

Leveraging Digital Twin Technology to Gain E-Service Quality for EdTech in India

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Abstract:

This study explores the influence of key factors on E-Service Quality in educational systems, with a focus on Digital Twin Technology. Using regression analysis, it identifies that Staff Training, Financial Investment in Technology, and Stakeholder Involvement significantly enhance e-service Quality. However, the Degree of Digital Twin Adoption and Digital Twin Features show no significant impact. These results highlight that the mere adoption of Digital Twin Technology or its features is insufficient for improving service quality. Instead, the effective implementation and integration of the technology are crucial. The study suggests that educational institutions should prioritize staff training, increase investments in technology, and engage stakeholders in decision-making. By addressing these areas, organizations can enhance their e-service offerings, leading to better service delivery, higher patron satisfaction, and improved overall performance. The findings emphasize the importance of a comprehensive and practical approach to leveraging Digital Twin Technology in education systems.

Keywords: Digital Twin, Staff Training, Stakeholder Involvement, EdTech

Introduction

In the contemporary era, educational systems are undergoing a transformative phase, driven by technological advancements and the increasing need for enhanced service delivery. Among the various technologies reshaping industries, Digital Twin (DT) technology has emerged as a powerful tool, offering innovative solutions to a range of challenges. Originally designed for manufacturing and industrial sectors, Digital Twin technology has begun to make its mark on

education systems, providing an advanced method for simulating, monitoring, and optimizing complex processes in real-time. As educational institutions strive to provide high-quality e-services that meet the expectations of students, educators, and other stakeholders, the integration of Digital Twin technology offers a promising pathway to gaining a competitive advantage. This introduction discusses the potential of Digital Twin technology to revolutionize e-service quality within education systems, exploring its applications, benefits, and the significant role it can play in enhancing service quality, optimizing operational efficiency, and creating a sustainable competitive edge in the sector.

The rapid growth of e-learning platforms, online degree programs, and digital classrooms has transformed the education sector, offering unprecedented access to learning resources. However, with the advent of these digital solutions, institutions are faced with an ever-increasing demand for higher levels of service quality, seamless user experiences, and more personalized learning environments. The concept of service quality in education is multifaceted, encompassing various dimensions such as academic services, student support, administrative efficiency, and technological infrastructure. Moreover, the emphasis on e-service quality has become even more pronounced in the wake of the COVID-19 pandemic, which forced educational institutions worldwide to rapidly shift to online and hybrid learning models. As institutions transition to digital platforms, the challenge lies not only in delivering educational content but also in providing a comprehensive and satisfying digital experience. Students now expect more than just well-organized lectures; they seek interactive, intuitive, and personalized learning experiences that cater to their individual needs. The need for robust e-service quality in this context is clear, as it directly influences student satisfaction, retention, and academic performance. Consequently, the ability to offer superior e-service quality has become a crucial competitive differentiator for educational institutions, especially in an increasingly crowded online education market. Digital Twin technology refers to the creation of a virtual replica of a physical object, process, or system, which is continuously updated with real-time data from sensors and other monitoring tools. This digital representation allows organizations to simulate, analyze, and optimize the performance of physical systems before making any changes to the real-world counterpart. While Digital Twin technology has been successfully applied in industries such as manufacturing, aerospace, and automotive, its potential for education systems remains underexplored.

In the situation of education, a Digital Twin can be understood as a virtual representation of various educational processes and environments, including classrooms, campuses, administrative workflows, and even the individual student learning journey. By integrating real-time data from various sources (such as student performance, engagement metrics, and technological infrastructure), Digital Twins offer educational institutions an innovative way to monitor, simulate, and improve the delivery of e-services. This technological approach enables educators and administrators to gain deep insights into the functioning of their educational systems, identify bottlenecks, and implement data-driven solutions for improvement. One of the key ways in which Digital Twin technology can enhance e-service quality in education systems is through its ability to optimize the learning environment. By creating virtual models of classrooms, learning platforms, and student interactions, institutions can simulate different teaching and learning scenarios to understand their impact on student performance. This can help educators design more engaging and effective digital curricula that cater to various learning styles and preferences. Furthermore, Digital Twin technology can monitor and analyze real-time data on student participation, satisfaction, and outcomes, allowing institutions to provide personalized feedback

and tailored interventions that foster improved learning experiences. Also, the integration of Digital Twins in administrative processes can significantly improve the efficiency and quality of non-academic services. For instance, universities can create digital replicas of their administrative workflows to identify inefficiencies and optimize service delivery. Whether it's the registration process, student support services, or the handling of academic records, Digital Twin technology can help streamline these processes, reducing delays and improving the overall student experience. Moreover, by simulating different scenarios and predicting future demands, institutions can better allocate resources, ensuring that the right services are available when needed.

