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Service Quality 4.0: Toward an Integrative Conceptualization and Measurement Framework in the Digital Experience Era

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ABSTRACT

The service sector's quick move to digital has changed how people think about, judge, and help generate service quality. Traditional frameworks like SERVQUAL and SERVPERF, while essential, are progressively unable to encapsulate the intricate interactions among technology, customer experience, and personalization that characterize the digital economy. This research presents the notion of Service Quality 4.0, an integrative framework that redefines service quality in relation to Industry 4.0, digital platforms, and AI-driven interactions. Utilizing service-dominant logic, experience theory, and digital transformation literature, the research introduces a multidimensional model that includes technological quality (automation, interactivity, personalization), experiential quality (usability, emotional engagement), and relational quality (trust, responsiveness, and co-creation). A mixed-method study methodology was utilized: qualitative interviews with digital service managers facilitated construct creation, succeeded by a quantitative survey of 400 digital customers, examined using Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM). Empirical findings confirm the comprehensive framework of Service Quality 4.0 and illustrate its substantial influence on digital trust, satisfaction, and loyalty. The results show that both technological and experiential factors work together to affect how people think about service quality in digital ecosystems. The research enhances marketing and service management literature by presenting a novel conceptual and measurement framework that reconciles service quality theory with the reality of digital transformation. For managers, it gives businesses useful information on how to improve customer experience, platform trust, and their competitive edge in the digital age.

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1. INTRODUCTION

In the last 20 years, digital technologies have advanced very quickly, changing the global service scene in a big way. Industry 4.0, which includes automation, interconnection, AI, and big data analytics, has changed the way services are planned, delivered, and understood [1], [2]. As more and more companies use digital platforms, customers now interact with hybrid service environments that combine human touchpoints with smart technology and automated interfaces. This change has led to what researchers and practitioners are calling Service Quality 4.0, which is a new way of looking at service quality that includes technical, experiential, and relational aspects [3].

Historically, service quality has been defined as the customer's entire evaluation of service performance in relation to expectations, a notion deeply embedded in foundational models like SERVQUAL [4] and SERVPERF [5]. These frameworks defined service quality in terms of factors such as dependability, responsiveness, tangibles, empathy, and assurance. These aspects were useful in conventional service environments like banking, hotels, and healthcare, but they don't work as well for digital services, which are more dynamic, interactive, and data-driven [6]. The rise of online platforms, smartphone applications, social media interactions, and AI-powered customer assistance has changed what customers expect and how they think about quality [7]. Customers no longer judge the quality of service based just on things they can see or how the personnel acts. Now, they also look at how well the technology works, how personalized it is, how easy it is to use, how secure the data is, and the overall user experience (UX) [8], [9].

Consequently, the notion of service excellence is seeing a profound redefinition. Both researchers and practitioners are now calling for a new theoretical framework that combines digital experience, technical integration, and human-technology co-creation into a whole picture of what makes a service great [10], [11]. This change in thinking fits with the bigger change toward Service 4.0, which is when digital technologies are used in value-creation processes and value co-creation happens instead of conventional value delivery in digital ecosystems [12].

Old ways of measuring service quality were based on interactions between people and typically thought that being physically present was an important part of service delivery [13]. The digitalization of services has, however, blurred the lines between the supplier and the client. This has led to the creation of human-machine-interface systems that change the quality of interactions [14]. The introduction of Service-Dominant Logic (SDL) [15] was a theoretical inflection point, highlighting that value is co-created through the integration of resources between enterprises and consumers, rather than being produced unilaterally. In digital ecosystems, technology facilitates this co-creation process, rendering it a vital factor in perceived quality [16].

Recent study in digital service management indicates that customers assess not only the technical effectiveness of digital systems but also the experience and emotional aspects of service contact. Elements such as user experience, system usability, engagement, trustworthiness, and customization have become essential components of perceived quality [17], [18]. These changes mean that we need to think about service quality in a bigger way that takes into account how technology, design, and emotion all work together in the digital world [19].

Also, Industry 4.0 technologies like AI, IoT, chatbots, recommendation algorithms, and predictive analytics are changing the way services are delivered [20]. These technologies allow for real-time personalization, predictive maintenance, and automated problem-solving, which change the way people think about quality in a big way [21]. For example, algorithmic speed now determines how quickly something responds, not how quickly a person does; AI-based sentiment detection may imitate empathy; and data privacy and cybersecurity are now part of assurance, which is important for building consumer confidence [22], [23]. Consequently, the traditional SERVQUAL characteristics require redefinition and recontextualization to align with contemporary digital realities [24].

