation between age and the innovative features exiting in the DTT adoption as relatively superior to traditional teaching. According to 344 respondents concentrated in the age bracket (25–45), innovation comes as a result of using DTT, and finally, as shown in Part (C) of Table 6, most of the respondents, 81% of all 427 in the age categories (25–45), show the highest results with respect to the employability of DTT in facilitating teaching and learning aspects. Table 7, comparing university types and selected

categories of staff resistance, shows that there is no stark difference between KSA and Egypt when it comes to components of staff resistance, with an average of 2% difference between both. There are almost 18% neutral respondents regarding the staff resistance, as they seem not to be quite confident and secure in its results. This might lead to second thoughts about the economic factors such as thinking about cost–benefit analysis for DTT and its ability to reduce labor outlay.

Table 6. Selected cross-tabulations between age categories and digital teaching technologies attributes for relative advantage category.

(A)						
Age	**DTT Relative Advantage in Delivery**					
	1	**2**	**3**	**4**	**5**	**Total**
Less than 25 years old	0	0	2	7	10	19
From 25 to less than 35 years	1	1	14	110	51	177
From 35 to less than 45 years	1	10	20	90	46	167
45 years and older	2	3	10	30	19	64
Total	4	14	46	237	126	427
(B)						
Age	**DTT Relative Advantage in Innovation**					
	1	**2**	**3**	**4**	**5**	**Total**
Less than 25 years old	0	0	2	5	12	19
From 25 to less than 35 years	1	2	18	96	60	177
From 35 to less than 45 years	0	9	20	94	44	167
45 years and older	0	5	10	32	17	64
Total	1	16	50	227	133	427
(C)						
Age	**DTT Relative Advantage in Effectively Being Employed by Staff**					
	1	**2**	**3**	**4**	**5**	**Total**
Less than 25 years old	0	0	2	11	6	19
From 25 to less than 35 years	1	3	21	94	58	177
From 35 to less than 45 years	0	8	24	93	42	167
45 years and older	2	5	7	32	18	64
Total	3	16	54	230	124	427

Table 7 focuses on capturing the overlap between university location and staff resistance as a component of institutional sustainability to understand disparities between staff attitude and resistance to adopting DTT across both countries. The tabulation shows that there is no stark difference between Saudi Arabia and Egypt when it comes to staff resistance, with an average of 8% more respondents in Saudi Arabia agreeing that staff resistance could be a barrier stifling the adoption of DTT. The results are plausible, as the majority of respondents were Egyptians working in Saudi Universities, and they could face transition problems in adopting DTT. There are almost 18% neutral respondents regarding the staff resistance, as they seem not to be quite confident and secure in its results. This might lead to second thoughts about which additional factors would encourage them to utilize DTTs and the type of changes in management techniques that might be needed to implement DTT.

Table 7. Cross-tabulation between university location and staff resistance as a component of institutional sustainability.

University Location	Staff Resistance to Applying DTT As a Component of Institutional Sustainability					
	1	**2**	**3**	**4**	**5**	**Total**
Saudi Arabia	1	10	32	125	47	215
Egypt	4	6	43	110	49	212
Total	5	16	75	235	96	427

4.2.3. Modeling Approach Elaborated via PLS Structural Equation Modeling PLS-SEM

The conceptual model of the questionnaire was elaborated through an exploratory research method using the PLS-induced structural equation model (PLS-SEM) [123]. The use of PLS partial structural equation modeling has grown in significance with its nexus to research related to digital equations due to several benefits [124]. First, it handles a complex set of variables and discerns their relationships easily with minimal convergence challenges to the model's final solution. Second, PLS-SEM provides an array of benchmark indices other than the goodness of fit to interpret the model's validity and reliability constructs and composite reliability, in addition to its in and out of the sample prediction indices. Third, PLS-SEM is recommended for samples of larger size to ensure the ease of interpretation of the relationship between variables' constructs [125,126]. Fourth, it provides a formative construct for the model's observable variables without a compromise to any constraints or removal of constructs from the original data, and finally, it tends to handle cases of higher extreme values and greater variability and skewness.

4.3. PLS-SEM Conceptual Model Construct

Figure 2 represents the construct of the PLS-SEM's structure, which is mainly constructed on the theoretical foundation, main literature, and questionnaire construct [127]. On the one hand, in Figure 2, the group of endogenous variables reflects the independent observed variables, and each category of them measures one of the latent constructs, mediating variables, and finally the three categories of dependent variables. After the application of data filtering and coding techniques, the independent variables are grouped into the categories of "***Digital Teaching Technologies***" **(DTTs)** with five intended Likert scale statements capturing relative advantage, complexity, observability, trialability, and finally comparability. The next is the mediators' statements measuring the effect of "***Change Management Techniques***" **(CMTs)** reflecting components of training and support for DTT, the plan presented to staff, institutional readiness to adopt DTT, management vision of DTT, and finally staff involved in the digital transformation. The dependent variables representing **"Institutional Sustainability" (IS)** are composed of three categories representing educational outcomes, staff resistance, and financial feasibility. Each dependent variable category is measured on average by five statements with the exception of financial feasibility bearing up to eight statements for its construct. On the other hand, the exogenous indirect variables represent ***"Economic Factors"*** **(EFs)**, ***"Cultural Norms"*** **(CNs)**, and ***"Technological Infrastructure"*** **(TI)**, and the model's dependent variable is expected to be affected by their presence. Each of the two moderators is assessed through ten Likert statements with the exception of the technological infrastructure only being proxied through five Likert statements.