In a highly competitive educational landscape, the ability to offer exceptional e-service quality is a significant differentiator. By leveraging Digital Twin technology, institutions can gain a competitive advantage in several ways. First, the ability to continuously monitor and improve educational services in real-time enables institutions to offer more efficient and responsive learning environments. This dynamic approach not only enhances the quality of education but also helps institutions build stronger relationships with students, as they feel that their individual needs and challenges are being addressed. Second, the use of Digital Twins allows institutions to be more agile in adapting to changes in the educational environment. Whether it's the integration of new technologies, changes in student preferences, or the need to respond to external factors (such as the COVID-19 pandemic), Digital Twin technology enables educational institutions to make data-informed decisions and implement changes quickly and effectively. This adaptability is crucial in maintaining a competitive edge in a rapidly evolving sector.

Finally, the data-driven insights provided by Digital Twin technology can help educational institutions to improve their strategic decision-making processes. By analyzing trends, identifying patterns, and forecasting future needs, institutions can proactively plan for changes in the educational landscape, ensuring that they remain ahead of the competition and continue to offer high-quality e-services. The integration of Digital Twin technology in education systems represents a significant opportunity for enhancing e-service quality and gaining a competitive advantage. By leveraging virtual models to simulate, monitor, and optimize various aspects of the learning and administrative processes, educational institutions can improve the quality of their services, foster student satisfaction, and stay ahead of the competition. As digital transformation continues to reshape the education sector, the adoption of Digital Twin technology is poised to play a central role in the future of higher education, driving innovation, efficiency, and personalized learning experiences. The time has come for educational institutions to explore the full potential of this technology and embrace its transformative capabilities to stay competitive in the digital age.

Review of literature

Benedek & Surman (2024) presented a framework called Quality Function Deployment (QFD) to improve the service quality of higher education institutions (HEIs), addressing institutional compliance management issues. The study involved questionnaires and focus group interviews to identify service quality attributes, while compliance management functions were derived from a thorough literature review. The research correlates ten service quality attributes with nine compliance management functions, providing a priority ranking of compliance functions for improvement. These insights can help educational leaders align compliance activities with student perceived quality, aiding policymakers in formulating strategic plans to enhance service quality for stakeholders, particularly students.

Puja (2024) examines technology-driven education in Indonesia, highlighting the critical role of online learning in the context of technological advancements and social media use. The study explores how online learning motivation mediates the relationship between service quality, social media engagement, pedagogical competence, and student satisfaction. Findings reveal that while high-quality educational services significantly enhance online learning motivation (0.301), increased social media use (0.031) and improved pedagogical competence (0.003) do not necessarily yield similar effects. The study concludes that fostering motivation and satisfaction in online learning requires a holistic approach, integrating quality services with thoughtful application of technology and pedagogy. Çoban (2022) highlights the importance of students' active participation and responsibility in learning activities to achieve effective outcomes in distance education. The study examines the relationships between higher education students' service quality perceptions, attitudes, and self-efficacy in the context of distance education. Findings reveal a positive relationship between service quality perceptions and attitudes, with self-efficacy and attitudes predicting service quality perceptions. However, these variables do not vary by gender. Notably, students' service quality perceptions and attitudes differ based on the devices used for online learning. The study offers valuable implications for practitioners and researchers in the field of distance education.

Dangaiso et al. (2022) investigate the impact of perceived e-learning service quality on student satisfaction and loyalty in a developing country, focusing on the reactive adoption of e-learning during the Covid-19 pandemic. Using the expectation-confirmation theory, a conceptual framework was developed and tested through a causal research design and structural equation modelling (SEM). Data collected from a stratified sample of 354 students in Zimbabwe's public and private universities revealed significant positive relationships between e-learning service quality dimensions system quality, information quality, and service quality and student satisfaction.