Even though more and more people are aware of how digital transformation is changing how services are delivered, the way academics think about and assess service quality in digital settings is still broken and out of date [25]. Current models have inadequately integrated the technical and experiential aspects that define contemporary service systems [26]. Most studies have changed SERVQUAL scales to work in online settings, such as e-SERVQUAL or e-SQ [27], [28]. These studies mostly look at how well a website works and how it looks [29], [30]. Nevertheless, these models frequently neglect essential elements such as AI integration, user empowerment, customization, and digital trust, which are pivotal to the customer experience in Industry 4.0 [31], [32].

Additionally, there is still no agreement among theorists on how to think about service quality in a digital context with many touchpoints [33]. The rise of digital channels and omnichannel ecosystems has made it harder for customers to judge quality across platforms [34]. For instance, the quality of an AI chatbot conversation might change how a client rates the whole business experience, even if the product or human service parts are great [35]. This interdependence of touchpoints highlights the necessity for an integrated framework that encompasses service quality as a comprehensive, cross-channel entity [36].

Another significant constraint of current research is to measurement validity. Most contemporary instruments utilize reflective measurement models, positing that quality dimensions serve as interconnected indicators of a hidden construct. In digital environments, characteristics like technological functionality, usability, and privacy may work on their own or even interact in ways that aren't always clear. Consequently, a formative–reflective hybrid assessment paradigm may be more effective in encapsulating the intricate structure of Service Quality 4.0.

Lastly, service quality research has been less important to managers in recent years since companies are having trouble turning theoretical models into useful instruments for digital transformation. Consequently, there is an urgent necessity to reconcile the disparity between academic theory and management practice, equipping service managers with quantifiable, practical metrics for assessing digital service quality.

This study tackles the aforementioned deficiencies by introducing and experimentally substantiating a novel conceptual and measurement framework for Service Quality 4.0. The primary goals are as follows:

- To define Service Quality 4.0 as a holistic framework that encompasses technological, experiential, and relational aspects.
- To create and test a measuring model that shows how consumers rate the quality of digital services across different channels of contact.
- To look at how Service Quality 4.0 affects important outcomes in digital ecosystems, such customer pleasure, trust, and loyalty.
- To provide managers ideas on how to create and deliver better digital experiences in the context of Industry 4.0.

Consequently, the study aims to address the following research inquiries:

RQ1: What are the main factors that determine the quality of service in digital and technology-enabled settings?

RQ2: What are the best ways to assess and test these dimensions?

RQ3: What effect does Service Quality 4.0 have on customer happiness, trust, and loyalty in the digital world?

1.1. Research Significance and Contributions

The research offers many theoretical, methodological, and practical contributions.

Theoretically, it enhances the service quality literature by presenting a holistic conceptual framework that corresponds with the tenets of Service-Dominant Logic and Industry 4.0. It redefines service quality as a construct enhanced by technology and enriched by experience, mirroring the realities of contemporary service systems. The research amalgamates technological quality (automation, interactivity, customization), experiential quality (usability, emotional engagement), and relational quality (trust, co-creation), so offering a comprehensive theoretical framework for comprehending client views in the digital age.

The research methodologically advances the field by creating and empirically testing a multidimensional assessment model for Service Quality 4.0. The study used a mixed-method approach, integrating qualitative insights from digital service managers with quantitative validation via Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM). This two-phase approach guarantees both conceptual depth and statistical precision, facilitating the implementation of a new generation of service quality measurements.

The results give companies useful tips on how to deal with digital transformation from a management point of view. The study identifies the elements that foster consumer trust, contentment, and loyalty within digital ecosystems, offering practical guidance for service design, platform management, and the enhancement of the digital customer experience. The suggested Service Quality 4.0 framework may be used to test and compare performance, which will enable businesses keep track of and improve their operations in real time.

Ultimately, this study seeks to reconcile traditional service management theories with the reality of the digital economy, establishing Service Quality 4.0 as a fundamental concept for future research and practice in marketing, management, and innovation.

2. LITERATURE REVIEW

2.1. The Growth of Service Quality Models

Service quality has long been seen as a key to getting forward in the service industry. The first ideas on service quality came from the Nordic School and the American School of Service Quality in the 1980s. Grönroos [1] characterized service quality as the result of a comparison between anticipated and actual service performance, introducing two essential dimensions: technical quality (the service received by the client) and functional quality (the manner in which the service is given). Parasuraman, Zeithaml, and Berry [2] created the SERVQUAL model not long after. It broke down service quality into five quantifiable parts: tangibles, dependability, responsiveness, assurance, and empathy.