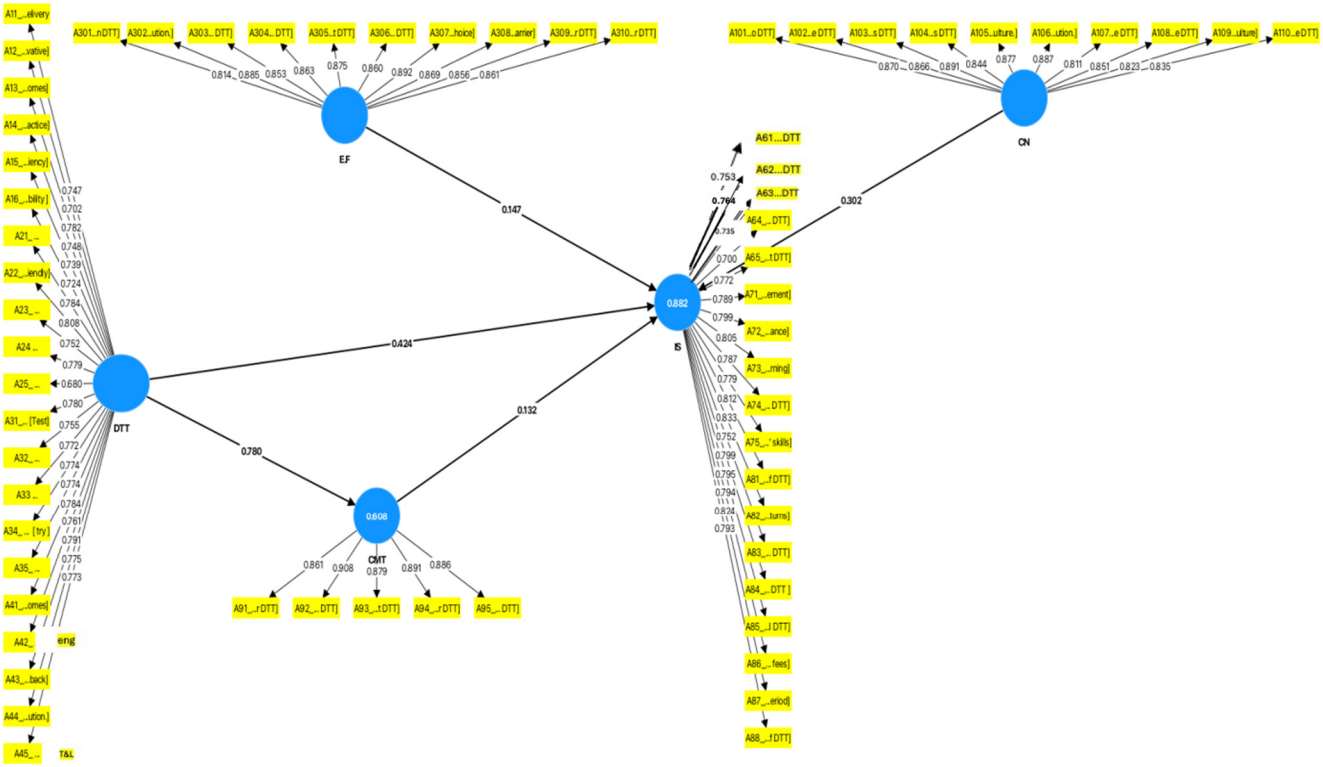

Figure 2. The graphical constructs of the PLS-SEM.

Figure 3 illustrates the modified model after removing the unsupported hypotheses.

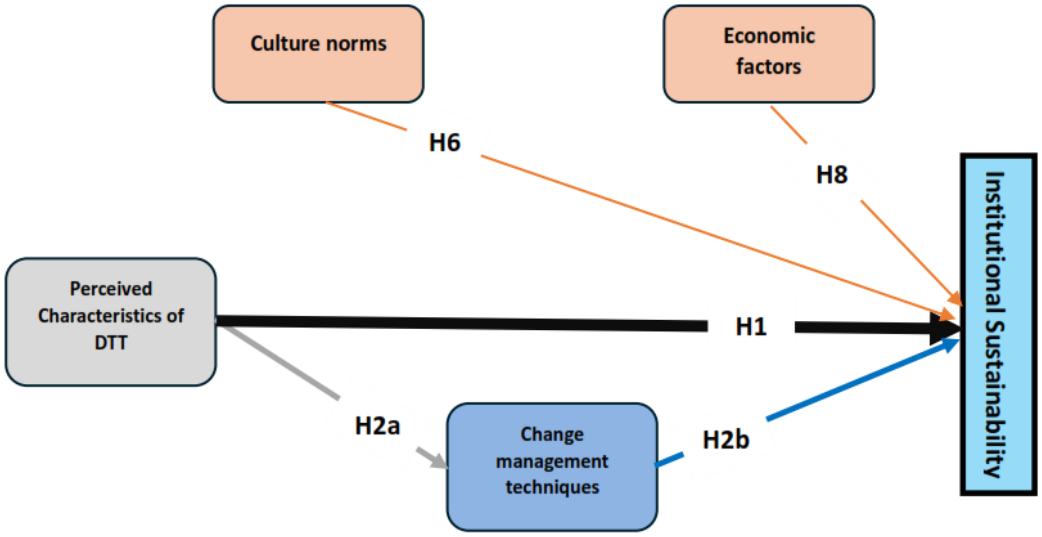

Figure 3. The modified conceptual model.