Ghosh et al. (2022) examined the service quality of hospitality education, focusing on the perspectives of faculty members. The study explored how service quality, service value, sacrifice, and satisfaction influenced faculty's behavioral intentions in hotel management institutes. The findings revealed that service quality had a significant positive indirect and total impact on faculty behavioral intentions.

Dirkse van Schalkwyk and Steenkamp (2020) aimed to develop an industry-specific total quality service framework for private higher education institutions (HEIs) in South Africa. Given the competitive, marketing-driven, and regulated nature of the higher education sector, service quality plays a critical role in performance. The study used a mixed-methods approach, beginning with qualitative semi-structured interviews with top management to explore service quality dimensions, followed by a quantitative phase involving lecturers and students' perspectives through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

Dirkse van Schalkwyk et al. (2020) highlighted the growing demand for private higher education in South Africa, underscoring the need for effective corporate quality management of service quality for both students and academics. The study developed a framework for the holistic management of service quality through a corporate total quality service approach, considering service quality from a corporate sociotechnical perspective. The research process was comprehensive and sequential, leading to the creation of a total quality service framework. The study concludes that a holistic approach to service quality should include the quality of work life as a performance objective, addressing sociotechnical needs beyond traditional service quality

dimensions. El Alfy and Abukari (2019) explore the dynamic and contextual nature of perceived service quality

(SQ) in higher education, focusing on its dimensions from the perspectives of postgraduate students and university staff. Drawing on theories from marketing and higher education, the study employs in-depth interviews and content analysis to identify four key SQ dimensions: academic services, academic facilities, administrative services, and students' service roles. Sardar et al. (2016) conducted a survey to examine the gap between students' expectations and perceptions of service quality in education, with a focus on identifying the least effective service quality dimension. Suh et al. (2015) investigated the role of customer education in enhancing customer loyalty through perceived service quality. While customer education has been acknowledged in marketing literature, it has not been thoroughly tested. The study developed hypotheses to assess the impact of customer education and other factors on customer loyalty. Sadeh and Garkaz (2014) emphasize the critical role of students as customers in higher education institutions (HEIs), particularly in private HEIs where students pay for education as a service. The study critiques the European Foundation for Quality Management (EFQM) model, widely applied in HEIs, for overlooking the mediating role of service quality between quality management enablers and customer satisfaction. Using data from 146 Iranian private HEIs, the study tests 11 hypotheses and confirms that service quality mediates the relationship between EFQM enablers and student satisfaction. The findings suggest that integrating service quality into quality management frameworks can enhance satisfaction through improved services.

Águila-Obra et al. (2013) examine the mediating role of online satisfaction in the relationship between electronic service quality (e-SQ) and online loyalty, encompassing both behavioural and attitudinal elements, in the postal services sector. In a competitive environment, postal operators must understand how service quality impacts satisfaction and loyalty. Kuo, C. M. (2013) evaluated an interactive multimedia instructional program designed to help prospective hospitality students understand service quality. Using a quasi-experimental research model, data were analysed through the ADDIE method (Analyze, Design, Develop, Implement, and Evaluate). The study involved second-year Level 2 students at a university in Taiwan, where the multimedia tool was assessed and refined to improve its instructional quality. The results indicated that students who used the multimedia instructional program demonstrated a better understanding of service quality in hospitality education compared to those in the control group.

Research Gaps

Currently, most research on digital twin education was based on theoretical concepts, with few practical case studies and actual case and transfer to private education centers. The lack of empirical data regarding the direct link between the features of digital twin technology and the eservice quality dimensions, such as response time or service reliability. How complementary are all of these factors to digital twins in attracting students and keeping them? Little focus on just how these barriers at a micro level prevent educators and staff from adopting the technology at the micro level, which could include financial constraints, technical expertise gaps or pedagogical resistance. We must learn to tackle the paucity of clear frameworks or models for doing so successfully, especially at a private school level, for effectively involving students, parents, and staff in the digital twin adoption process.