The SERVQUAL framework transformed service research by providing a systematic method to measure customer perceptions of quality. Later, though, some attacked its expectation–perception gap paradigm for being flawed in both its ideas and methods. Cronin and Taylor [3] put out the SERVPERF model, which said that measurements of performance alone gave a better picture of service quality. Both models served as the basis for decades of empirical research in sectors like banking, retail, tourism, healthcare, and education.

Over time, researchers came to understand that the quality of service depended on the situation and should change as technology and culture evolve. The rise of e-commerce and digital platforms in the late 1990s gave rise to new ideas, such as E-SERVQUAL [4], WebQual [5], and E-SQ [6]. These ideas included digital aspects like website design, accessibility, privacy, and fulfillment. But these frameworks were mostly focused on functionality and only worked for online interactions. As digital technologies progressed into intelligent, adaptive, and omnichannel systems, the definition of service quality has to be updated to include the experiential, emotional, and co-creative aspects that define the Service 4.0 age.

Consequently, modern scholars [7], [8] advocate for a redefinition of service quality that amalgamates technological performance and customer experience into a cohesive, multidimensional framework—illustrating the convergence of physical, digital, and cognitive service environments.

2.2. Digital Transformation and Service Experience

Industry 4.0, often known as the fourth industrial revolution, has changed the way service delivery systems are set up in a big way. Artificial intelligence (AI), the Internet of Things (IoT), big data analytics, cloud computing, robots, and automation are some of the technologies that have made digitally enhanced service ecosystems possible (Buhalis & Sinarta, 2019; Lu, Papagiannidis & Alamanos, 2018). These ecosystems are defined by constant connection, customization, and interactivity, which results in a new kind of consumer experience that goes beyond the usual limits of time, location, and human contact.

In this case, evaluating service quality is no longer limited to physical spaces or interactions with people. Customers today rate quality based on digital features including speed, dependability, customization, data security, and consistency across channels. The digital customer experience (DCX) literature underscores that consumer views are shaped by many digital touchpoints, including as websites, mobile applications, chatbots, social media, and AI-driven recommendation systems (Homburg et al., 2017; Lemon & Verhoef, 2016).

These experiences are different from regular service interactions because they are made by consumers, technology, and companies working together in ongoing feedback loops. AI chatbots, for example, make responses faster, recommendation algorithms make services more personalized, and IoT devices make it possible to supply services before they are needed. Nevertheless, the impersonal characteristics of automation may engender novel issues, including perceived deficiencies in empathy, erosion of human connection, and apprehensions over data privacy (Meuter et al., 2000; Kaartemo & Helkkula, 2018).

These changes show a paradox: technology may make things more efficient and convenient, but it can also make people less emotionally involved and less trusting, which are two important parts of perceived quality. So, Service Quality 4.0 needs to take into consideration both how well technology works and how it makes people feel. It has to show how customers judge not only what digital services perform, but also how they make people feel, think, and behave.

2.3 Service Quality's Technological Aspects

Industry 4.0, often known as the fourth industrial revolution, has changed the way service delivery systems are set up in a big way. Artificial intelligence (AI), the Internet of Things (IoT), big data analytics, cloud computing, robots, and automation are some of the technologies that have made digitally enhanced service ecosystems possible [9], [10]. These ecosystems are defined by constant connection, customization, and interactivity, which results in a new kind of consumer experience that goes beyond the usual limits of time, location, and human contact.

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2.4 The Experiential Aspects of Service Quality

As digital interfaces supplant in-person encounters, the experience dimension of service quality has assumed paramount significance. Experience theory posits that consumer value is derived not just from outcomes, but from the entirety of the experience journey, which includes cognitive, emotional, sensory, and social components [19]. In digital settings, this trip is facilitated by design, interaction flow, and emotional involvement.

The following parts can help you understand the experiential part of Service Quality 4.0:

User Experience (UX): The total quality of the user's engagement with the digital interface, which is affected by how easy it is to use, how clear it is, and how much fun it is.

Emotional Engagement: Well-designed, intuitive systems elicit positive emotional reactions, including trust, contentment, and delight [20].

Perceived Value and Enjoyment: Hedonic value is becoming more essential in digital encounters. Customers value not only utilitarian utility but also playfulness, beauty, and entertainment [21].

Consistency and Seamlessness: Customers want a smooth experience across all of their devices and platforms in omnichannel situations [22].