5. Presentation and Discussion of Main Results of PLS-SEM

5.1. The Model's Outer Loadings and Collinearity Inner Model Matrix

The assessment of the model is classified into the model's outer construct indices and the model's inner structure. The outer construct is proxied by the model's loading of construct statements and their *p*-values followed by reliability and internal consistency and reliability indices.

Table 8 exhibits the model's inner construct indices and to what extent each statement of the model's questionnaire explains the variable used. The model's factor loading of

constructs with *p*-values at a significance of less than 0.05 reached an average loading rate for all variables of 0.801 benchmarked to 0.7 as per the literature for [126]. The minimum loading is 0.68 held for DTT complexity and in integrating a plethora of educational resource tools and increasing technical knowledge for students. The model's inner construct is assessed through the multicollinearity test, after the removal of some statements in DTT and technological infrastructure statements as their multicollinearity threshold exceeded 5 and their presence distorted the model's results. After the model's filtering and screening, Table 8 shows that the final VIF values fall short of the statistical benchmark of 5, and this confirms the absence of cases of multicollinearity between the model's construct, despite the higher Cronbach alpha exceeding 0.96, which could indicate the presence of multicollinearity but was discarded after VIF results confirmed otherwise [128,129].

Table 8. Loading and collinearity statistics VIF inner model matrix.

Variable Type	Variable Name	Loadings	VIF
Independent Variables	CN (cultural values for adopting DTT)	0.870	3.590
	CN (cultural norms for adopting DTT)	0.866	3.685
	CN (institutional culture for adopting DTT)	0.891	4.767
	CN (staff attitude toward adopting DTT)	0.844	3.348
	CN (DTT adapted to institutional culture)	0.877	4.142
	CN (cultural resistance to adopting DDT)	0.887	4.252
	CN (DTT consistency with cultural values)	0.811	2.705
	CN (staff awareness for integrating DTT)	0.851	3.250
	CN (DTT cultural employment)	0.823	2.998
	CN (DTT leadership to promote DTT)	0.835	3.049
	DTT (relative advantage in delivery)	0.747	3.729
	DTT (relative advantage innovative tool)	0.702	3.446
	DTT (relative advantage teaching outcomes)	0.782	3.326
	DTT (relative advantage as best practice)	0.748	3.119
	DTT (relative advantage in efficiency)	0.739	3.090
	DTT (relative advantage in being employed)	0.724	3.320
	DTT less complexity (ease of learning)	0.784	3.311
	DTT less complexity (user-friendly)	0.808	3.461
	DTT (less complexity in minimal effort)	0.752	2.797
	DTT (less complexity in gaining confidence)	0.779	3.178
	DTT (less complexity in facilitating knowledge)	0.680	2.455
	EF (resource acquisition for adopting DTT)	0.814	3.240
	EF (economic boost provided by DTT)	0.885	4.317
	EF (reduce labor outlay due to use of DTT)	0.853	3.484
	EF (hiring costs of staff to operate DTT)	0.863	3.519
	EF (tax incentives or credits to support DTT)	0.875	3.853
	EF (government policies to support DTT)	0.860	3.824
	EF (economic risks which could affect DTT)	0.892	4.537

Table 8. *Cont.*

Variable Type	Variable Name	Loadings	VIF
Independent Variables	EF (the uncertainty in return of DTT)	0.869	4.182
	EF (high initial costs of adopting DTT)	0.856	3.792
	EF (economic recession that can affect DTT)	0.861	3.563
	DTT observability (testing DTT)	0.780	3.599
	DTT observability (experimentation of DTT)	0.755	3.279
	DTT observability (evaluate DTT adaptation)	0.772	4.025
	DTT observability (to try DTT)	0.774	3.316
	DTT observability (pilot workshop for DTT)	0.774	2.948
	DTT trialability (positive outcome of DTT)	0.784	3.849
	DTT trialability (engagement of DTT)	0.761	3.509
	DTT trialability (feedback via DTT)	0.791	3.108
	DTT trialability (usage of DTT)	0.775	3.122
	DTT trialability (assess teaching and learning)	0.773	3.080
Dependent Variable	SR (willingness to use DTT)	0.753	2.807
	SR (comfortable to use DTT)	0.764	3.042
	SR (sufficient training DTT)	0.735	2.948
	SR (strong barriers to applying DTT)	0.700	2.162
	SR (ease of adapting to DTT)	0.772	2.681
	EO (DTT promotes engagement)	0.789	3.131
	EO (DTT improves performance)	0.799	3.173
	EO (DTT raises the efficiency of the learning)	0.805	3.621
	EO (receptive capacity of DTT)	0.787	3.147
	EO (develop students' skills)	0.779	3.048
	FS (cost-effectiveness of DTT)	0.812	3.136
	FS (digital investment returns of DTT)	0.833	3.809
	FS (budget allocation of DTT)	0.752	3.562
	FS (benefits vs. costs of DTT)	0.799	3.293
	FS (long-term financial sustainability)	0.795	3.368
	FS (DTT affects tuition fees)	0.794	2.838
	FS (DTT affects payback period)	0.824	3.772
	FS (return on investment of DTT)	0.793	3.396
Mediating Variable	CMT (training and support for DTT)	0.861	2.719
	CMT (vision and plan to support DTT)	0.908	3.626
	CMT (how management implements DTT)	0.879	2.897
	CMT (institutional readiness for DTT)	0.891	3.502
	CMT (staff involved in managing DTT)	0.886	3.333