Statement of the Problems

Educational institutions are increasingly challenged to improve e-service quality in the face of growing demands for personalized, efficient, and responsive learning environments. While digital platforms are widely adopted, many educational systems struggle to maintain high levels of service quality, particularly in terms of personalized learning experiences, seamless administrative processes, and real-time support services. Existing service quality frameworks are often limited and reactive, failing to address the complex dynamics of the digital education ecosystem. The introduction of Digital Twin (DT) technology originally successful in fields like manufacturing and healthcare has the potential to revolutionize educational service delivery. However, its application within education systems remains underexplored. Educational institutions lack a comprehensive framework for utilizing DT technology to optimize service quality, enhance operational efficiency, and deliver better student experiences.

Research Questions

1. How does the adoption of digital twin technology specifically improve service responsiveness, accessibility, and reliability in EdTech Systems?
2. Which specific features of digital twin technology (e.g., real-time simulation, predictive analytics) have the most direct impact on creating a competitive advantage for EdTech Systems?
3. What are the specific challenges (financial, technical, operational) faced by private schools when adopting digital twin technology, and how can they be overcome?
4. How does digital twin technology affect operational efficiency in private schools, particularly in terms of administrative tasks and resource management?
5. What is the micro-level impact of digital twin technology on student, parent, and teacher satisfaction in private education systems?

Research Objectives

1. To assess the micro-level impact of digital twin technology on the responsiveness and reliability of e-services in EdTech Systems?
2. To identify and evaluate the most impactful features of digital twin technology that provide a competitive advantage for EdTech Systems.
3. To explore and document the specific barriers to adopting digital twin technology in EdTech Systems.
4. To evaluate how digital twin technology enhances operational efficiency in specific areas like resource management, class scheduling, and student data handling.
5. To measure the direct influence of digital twin technology on satisfaction levels among students, parents, and educators in EdTech Systems.

Research Methods

This study uses a descriptive research design, which aims to explore and describe the impact of Digital Twin Technology on the competitive advantage and e-service quality in education systems. Descriptive research is chosen because it helps to understand how Digital Twin Technology is being adopted and how it affects the education sector's service quality and competitiveness. Data is collected using a questionnaire survey. The questionnaire is designed to gather opinions from EdTech business managers who are involved in decision-making processes within their companies.

These managers are knowledgeable about how digital technologies, including Digital Twin Technology, influence e-service quality and competitiveness in the education sector.

The study uses a Likert scale ranging from 1 to 5 (where 1 = Strongly Disagree, 5 = Strongly Agree) to measure how strongly respondents agree with different statements about the use of Digital Twin Technology and its effect on e-service quality and competitive advantage. This scale helps in quantifying respondents' views in a structured manner.

Mean and Standard Deviation (SD): These tools are used to understand the average responses and how varied the responses are from the average. ANOVA (Analysis of Variance) this method helps to see if there are significant differences in responses based on factors like job roles or experience levels within the EdTech industry.

Regression Analysis: Regression analysis will be used to find the relationship between Digital Twin Technology adoption and improvements in service quality and competitive advantage. This will show how changes in one variable affect the other.

The study focuses on 158 EdTech business-level managers in Bangalore, a key hub for the EdTech industry. These managers are selected because they are involved in strategic decisions related to technology in education systems, providing valuable insights into the impact of Digital Twin Technology on service quality and competitiveness. By using descriptive research and simple yet effective data collection methods like surveys and statistical tools such as mean, SD, ANOVA, and regression, this study will provide important insights into how Digital Twin Technology can enhance the competitive advantage and service quality in the education sector.

Results and Discussions

Table 1: Respondents Outline

		Frequency	Percentage
Education	Engineering	43	24.7
	Technology	113	64.9
	Science	18	10.3
Experience in Years	<=5	63	36.2
	6-10	69	39.7
	11-15	25	14.4
	>15	17	9.8
	Total	174	100

Table 1 the data shows that most of the individuals have a background in Technology (64.9%), followed by Engineering (24.7%), and only a small portion in science (10.3%). When it comes to work experience, the largest group has 6 to 10 years of experience (39.7%). This is followed by those with 5 or fewer years of experience (36.2%). A smaller number of individuals have 11 to 15 years of experience (14.4%) and more than 15 years (9.8%). In total, the data covers 174 individuals, indicating a predominantly technology-oriented group with a mix of career stages.