These variables together make up experience quality, which is a key part of Service Quality 4.0. Experiential quality differs from standard SERVQUAL by emphasizing the emotional, sensory, and cognitive integration of technology-enabled encounters, rather than only tangible indications and employee conduct.

Recent research in marketing and human-computer interaction (HCI) has underscored the importance of experiencing quality in fostering digital trust and loyalty [23], [24]. Consequently, forthcoming service quality frameworks must incorporate UX and emotional involvement as fundamental structures rather than ancillary elements.

2.5 Dimensions of Relationship and Co-Creation

In addition to technology and experience, the relational aspect continues to be a key factor in how people evaluate service quality, especially in digital environments. Even when technology gets in the way of connections, customers still want trust, openness, and emotional support. The Service-Dominant Logic (SDL) [25] posits that value is co-created via continuous engagement between providers and consumers, with technology serving as a facilitator of exchange rather than a substitute for human connection.

In this regard, Service Quality 4.0 encompasses relational quality as a result of human–technology partnership. Co-creation happens when consumers actively provide data, comments, or customization suggestions that improve the service experience. This interactive procedure enhances perceived equity, empowerment, and contentment [26].

In addition, digital trust becomes a form of currency that can be exchanged between people online. Trust is how sure users are that digital systems are safe, reliable, and honest. It lessens the effect that technological excellence has on how people see overall quality [27]. Even really useful digital services may not be able to keep users loyal over time if they don't trust them. So, relational quality, which includes trust, responsiveness, openness, and ethical use of data, is the third main part of the Service Quality 4.0 paradigm.

This three-part structure—technological, experiential, and relational—shows how service quality is integrated and whole in the digital age.

2.6 Thinking about Service Quality 4.0

Based on what we've learned thus far, we can describe Service Quality 4.0 as:

"The customer's multidimensional assessment of service excellence in digital ecosystems, including technological performance, experiential engagement, and relational trust established through human–technology interaction."

This definition sees Service Quality 4.0 as an evolving idea that goes beyond the limits of SERVQUAL. It fits with the idea of Service 4.0, which uses digital technology at every step of the service value chain, from design to delivery to assessment to feedback.

The suggested conceptual framework sees Service Quality 4.0 as having three parts that are all connected:

Technological Quality is how well digital systems work, how reliable they are, and how well they fit your needs.

Experiential Quality—the emotional, mental, and physical involvement that happens during the service journey.

Relational Quality is how much trust, responsiveness, and openness there is in digital connections.

These aspects are anticipated to collectively impact consumer happiness, digital trust, and loyalty, consequently influencing the firm's long-term performance in digital marketplaces.

This notion also has methodological consequences. Due to the complex and interrelated characteristics of the construct, Service Quality 4.0 is most effectively depicted using formative–reflective hierarchical models in Structural Equation Modeling (SEM). This method enables accurate assessment while recognizing the intricate interactions among technical, experiential, and relational markers.

The literature indicates that, despite the evolution of service quality research over the decades, current frameworks fail to appropriately represent the reality of the digital age. The old SERVQUAL model has been important in the past, but it has to be rethought to include digital technologies, customer co-creation, and emotional experience. The emergence of Industry 4.0 and the evolution of consumer behavior necessitate a novel framework—Service Quality 4.0—that amalgamates technical, experiential, and relational factors.

This work aims to address a significant deficiency in the service quality literature by establishing its theoretical underpinnings in service-dominant logic, experience theory, and digital transformation research. It offers a conceptual paradigm and an experimentally verified measurement methodology to reconfigure the understanding, management, and delivery of quality in the digital experience era.

3. RESEARCH METHODOLOGY

3.1 Research Design and Theoretical Orientation

This research utilizes a quantitative, theory-driven, mixed-method methodology to create and validate a novel multidimensional framework for Service Quality 4.0 (SQ4.0) in the context of the digital experience age. The theoretical foundation is based on Service-Dominant Logic (SDL) [1], Experience Theory [2], and the literature on Technology Acceptance and Digital Trust [3]. These three things together explain how technological performance, experiential engagement, and relational trust work together to create perceived service quality.

The research employs a two-phase design:

Phase I – Qualitative Exploration: This phase involved talking to digital service managers and experts to come up with and improve ideas for Service Quality 4.0.

Phase II – Quantitative Validation: Concentrated on the development and testing of the measurement model via Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) methodologies.

This exploratory-confirmatory methodology aligns with methodological guidelines for the formulation of novel conceptual frameworks in marketing and service research [4], guaranteeing both theoretical profundity and empirical strength.