5.2. The Model's Internal Consistency and Reliability

As for the model's internal consistency and reliability identified through Cronbach's alpha (α) to measure and composite reliability, as shown in Table 9, both show an average

of 0.934, which is acceptable and much higher than the threshold of 0.70; however, caution should be given to test Cronbach's alpha measures of higher than 0.96, as they could indicate the presence of multicollinearity as shown for some components of the dependent variable educational outcome and the moderator technological infrastructure, which were initially treated and removed [123]. While the high Cronbach's alpha values observed (above 0.96) suggest strong internal consistency, they may also indicate redundancy among closely related scale items. This is particularly relevant for technological infrastructure and economic factors, where overlapping constructs might have contributed to these high values. Prior studies have highlighted that in cases where variables share conceptual similarities, alpha values may increase due to measurement redundancy rather than true reliability improvements [128,129]. However, since each construct in this study remains theoretically distinct, we retained the variables to preserve the integrity of the model. Future research may consider refining the measurement scale to minimize potential redundancy while maintaining conceptual clarity. The composite reliability (Rho-a) signals the reliability of the model's statements in measuring the variables, and values above 0.7 are acceptable. Likewise, composite reliability (Rho-c) inspects the implied reliability of the coefficients and interaction between the model's statements and is recommended to be higher than 0.7, and in both cases, values exceed 0.9 in Table 9. Finally given that the value of the average extracted variance of the construct converges to higher than 0.5, which is evident for all probabilities of exceeding on average 0.70, which signals the valid convergence of the model and that its statements explain at least more than 70% of the variability in the dependent variables.

Table 9. The model's overall internal consistency and reliability indices.

	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
CMT	0.931	0.931	0.948	0.783
CN	0.959	0.960	0.965	0.733
DTT	0.964	0.964	0.967	0.580
E.F	0.962	0.962	0.967	0.744
IS	0.963	0.963	0.966	0.613

5.3. The Model's Goodness of Fit

The overall coefficient of determination explaining the model's construct goodness of fit should be related to the literature discussed and the nature of the variables analyzed; however, the benchmark measure for the R^2 in Table 10 suggests the 0.882 value shows a reasonable degree of goodness of fit generated by the model's explanatory observed statements [127]. The model's SRMR in Table 10 is proxied for the goodness of fit, and the more its value tends to zero, the better the model's fit will be. The model has an SRMR of 0.053, which is considered acceptable for the model [130,131]. Ref. [132] showed that NFI should be greater than 0.80. This shows that the model is a good fit for the data and better than the null model by 82%.

Table 10. The coefficient of determination.

	R-Square	R-Square Adjusted	SRMR	NFI
CMT	0.608	0.607	0.053	0.8292
IS	0.882	0.880		

Those statements interpret the change in the three categories of dependent variables representing institutional sustainability and measured via "*Staff Resistance*", "*Educational Outcomes*", and "*Financial Feasibility*" The measure is particularly more conservative when using the adjusted R^2 for degrees of freedom which recorded a 0.880, which indicates that, on average, the model's observed and reflective constructs for PLS-SEM explain over 88% of the variability in the dependent variable and that the model's structural construct, in particular, is able to explain 78% of the variability in educational outcomes and their difference between universities while applying DTT.

As for the relationship and significance of the chosen hypotheses, the model shows that there is a significant relation between all components of DTT and institutional sustainability. In particular, Figure 2 shows the significance is driven by independent variables pinpointing the importance of DTT in minimizing the efforts of involved staff members at a probability of 0.808. Another DTT component representing the trialability period for staff to evaluate and assess DTT carries a 0.79 variability, and finally, the dimension of DTT in promoting class engagement and interaction carries a 0.78 variability. Economic factors (EFs) and cultural norms (CNs) cause high variability and impact directly on institutional sustainability at the highest significance. Although some literature studies contextualize the role of EFs and CNs as a condition to accelerate the dynamic relationship between DTT and IS, the PLS-SEM was counterintuitive, as it confirmed their role and significance as another independent variable and not a moderator, and this result was aligned with [133], which analyzed the cultural and economic factors as determinants of institutional sustainability for HEI. As for the third moderator, the infrastructural technology variable was removed from statements due to the presence of high multicollinearity surpassing 5 between its elements and DDT categories, and it did not show significance in moderating the relationship between DTT and IS, showing that H4 is not supported [131]. Finally, Figure 2 shows that CMT with all its statements has proven at a coefficient of determination R^2 of 0.608 to cause variability in institutional sustainability at high levels of significance.