Table 2: Mean and SD of Variables (*Independent and dependent variables*)

	Mean	SD
Degree of Digital Twin Adoption	2.22	1.18
Digital Twin Features	2.64	1.20
Staff Training	2.18	0.87
Financial Investment in Technology	2.76	1.14
Stakeholder Involvement	2.55	1.12
E-Service Quality	2.80	1.17

Table 2 provides insights into several aspects of Digital Twin Adoption and related factors. The Degree of Digital Twin Adoption has a mean value of 2.22 and a standard deviation of 1.18, indicating moderate adoption levels with some variability. Digital Twin Features exhibit a mean of 2.64 and a standard deviation of 1.20, suggesting fairly well-developed features with moderate variability. Staff Training shows a mean of 2.18 and a lower standard deviation of 0.87, indicating moderately consistent training levels that are not particularly high. Financial Investment in Technology has a mean of 2.76 and a standard deviation of 1.14, reflecting a relatively higher investment level with some variability among entities. Stakeholder Involvement has a mean of 2.55 and a standard deviation of 1.12, indicating moderate involvement with some variability. E-Service Quality, with the highest mean of 2.80 and a standard deviation of 1.17, points to relatively high e-service quality despite moderate variability. Lastly, Competitive Advantage, with a mean of 2.20 and a standard deviation of 1.16, shows moderate competitive advantage with some variability.

H₀₁: There is no significant different between Education Vs Independent variables

Table 3: One way ANOVA - Education Vs Independent variables

	F	Sig.
Degree of Digital Twin Adoption	33.38	0.000
Digital Twin Features	18.50	0.000
Staff Training	17.42	0.000
Financial Investment in Technology	3.93	0.022
Stakeholder Involvement	10.38	0.000

Table 3 the One-Way ANOVA analysis aimed to evaluate the relationship between various independent variables and education systems in the context of Digital Twin Technology. The hypothesis tested was: H₀₁ (Null Hypothesis): There is no significant difference between education and the independent variables. The results revealed significant differences for all the independent variables considered. Firstly, for the Degree of Digital Twin Adoption, the F-value was 33.38 with a p-value of 0.000, which is less than the significance level of 0.05. This indicates that the null hypothesis is rejected, and we conclude that there is a significant difference in the adoption of Digital Twin Technology across different educational groups. Similarly, the Digital Twin Features also showed significant differences, with an F-value of 18.50 and a p-value of 0.000. Again, this led to rejecting the null hypothesis, confirming that the features of Digital Twin Technology differ significantly among the groups.

When evaluating Staff Training, the F-value was 17.42 with a p-value of 0.000, meaning we reject the null hypothesis and assert that staff training related to Digital Twin Technology is perceived differently across the groups. Furthermore, the analysis of Financial Investment in Technology indicated an F-value of 3.93 with a p-value of 0.022, leading to the rejection of the null hypothesis, suggesting that financial investment in Digital Twin Technology varies significantly among educational institutions. Lastly, Stakeholder Involvement showed an F-value of 10.38 and a p-value of 0.000, again indicating significant differences. Therefore, we reject the null hypothesis and confirm that the level of stakeholder involvement in Digital Twin adoption is significantly different across the groups. In inference, the One-Way ANOVA results indicate that all the independent variables Degree of Digital Twin Adoption, Digital Twin Features, Staff Training, Financial Investment in Technology, and Stakeholder Involvement significantly influence the adoption and application of Digital Twin Technology in education systems. Consequently, the null hypothesis is rejected for all factors, highlighting the importance of these variables in shaping the future of education technology.

H₀₂: There is no significant different between Experience Vs Independent variables

Table 4: One way ANOVA Experience Vs Independent variables

	F	Sig.
Degree of Digital Twin Adoption	6.98	0.000
Digital Twin Features	1.40	0.246
Staff Training	6.28	0.000
Financial Investment in Technology	3.26	0.023
Stakeholder Involvement	2.88	0.038

Table 4 based on the results of the one-way ANOVA test, we can draw several important inferences regarding the relationship between experience and various independent variables.

For the degree of digital twin adoption, the results indicate a significant difference (F-value = 6.98, p-value = 0.000). This suggests that the experience level significantly influences the extent to which digital twin technology is adopted. Similarly, for staff training, the data reveals a significant difference (F-value = 6.28, p-value = 0.000), indicating that experience plays a crucial role in how staff training is conducted and perceived.