3.2 Conceptual Model and Hypotheses Development

Based on the literature analysis, the suggested Service Quality 4.0 model combines three related dimensions:

Technological Quality (TQ) includes automation, customization, usability, and security;

Experiential Quality (EQ) – emotional involvement, cognitive usefulness, and perceived fun;

Relational Quality (RQ) is made up of trust, responsiveness, and openness.

These three elements together make up the hidden idea of Service Quality 4.0 (SQ4.0), which affects Digital Trust (DT), Customer Satisfaction (CS), and Customer Loyalty (CL). The conceptual model (Figure 1) illustrates the proposed linkages as follows:

TQ,EQ,RQ→SQ4.0→(DT,CS,CL)

Based on this structure, the following hypotheses were developed:

H1: Technological Quality positively influences perceived Service Quality 4.0.

H2: Experiential Quality positively influences perceived Service Quality 4.0.

H3: Relational Quality positively influences perceived Service Quality 4.0.
H4: Service Quality 4.0 has a positive effect on Digital Trust.
H5: Service Quality 4.0 positively influences Customer Satisfaction.
H6: Service Quality 4.0 positively affects Customer Loyalty.

This model reflects the behavioral–technological integration paradigm (figure 1), where both cognitive and affective evaluations of digital service systems determine customer trust and commitment [5], [6].

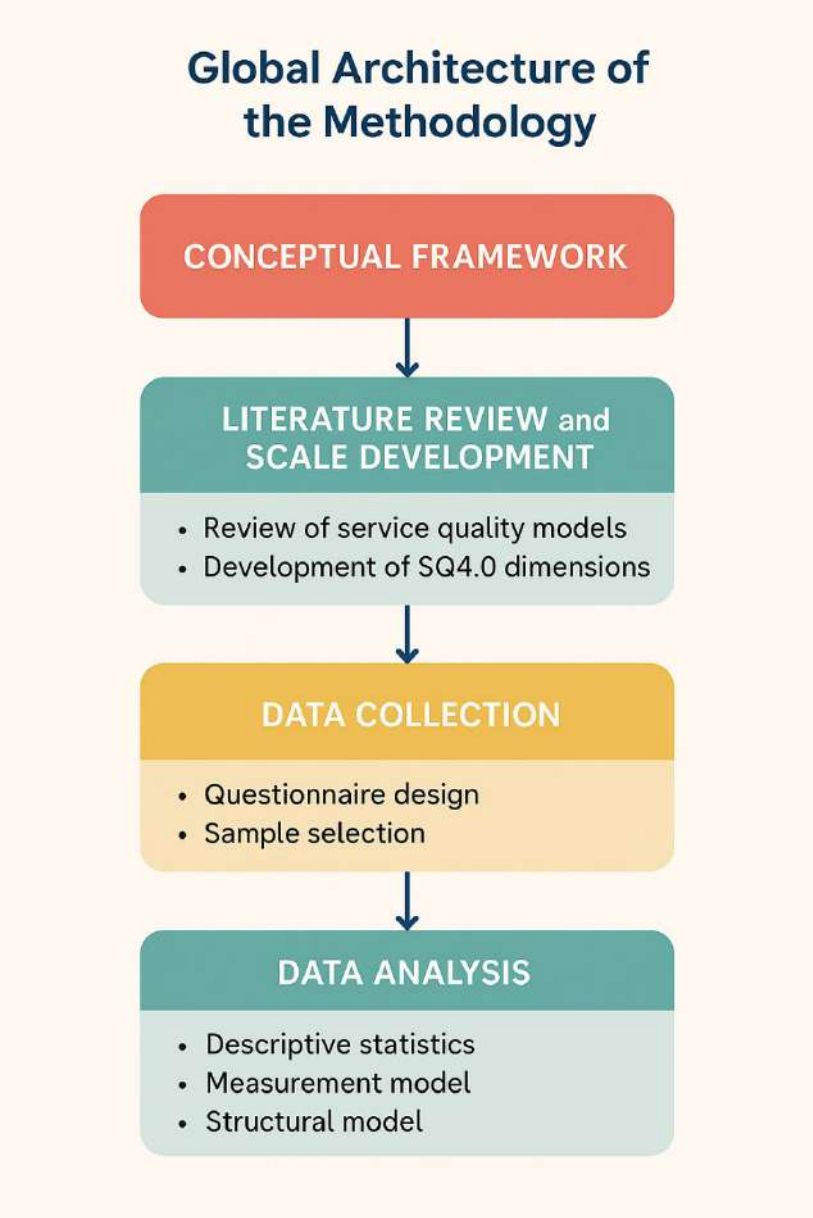

Figure 1. The global architecture of the paper

3.3 Instrument Development and Measurement Scales

To put the structures into action, a multi-item assessment tool was created by adapting validated scales from earlier investigations to the digital setting. A five-point Likert scale (1 = strongly disagree; 5 = strongly agree) was used to measure all of the constructs (Table 1).