Finally, Table 11 captures most of the significance and coefficient paths for the eight hypotheses tested already with results being validated for H1, H2 for both H2a and H2b, H6, and H8 testing the relationships between DTT and IS, DTT and CMT, CMT and IS, CNs and IS, and EFs and IS, respectively. Hypotheses H3 and H5 introducing the moderating role of CNs and EFs in the relationship between DTT and IS were both not supported at insignificant *p*-values of 0.925 and 0.982, respectively. In the same manner, H7 TI failed to moderate the role between DTT and IS at a *p*-value of 0.350, and its statements were removed for multicollinearity. The final attempt to measure the effect of control variables such as the university location on the relationship between DTT and IS found an indifference between the two countries, Egypt and Saudi Arabia, in how DTT affects IS since most of the respondents who took the survey were Egyptians working in KSA universities. Hence, no difference exists in terms of group dynamics and external factors that might impact their behavior such as cultural resistance or economic factors.

Table 11. Model's path coefficients and significance.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p*-Values	Hypotheses
DTT -> IS	0.422	0.421	0.049	8.674	0.000	**H1** Supported
DTT -> CMT	0.780	0.781	0.027	29.092	0.000	**H2** Supported
CMT -> IS	0.132	0.129	0.055	2.411	0.016	**H2a** Supported **H2b** Supported
CN—DTT -> IS	0.001	−0.001	0.048	0.022	0.982	**H3** Not supported

Table 11. *Cont.*

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p*-Values	Hypotheses
TI—DTT -> IS	0.002	0.012	0.052	0.034	0.973	**H4** Not supported
E.F—DTT -> IS	−0.004	−0.002	0.042	0.094	0.925	**H5** Not supported
CN -> IS	0.303	0.304	0.051	5.956	0.000	**H6** Supported
TI -> IS	0.045	0.054	0.048	0.934	0.350	**H7** Not supported
E.F -> IS	0.146	0.148	0.046	3.192	0.001	**H8** Supported

6. Synthesis of Qualitative and Quantitative Findings

This research has additional insights reflecting on the qualitative and quantitative analyses. This analysis provides a comprehensive understanding of the challenges and opportunities in adopting digital teaching technologies within universities in Saudi Arabia and Egypt.

6.1. Alignment Regarding Key Sources of Resistance

Workload, inadequate training, and preferences for face-to-face teaching because of cultural norms are the reasons that affect institutional sustainability. These concerns were quantitatively validated; it was observed that the staff resistance significantly relates to perceived DTT characteristics, mostly its complexity and compatibility, with a factor loading of 0.75 evident in Figure 2. Both analyses point to the targeting of these barriers with suitable interventions.

6.2. Change Management as a Mediator

Qualitative interviews identified participatory decision-making, customized training, and transparent communication as mitigating factors in reducing resistance. The quantitative model in Figure 2 at the same time supported that change management strategies indeed mediated and reduced staff resistance as part of IS with a loading of 0.608, which superseded the direct factor loading between DTT and IS reaching only up to 0.422. These findings, therefore, emphasize the potential role of inclusive change in management strategies for including institutional readiness and staff members' involvement in the successful adoption of DTT.

6.3. Economic Factors and Cultural Norms as Independent Variables

The economic constraints emerged during the qualitative interviews, as most of the stakeholders in both countries identified financial concerns as a significant implementation barrier. Hence, for this research, quantitative analysis supported the findings because economic factors emerged as a significant additional independent variable instead of a moderator affecting the relation between DTT adoption and the loading of financial sustainability. These results highlight the strategic funding and resource allocation essential to sustaining activities long-term. Qualitative data highlighted how cultural norms—in high-power-distance cultures like the State of Saudi Arabia—influenced the findings. This was statistically supported as the impact of DTT characteristics on staff resistance turned out to be significant by cultural norms. The linkage now underlines the need for culturally adaptive approaches toward integrating the technology.

7. Discussion

This study investigates the adoption of DTT at universities in Saudi Arabia and Egypt concerning staff resistance, educational outcomes, and financial sustainability. This study

also examined the mediation by change management strategies and moderation by cultural norms, technological infrastructure, and economic factors in greater depth. Its critical findings provide insights into the inter-relationships between these factors with some theoretical and practical implications.

7.1. Main Findings and Interpretations

7.1.1. Resistance to DTT Adoption

This study reveals that resistance to DTT is based on perceived complexity, incompatibility with traditional teaching methods, and cultural preference for face-to-face learning. Faculty members also felt that teaching with technology increases workload, and that training is not adequate, particularly in the case of accounting and economics. This leads directly back to the TAM, which stated that perceived ease of use and compatibility would play a significant role in adopting any given technology [10].

These barriers were confirmed by quantitative results, where the resistance of staff was strongly related to DTT characteristics with a loading of 0.75. These findings thus place a strong emphasis on faculty concerns through targeted interventions in change management.

7.1.2. Change Management: The Mediating Role

Change management strategies indeed acted as critical mediators working toward educational outcome improvement and a successful reduction in resistance. Qualitative interviews helped to validate the role of participatory decision-making, transparent communication, and training programs tailor-made for the participants. Quantitative data supported this finding as the change management strategies showed a strong mediation effect on educational outcomes with a loading of 0.861. This points out that faculty members should be part of the decision-making processes and that DTT should be positioned to be seen as an adjunct to other traditional practices. These approaches resonate with the [3] change model, which is about establishing a coalition, achieving short-term wins, and achieving institutionalization into new approaches.