Financial investment in technology also shows a notable difference (F-value = 3.26, p-value = 0.023), implying that those with varying levels of experience might allocate financial resources differently towards technology. Stakeholder involvement follows the same pattern (F-value = 2.88, p-value = 0.038), highlighting that experience significantly impacts how stakeholders are involved in processes related to digital twin adoption and implementation.

On the other hand, digital twin features (F-value = 1.40, p-value = 0.246) do not show a significant difference based on experience. This suggests that regardless of experience, the perceived features and capabilities of digital twin technology are viewed similarly across different levels of experience.

In summary, experience significantly affects the degree of digital twin adoption, staff training, financial investment in technology, and stakeholder involvement, but it does not significantly influence the perception of digital twin features.

H₀₃: There is no positive relationship between Independent and dependent variables

Table 5: Regression analysis

R	R Square	Adjusted R Square	Std. Error of the Estimate
.989 ^a	0.98	0.98	0.17

a. Predictors: (Constant), Stakeholder Involvement, Staff Training, Degree of Digital Twin Adoption, Financial Investment in Technology, Digital Twin Features

			Standardized Coefficients	t	Sig.
			Beta		
(Constant)	0.19	0.05		3.95	0.00
Digital Twin Adoption	-0.01	0.03	-0.01	-0.20	0.84
Digital Twin Features	-0.04	0.06	-0.04	-0.62	0.54
Staff Training	-0.11	0.02	-0.08	-6.04	0.00
Financial Investment in Technology	0.69	0.03	0.67	20.95	0.00
Stakeholder Involvement	0.41	0.05	0.40	7.68	0.00

a. Dependent Variable: E-Service Quality

Table 5 based on the provided regression analysis data, we can infer the relationship between the independent variables (Stakeholder Involvement, Staff Training, Degree of Digital Twin Adoption, Financial Investment in Technology, Digital Twin Features) and the dependent variable (E-Service Quality). The high R Square value of 0.98 indicates that 98% of the variance in E-Service Quality can be explained by the independent variables, suggesting a strong relationship.

The constant term is significant (Beta = 0.19, t-value = 3.95, p-value = 0.00). For the individual predictors, Staff Training (Beta = -0.11, t-value = -6.04, p-value = 0.00), Financial Investment in Technology (Beta = 0.69, t-value = 20.95, p-value = 0.00), and Stakeholder Involvement (Beta = 0.41, t-value = 7.68, p-value = 0.00) all show significant relationships with E-Service Quality. These results indicate that these variables positively impact E-Service Quality, as their p-values are less than 0.05.

On the other hand, the Degree of Digital Twin Adoption (Beta = -0.01, t-value = -0.20, p-value = 0.84) and Digital Twin Features (Beta = -0.04, t-value = -0.62, p-value = 0.54) do not show significant relationships, as their p-values are greater than 0.05. This suggests that these variables do not have a significant positive impact on E-Service Quality.

Findings and Suggestions

In inference, the regression analysis indicates that Staff Training, Financial Investment in Technology, and Stakeholder Involvement have a significant positive impact on E-Service Quality, while the Degree of Digital Twin Adoption and Digital Twin Features do not. This leads us to reject

the null hypothesis for the significant variables and accept the alternative hypothesis, establishing a positive relationship between these independent variables and E-Service Quality. For the nonsignificant variables, we fail to reject the null hypothesis, indicating no significant positive relationship with E-Service Quality. The Degree of Digital Twin Adoption, Digital Twin Features, Staff Training, Financial Investment in Technology, and Stakeholder Involvement all significantly impact the adoption and application of Digital Twin Technology in education systems. Focus on comprehensive staff training programs, increase financial investments in technology, and actively involve stakeholders in the decision-making processes. Ensure effective implementation and utilization of digital twin technology within educational institutions.