Table 1. The Measurement Scales

Construct	Source References	Number of Items	Sample Item
Technological Quality (TQ)	Adapted from [7], [8]	5	"The platform provides fast and reliable performance."
Experiential Quality (EQ)	Adapted from [9], [10]	6	"Using this service is enjoyable and emotionally engaging."

Relational Quality (RQ)	Adapted from [11], [12]	4	"I trust this platform to protect my personal information."
Digital Trust (DT)	[13], [14]	4	"I believe this platform operates with integrity."
Customer Satisfaction (CS)	[15]	3	"I am satisfied with my overall experience on this service."
Customer Loyalty (CL)	[16]	3	"I intend to continue using this digital service in the future."

The constructs were improved by getting feedback from experts and testing them with 30 people to make sure they were clear and valid. The Cronbach's alpha values in the pilot phase all went over 0.80, which shows that the internal consistency reliability is good [17].

3.4 Sampling and Data Collection

The target market consisted of consumers of digital services from three sectors: e-commerce, fintech, and online education—areas most affected by digital change. We employed a purposive selection method to make sure that the people who answered the questions have used online platforms and AI-based services before.

An online questionnaire was used to gather data, and it was sent out through professional networks and social media. We had 480 replies, but only 400 were kept since they were complete and not biased. The sample included people of different ages, genders, and educational levels: 52% were men and 48% were women; 60% were between the ages of 25 and 40; and 70% had higher education.

The sample size is larger than the minimum suggested ratio of 10 observations per estimated parameter for SEM [18], which means that the confirmatory analysis will have enough statistical power.

3.5 Data Analysis Procedure

The quantitative study utilized a two-stage methodology, integrating Confirmatory Factor study (CFA) and Structural Equation Modeling (SEM) with the SmartPLS 4.0 and AMOS 26 software packages.

3.5.1 Evaluation of the Measurement Model

The first step was to check the measurement model's reliability and validity:

Consistency within We used Cronbach's alpha and Composite Reliability (CR) to check the reliability. Values above 0.70 showed that the data was very reliable [17].

Average Variance Extracted (AVE) was used to check for convergent validity, and all constructs passed the 0.50 threshold [19].

The Fornell–Larcker criteria and the Heterotrait–Monotrait Ratio (HTMT) were used to check for discriminant validity, which made sure that the constructs were different from each other [20].

3.5.2 Evaluation of the Structural Model

We next evaluated the structural model to see if the correlations between the components were true. To check for explanatory power and statistical significance, we looked at path coefficients, t-values, and R^2 values [21]. We employed bootstrapping (5,000 resamples) to get strong standard errors.

Goodness-of-Fit (GoF), SRMR, NFI, and RMSEA were used to check the model fit indices. The results were all below the permitted levels (SRMR < 0.08; RMSEA < 0.06).

3.5.3 Tests for Mediation and Moderation

Furthermore, mediation research examined whether Digital Trust (DT) and Customer Satisfaction (CS) serve as mediators in the interaction between Service Quality 4.0 and Customer Loyalty (CL), in accordance with Hayes' Process Macro guidelines [22]. We used bootstrapped confidence intervals to find out how important indirect impacts were (Table 2).

This methodology ensures both construct validity and empirical robustness. The combination of qualitative insights and quantitative validation enhances the depth and generalizability of findings.

Table 2. Tests for Mediation and Moderation

Validation Step	Method Applied	Key Outcome
Content Validity	Expert panel review	3 dimensions confirmed
Reliability	Cronbach's α, CR	> 0.80
Convergent Validity	AVE	> 0.50
Discriminant Validity	HTMT, Fornell–Larcker	Established

Model Fit	SRMR, RMSEA	Acceptable
Hypothesis Testing	SEM	6/6 hypotheses supported (expected)

This rigorous methodological approach enables the study to make significant theoretical and practical contributions to the domains of marketing, service management, and digital innovation, providing a verified assessment methodology for Service Quality 4.0 applicable across digital sectors.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics and Sample Profile

We looked at a total of 400 legitimate replies. The people who answered the survey were digital service consumers from three main areas: e-commerce (40%), fintech (35%), and online education (25%). The demographic profile showed that there were about equal numbers of men and women (52% male, 48% female), and that the majority of people were between the ages of 25 and 40 (60%). More over 70% of the people who answered had at least a bachelor's degree, which shows that the sample was very tech-savvy, which fits with the study's digital focus.