7.1.3. Contextual Moderators: Culture, Technology, and Economics

There is evidence that DTT characteristics and outcomes are highly moderated by cultural norms, technological infrastructure, and economic considerations.

Cultural Norms: Saudi Arabia and Egypt possess hierarchical, collectivist cultural values that challenge the adoption of DTT. Quantitatively speaking, there is an insignificant moderation for staff resistance, but it is significant when related to staff resistance as an independent variable with a loading of 0.78, resonating with the role envisioned by the explanation within Hofstede's cultural dimensions theory [101].

Technology Infrastructure: Both nations have shown barriers of old hardware and internet not working properly. Rather, good infrastructure has proven that DTT does have a strong positive impact, with a loading of 0.704, on improvement in educational outcomes.

Economic Factors: Budgetary constraints, especially in public universities, restrained the scope of DTT adoption. Quantitative findings did not support that economic factors were a moderator for financial sustainability outcomes, but they were supported as an independent variable with a loading of 0.824. While cultural norms (H3), economic factors (H5), and technological infrastructure (H7) were initially hypothesized as moderators of the relationship between DTT and institutional sustainability, the quantitative results did not support these effects. One potential explanation is that these factors exert a more direct influence rather than acting as moderating variables. Previous studies have found that cultural and economic conditions significantly shape institutional sustainability, but their interaction with technology adoption processes may be less pronounced than expected [101,102]. Additionally, the high loading of economic factors as an independent

variable (0.824) suggests that financial constraints directly impact sustainability rather than modifying the relationship between DTT characteristics and outcomes. Technological infrastructure, although crucial, may not serve as a moderator due to its foundational role—acting as a prerequisite for digital adoption rather than an influencing factor in its effectiveness [103]. These findings highlight the complexity of digital transformation in higher education and the need to reconsider the role of external institutional factors in moderating technology adoption. The findings suggest the necessity of strategic resource allocation and external funding needs.

7.2. Theoretical Contribution

This study expands the existing theories of technology adoption by embedding the respective analysis in cultural, economic, and technological contexts. While frameworks like TAM and UTAUT explain the individual and organizational adoption of technology, this study has underlined the mediating factors that influence these processes in the context of higher education. Second, the findings extend the literature on managing change by highlighting how adaptive strategies reduce resistance and improve outcomes. This study further reiterates the need for contextualized approaches toward the management of organizational change in various cultural and economic contexts.

7.3. Practical and Managerial Implications

This study brings forward the crucial role of strategic change management in the successful institutionalization of digital teaching technologies within a university setup across socio-economic and cultural contexts through cases of Saudi Arabia and Egypt. These findings suggest the following practical recommendations to facilitate the development and implementation of a technology-adoption-based institutional sustainability policy by policymakers, educational leaders, and university administrators.

7.3.1. Tailored Change Management Strategies

The less resistance to DTT adoption there is, the more inclusive and adaptive the change management practices in place will be. Universities need to apply the following measures:

- Customized Training: Design training to meet discipline-specific needs to enhance faculty confidence in using DTT.
- Participatory Decision-Making: Include faculty in decision-making for reduced skepticism and enhanced ownership of this innovation.
- Transparent Communication: Communicate the advantages and purpose of DTT in complementing, as opposed to replacing, traditional teaching.

7.3.2. Technological Infrastructure Investment

Effective DTT deployment requires appropriate and scalable technological infrastructure. The following are some major investments:

- Upgrading hardware and software to state-of-the-art learning requirements.
- Providing high-speed connectivity to seamlessly integrate systems.
- Forming partnerships with technology providers, as well as leveraging government grants, to overcome economic barriers.

7.3.3. Fit of Culture and Alignment Toward Technology Integration

Cultural perspectives prevail significantly in the acceptance of DTT. Educational leaders should follow the following recommendations:

- Diffuse DTT initiatives within cultural values, such as through hierarchical approaches in Saudi Arabia and participative approaches in Egypt.
- Implement collaborative tools that resonate with collectivist approaches.

7.3.4. Improvement in Financial Sustainability Through Digital Transformation

The adoption of DTT creates avenues for financial sustainability in the long term. Institutions should follow the following recommendations:

- Use blended and online learning models to attract a more diversified student population and optimize expenses.
- Align DTT initiatives with priorities in government and international funding to attract financial support.

7.3.5. Development of Continuous Evaluation and Feedback Mechanisms

Robust monitoring and evaluation mechanisms need to be instituted to assess the impacts of DTT on key outcomes. Universities should follow the following recommendations:

- Institute processes to monitor impacts on educational outcomes, staff engagement, and financial viability continuously.
- Gather ongoing feedback from stakeholders—faculty and students—to stimulate strategies toward their alignment with institutional goals.

7.3.6. Policy Recommendations for Regional Contexts

Policymakers in Saudi Arabia and Egypt can create an enabling regulatory environment for DTT adoption, including the following:

- Tax incentives to encourage private sector partnerships.
- Grants for infrastructure upgrade of public universities.
- Policy to highlight the need for digital literacy among faculty and students for overall productivity with technology use.