Organizations should invest in comprehensive staff training programs, allocate more financial resources towards technological advancements, and actively involve stakeholders in decision-making processes. These measures can significantly enhance the quality of e-services. Additionally, the focus should be on the effective implementation and utilization of digital twin technology rather than merely adopting it or highlighting its features. By addressing these key areas, organizations can achieve better customer satisfaction and overall performance in their eservices. Based on the findings from the regression analysis, several key insights have been identified. Firstly, staff training, financial investment in technology, and stakeholder involvement all show a significant positive relationship with E-Service Quality. This indicates that enhancing training programs for employees, allocating more financial resources towards technological advancements, and actively engaging stakeholders can lead to higher quality e-services. On the other hand, the degree of digital twin adoption and digital twin features do not show a significant impact on E-Service Quality. This suggests that merely adopting digital twin technology or having advanced features is not sufficient to improve service quality unless these technologies are effectively integrated and utilized in daily operations.

In light of these findings, several suggestions can be made to improve E-Service Quality. Organizations should invest in comprehensive staff training programs to ensure that employees are well-equipped and competent in their roles. Increasing financial investment in technology is also crucial, as this can enhance service delivery through better infrastructure and advanced tools. Moreover, actively involving stakeholders in the decision-making process can lead to more efficient and effective services. Lastly, efforts should be focused on the effective implementation and utilization of digital twin technology, rather than just its adoption and features. By addressing these key areas, organizations can significantly enhance the quality of their e-services, leading to better customer satisfaction and overall performance.

Conclusion

The regression analysis highlights significant positive impacts of Staff Training, Financial Investment in Technology, and Stakeholder Involvement on E-Service Quality. This finding leads to the rejection of the null hypothesis for these variables, establishing a positive relationship between these independent variables and E-Service Quality. Conversely, the Degree of Digital Twin Adoption and Digital Twin Features do not significantly impact E-Service Quality, leading to the failure to reject the null hypothesis for these variables. This suggests that the effective integration and utilization of digital twin technology are crucial to realizing its potential benefits rather than merely adopting it. Moreover, the analysis underscores the significant influence of the Degree of Digital Twin Adoption, Digital Twin Features, Staff Training, Financial Investment in Technology, and Stakeholder Involvement on the adoption and application of Digital Twin

Technology in education systems. This suggests that a comprehensive approach, which includes enhancing staff training programs, increasing financial investments in technology, and actively involving stakeholders in decision-making processes, is essential for the successful implementation of digital twin technology.

To enhance E-Service Quality, organizations should prioritize comprehensive staff training programs to ensure employees are well-equipped and competent. Allocating more financial resources towards technological advancements is also crucial, as it can enhance service delivery through better infrastructure and advanced tools. Additionally, actively involving stakeholders in decision-making processes can lead to more efficient and effective services. Efforts should also focus on the effective implementation and utilization of digital twin technology within educational institutions to maximize its potential benefits. By addressing these key areas, organizations can significantly enhance the quality of their e-services, leading to better customer satisfaction and overall performance.

Managerial Implications

The findings from the regression analysis and ANOVA results have important managerial implications for organizations looking to enhance their e-services and effectively implement digital twin technology. **Investing in Staff Training:** Managers should prioritize comprehensive staff training programs. Ensuring that employees are well-equipped and competent can lead to higher quality e-services. Continuous learning and development opportunities will also keep the workforce updated with the latest technological advancements. **Allocating Financial Resources:** Financial investment in technology is crucial. Managers need to allocate sufficient resources towards advanced infrastructure, software, and tools that enhance service delivery. Budget planning should include provisions for upgrading technology and investing in new solutions that drive efficiency. **Engaging Stakeholders:** Active stakeholder involvement is essential for the successful implementation of digital twin technology. Managers should facilitate regular consultations, feedback sessions, and collaborative decision-making processes. This ensures that all stakeholders are aligned and contribute to the effective deployment of new technologies.

Effective Utilization of Technology: Simply adopting digital twin technology is not enough. Managers need to focus on its effective implementation and utilization within the organization. This involves integrating the technology into daily operations and ensuring that it is used to its full potential to achieve desired outcomes. **Strategic Planning:** Managers should develop strategic plans that incorporate these findings to enhance e-service quality. This includes setting clear objectives, identifying key performance indicators, and monitoring progress. By aligning strategies with these insights, managers can drive better customer satisfaction and overall performance. By addressing these managerial implications, organizations can not only improve the quality of their e-services but also ensure the successful adoption and application of digital twin technology, leading to long-term benefits and competitive advantage.

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