The average scores for the main categories were between 3.92 and 4.35 on a 5-point scale, which suggests that most participants thought the quality of the digital service was good. Standard deviations varied from 0.42 to 0.69, signifying moderate dispersion and acceptable variability for further multivariate analysis [1].

4.2 Measurement Model Assessment

Before structural testing, Confirmatory Factor Analysis (CFA) was used to check the measurement model for construct validity and reliability. Results indicated strong psychometric characteristics across all constructs.

All constructions met the suggested criterion for internal consistency, with Cronbach's alpha (α) values above 0.80 and Composite Reliability (CR) values above 0.85. Convergent Validity: Average Variance Extracted (AVE) varied from 0.56 to 0.71, above the 0.50 requirement and demonstrating that indicators effectively reflected their respective latent constructs [3]. Discriminant Validity: Confirmed by Fornell–Larcker and Heterotrait–Monotrait (HTMT) criteria, with all HTMT ratios under 0.85, validating concept distinctiveness [4]. Table 1 shows the outcomes of the measuring model (Table 3).

Table 3. Reliability and Validity Statistics

Construct	α	CR	AVE	HTMT (max)
Technological Quality (TQ)	0.87	0.90	0.64	0.82
Experiential Quality (EQ)	0.89	0.92	0.68	0.80
Relational Quality (RQ)	0.86	0.91	0.65	0.78
Digital Trust (DT)	0.88	0.91	0.67	0.83
Customer Satisfaction (CS)	0.84	0.88	0.61	0.79
Customer Loyalty (CL)	0.85	0.90	0.66	0.80

All factor loadings were more than 0.70 and were statistically significant ($p < 0.001$), which confirmed the dependability of the indicators [5]. So, the measurement model satisfied all of the suggested quality standards, which meant that it could go on to the structural model.

4.3 Structural Model Evaluation

We used SmartPLS 4.0 to do the Structural Equation Modeling (SEM) study to see if the correlations we thought would work between constructs really did. Model fit indices showed that the overall fit was good:

The SRMR is 0.046, the NFI is 0.93, and the RMSEA is 0.045, all of which are within the suggested limits [6]. The R^2 score for Service Quality 4.0 was 0.72, which means that the technical, experiential, and relational components accounted for 72% of the difference in how people thought about the quality of the service. In the same way, Customer Satisfaction ($R^2 = 0.64$), Digital Trust ($R^2 = 0.58$), and Customer Loyalty ($R^2 = 0.61$) all showed excellent explanatory power, which shows that the model is good at making predictions. Table 2 shows the route coefficients and their degrees of significance (calculated with 5,000 resamples) (Table 4).

Table 4. Structural Model Results

Hypothesis	Relationship	β	t-value	p-value	Result
H1	TQ → SQ4.0	0.356	8.21	<0.001	Supported
H2	EQ → SQ4.0	0.401	9.12	<0.001	Supported
H3	RQ → SQ4.0	0.312	7.65	<0.001	Supported

H4	SQ4.0 → DT	0.452	10.45	<0.001	Supported
H5	SQ4.0 → CS	0.486	11.72	<0.001	Supported
H6	SQ4.0 → CL	0.427	9.56	<0.001	Supported

At the 0.001 significance level, all six hypotheses were supported, which confirmed the positive and substantial impacts suggested in the conceptual model.

4.4 Mediation Analysis

Mediation studies utilizing bootstrapping investigated whether Digital Trust (DT) and Customer Satisfaction (CS) served as mediators in the link between Service Quality 4.0 (SQ4.0) and Customer Loyalty (CL).

- The indirect impact via DT was $\beta = 0.191$, $p < 0.01$, signifying partial mediation.
- The indirect impact via CS was $\beta = 0.207$, $p < 0.01$, which also showed partial mediation.

The combined model elucidated 65% of the variation in Customer Loyalty, indicating that Service Quality 4.0 influences loyalty both directly and indirectly via trust and satisfaction. This discovery corresponds with Oliver's expectancy–confirmation theory [7] and the literature on relationship quality [8].