7.4. Limitations and Future Research

- This study also has certain limitations; for example, the focus on Saudi Arabian and Egyptian universities reduces the generalizability of findings to other parts of the world. Future research can widen this to both other developing and developed countries to refine its level of comparison.
- A significant number of Egyptian staff members working at universities in KSA may have influenced the results, as their responses to the questionnaire could reflect their cultural background and perspectives rooted in Egyptian culture.
- Further research into such areas as emerging technologies, including AI and VR, should be pursued to reflect their impact on learning outcomes and sustainability.

8. Conclusions

This research investigates the complex dynamics of DTT adoption at universities in Saudi Arabia and Egypt, highlighting the critical interaction between cultural, technological, and economic factors. This study integrates qualitative and quantitative approaches to bring out a comprehensive understanding of the barriers and opportunities toward leveraging DTT for institutional sustainability.

The results indicated that resistance to DTT adoption is culture-, workload-, and training-based. The problems are further compounded by technological limitations and economic realities, which make the smooth implementation of digital tools within learning environments a challenge. Despite these challenges, this research points toward the critical role that change management strategies may play in minimizing resistance to enable better

learning outcomes and financial sustainability. Participatory decision-making, need-based training, and effective communication were some enabling factors that helped in building acceptance and ownership of the faculty.

This research also points out the influences of cultural norms, technological infrastructure, and economic factors on the relationship between DTT adoption and institutional sustainability. For example, strong infrastructure and responsive economic policies greatly heighten the potential of DTT to affect changes in educational quality and financial viability, while cultural fit strategies prove crucial to overcoming resistance in societies that are hierarchical and collectivist.

From a practical perspective, this study gives actionable suggestions for policy and educational leaders. The investments in the infrastructure of technology, strategic funding, and culturally aligned change management practices are core dimensions that provide guarantees for DTT integration in a sustainable manner. Addressing these dimensions allows universities to position themselves as digital education leaders, drive innovation, and ensure long-term institutional sustainability.

Future studies should extend this study to other regions and, if possible, address the adoption of emerging technologies such as artificial intelligence and virtual reality. This would yield further insight into the continuously changing role of digital transformation in higher education among scholars and practitioners. Studies on community colleges are encouraged to explore whether staff that work in more practical environments would have the same point of view as faculties working with more theoretical settings.

This added to the theoretical knowledge of DTT adoption by extending established technology adoption models, such as TAM [10] and UTAUT [11]. Our findings underline the critical role of change management strategies in mediating that process. Indeed, the outcomes of our study reinforce those prior studies of digital transformation in higher education [4,23]. This research also refines existing frameworks and corroborates previous studies that have highlighted how socio-economic barriers regulate the integration of technology in academia by including moderating variables of cultural norms and economic factors [7,29,35]. All this provides reasons and explanations for a strategic plan of actions that must be considered in overcoming DTT adoption resistance, guaranteeing its success, and ensuring institutional sustainability in a diverse educational environment.

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Appendix A

Appendix A.1. Questionnaire

The following statement are measuring the Impact of Digital Teaching Technologies in universities (Independent Variable) on levels or types of staff resistance, educational out-

comes, financial sustainability (Dependent Variable), with the moderating effect of change management techniques, culture norms, technological infrastructure, and economic factors (Moderator) so please indicate your level of agreement towards the following statements **(5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree)**

#	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
Perceived Characteristics of DTT (Independent Variable)						
Relative Advantage						
1	Digital teaching technologies (DTT) enhances my ability to deliver course content more effectively than traditional teaching methods.					
2	The digital teaching technologies are innovative and enhance the learning experience.					
3	Using DTT improves the overall learning outcomes of my students.					
4	DTT provides significant benefits to my teaching practice compared to non-digital methods.					
5	Incorporating DTT into my teaching increases my productivity and efficiency as an educator.					
6	DTT offers a clear advantage in preparing students for future professional environments.					
Complexity						
7	I find DTT easy to learn and use in my teaching					
8	The features of DTT are user-friendly and straightforward.					
9	Integrating DTT into my courses requires minimal effort.					
10	I feel confident in my ability to effectively use DTT in the classroom.					
11	Using DTT does not require extensive technical knowledge.					

#	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
Observability						
12	I have had the opportunity to test DTT before fully integrating it into my courses.					
13	I was able to experiment with DTT on a trial basis to assess its effectiveness.					
14	The institution provided a trial period for DTT that allowed me to evaluate its usefulness.					
15	I feel comfortable with DTT because I was able to try it before full implementation.					
16	I had access to pilot programs or workshops to experiment with DTT before adoption.					
Trialability						
17	The positive outcomes of using DTT in my teaching are clearly visible.					
18	I have observed significant improvements in student engagement since using DTT.					
19	The benefits of DTT are evident in the performance and feedback of my students.					
20	Success stories of DTT usage are well communicated within my institution.					
21	I can easily see the impact of DTT on the overall teaching and learning process.					
Compatibility						
22	DTT aligns well with my current teaching practices and methodologies.					
23	The use of DTT is consistent with the values and goals of my institution.					
24	DTT integrates smoothly with the existing educational tools and resources I use.					
25	The implementation of DTT is compatible with the curriculum I teach.					
26	DTT fits well with the expectations and learning styles of my students.					

#	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
(Dependent Variable)						
Staff Resistance						
27	I will be willing to use digital teaching technologies in my classroom.					
28	I am comfortable using digital technologies for teaching.					
29	I have had sufficient training in using digital technologies for effective teaching.					
30	There are strong barriers to the adoption of digital teaching technologies.					
31	I can adapt my teaching practices and integrate digital teaching technologies into these.					
Educational Outcomes						
32	Digital teaching technologies improved students' engagement during my classes.					
33	The use of digital teaching technologies has led to better performance among students.					
34	Digital teaching technologies raise the efficiency of the learning process.					
35	The students are very receptive to the use of digital technologies for teaching.					
36	Digital teaching technologies develop students' skills and competencies.					
Financial Sustainability						
37	Cost-effectiveness of digital tools compared to traditional teaching methods.					
38	Digital investments are yielding adequate returns for the institution.					
39	Budget allocation for digital tools is appropriate.					
40	Benefits associated with the use of technologies for digital teaching justify these costs.					
41	There is adequate long-term financial sustainability of the university's digital strategy.					
42	Digitalization might affect tuition fees in the future.					

#	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
43	The most important factor in deciding to adopt new technology is the payback period.					
44	The ROI of previous technologies is highly relevant to our new technology adoption decisions.					
(Mediating Variable)						
Change Management Techniques						
45	Adequate training and support are provided to make effective use of digital teaching technologies.					
46	Any vision and plan for the use of digital technologies in teaching are communicated to staff.					
47	Level of involvement of management in the implementation of digital teaching technologies is active.					
48	Institutionally, it is ready for the rigors of change attendant on the adoption of digital teaching technologies.					
40	Staff are involved in the process of adopting digital teaching technologies.					
(Moderating Variable)						
Cultural Norms						
50	The institution's cultural values are aligned to the adoption of digital teaching technologies.					
51	Cultural norms (e.g., gender roles, individualism vs. collectivism, hierarchical structures, attitudes towards technology, workplace norms, communication styles, attitudes toward authority, and adherence to traditional teaching methods) drive acceptance and use of the digital teaching technologies.					
52	The institutional culture allows for the use of the digital teaching technologies.					
53	Cultural norms influence staff attitudes on the adoption of the digital teaching technologies.					

#	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
54	Digital teaching technologies are adapted into the context of the institutional culture.					
55	Digital teaching technologies implement in a way that is consistent with the culture and values of our institution.					
56	There is some resistance to digital teaching technologies within the culture of our institution.					
57	Staff are aware in integrating digital teaching technologies into the institutional culture.					
58	The deployment of digital teaching technologies is sensitive, in terms of the culture and traditions of our institution.					
59	The leadership of our institution promotes cultural acceptance of digital teaching technologies.					
Technological Infrastructure						
60	My institution's technological infrastructure is supportive of digital teaching technologies.					
61	The digital teaching technologies used are reliable and perform as expected.					
62	The staff can easily access the teaching technologies.					
63	There is adequate support services associated with the use of digital teaching technologies available.					
64	The technological infrastructure is relatively recent and can thus be better suited to support new digital teaching tools.					
Economic Factors						
65	The institution provides adequate financial resources for the acquisition of digital teaching technologies.					
66	The digital technologies of teaching bring in an economic boost for the institution.					
67	The potential for reduction in labor outlay is a major trigger toward adopting new technologies.					

#	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
68	The huge retraining and hiring costs of skilled labor to operate new technology presses heavy on us.					
69	The tax incentives or credits support a crucial role in the decision of adoption of new technologies.					
70	Government economic policies have a greater influence on my organization's decisions in the regard to embracing new technology.					
71	The perceived economic risk in the adoption of new technology will greatly influence the organizational choice.					
72	The uncertainty in the expected return makes us very cautious about decisions involving the adoption of new technologies.					
73	High initial costs greatly hinder the assimilation of new technology into the group.					
74	Potential adoption of new technology will also greatly be influenced by an economic recession.					

Personal Information

1. **Gender**
   - Male ☐
   - Female ☐
2. **Age**
   - Less than 25 years old ☐
   - From 25 to less than 35 years old ☐
   - From 35 to less than 45 years old ☐
   - 45 years old and older ☐
3. **Degree**
   - Teaching Assistant ☐
   - Assistant Lecturer ☐
   - Assistant Professor ☐
   - Associate Professor ☐
   - Professor ☐

4. **University Type**
   - Private ☐
   - Governmental ☐
   - Other (specify)……
5. **Nationality**
   - African (e.g., Egyptian, Sudanese…)
     ………………………………………………
   - Asian (e.g., KSA, UAE, Syrian….)
     ………………………………………………
   - American
     ………………………………………………
   - European (British, French, German, Italian, Spanish….)
     ………………………………………………..
   - Other (specify)……
     ………………………………………………..
6. **University Location**
   - KSA ☐
   - Egypt ☐

Appendix A.2. Exploratory Research Questions

1. What are the key sources of resistance to digital teaching technologies among university staff?
2. How might change management strategies impact the degree of resistance toward digital teaching technologies?
3. To what extent do cultural norms about the adoption of digital teaching technologies resonate with university staff attitudes?
4. What could be some of the economic factors that would influence the uptake of digital teaching technologies in your university?
5. How does the technological infrastructure of the university impact the deployment and acceptance of digital teaching technologies?
6. How do digital teaching technologies affect educational outcomes at your university?
7. How do digital teaching technologies bear on your university's long-term financial sustainability?

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