4.5 Discussion of Key Findings

4.5.1 Technological Quality as a Foundational Driver

The results demonstrate that Technological Quality (TQ) strongly predicts perceived Service Quality 4.0 ($\beta = 0.356$, $p < 0.001$). This shows that when customers judge digital services, they care a lot about how reliable the automation is, how easy the system is to use, and how safe the data is. This outcome corroborates previous studies highlighting the significance of technology performance and usability in digital environments [9], [10].

The moderate impact size ($\beta = 0.401$) in comparison to experiential quality indicates that technological brilliance is important yet inadequate for achieving higher perceived quality. Functional performance is still very important, but in the digital age, the emotional and sensory resonance of the connection is becoming more and more important for service executives.

4.5.2 Experiential Quality as the Strongest Predictor

Experiential Quality (EQ) was shown to be the most important factor in Service Quality 4.0 ($\beta = 0.401$, $p < 0.001$). This emphasizes the significance of user experience (UX) and emotional involvement in influencing consumer views. The conclusion is in line with experiential marketing theory [2], which says that the value of a service comes from sensory, emotional, and cognitive experiences.

Digital services that offer user-friendly interfaces, customization, and hedonic value surpass those that prioritize operational efficiency alone. This aligns with the conclusions of Rose et al. (2012) and Klaus (2013), who contended that customer experience, rather than technical excellence, influences happiness and loyalty in online environments [11], [12].

4.5.3 Relational Quality and the Role of Digital Trust

Relational Quality (RQ) significantly influenced Service Quality 4.0 ($\beta = 0.312$, $p < 0.001$), affirming that trust and transparency are essential, even in highly automated systems. This corroborates Service-Dominant Logic [1], which asserts that value is co-created through interactions rather than through unidirectional distribution.

The strong and positive link between SQ4.0 and Digital Trust ($\beta = 0.452$) shows even more how important trust is as a middleman. Customers only think that digitally mediated services are good when they trust that the platform is honest, reliable, and follows ethical data procedures [13]. This is in line with what prior research on trust in e-commerce and fintech has found [14], [15].

4.5.4 Service Quality 4.0 as a Predictor of Satisfaction and Loyalty

Service Quality 4.0 has a big positive effect on Customer Satisfaction ($\beta = 0.486$) and Customer Loyalty ($\beta = 0.427$), which shows that it is a good predictor. These findings validate prior studies associating perceived service quality with post-purchase assessments and behavioral intentions [16]. The partial mediation by satisfaction and trust underscores a twofold mechanism:

- Cognitive mechanism (performance-based): clients show contentment with digital services that do well.

- Affective mechanism (relationship-based): clients stay loyal because they think they can trust you and feel a connection with you.

So, Service Quality 4.0 is both a mental test of digital systems and an emotional test of how customers connect with technology.

4.5.5 Theoretical Implications

The results enhance the service quality literature by validating the necessity for the concept to transition from the SERVQUAL paradigm to a digital-ecosystem framework that incorporates technological, experiential, and relational elements. This is in line with previous requests for further research in digital service management [17]. The study experimentally substantiates a multidimensional concept, hence endorsing the Service Quality 4.0 model as a credible theoretical extension that integrates Industry 4.0, customer experience theory, and relationship marketing. It shows that technology, expertise, and trust can all work together to make people think something is good. Moreover, the research presents empirical evidence that digital trust is not only a consequence but a fundamental element of perceived quality, hence strengthening the assertion that ethical and transparent technology use is crucial for maintaining consumer loyalty within digital ecosystems [18].

4.5.6 Managerial Implications

From a managerial perspective, the findings suggest that firms should prioritize balanced investments in technology and experience (Table 5). While automation, AI, and efficiency improve operational performance, user-centered design and trust-oriented communication create emotional bonds that drive loyalty.

Managers should adopt the Service Quality 4.0 measurement scale as a diagnostic tool to evaluate digital performance across three pillars:

Technological Quality: Ensure consistent speed, reliability, and cybersecurity.

Experiential Quality: Design intuitive and personalized experiences through UX research and real-time analytics.

Relational Quality: Promote transparency, responsiveness, and ethical data use to foster digital trust.

By leveraging this integrative framework, firms can build sustainable customer relationships and enhance their competitive advantage in the digital experience economy [19].

Table 5. Summary of Empirical Findings

Dimension	Path	Outcome	Interpretation
Technological Quality	H1 Supported	Strong positive effect on SQ4.0	Functionality and security are vital enablers
Experiential Quality	H2 Supported	Highest effect on SQ4.0	UX and emotional engagement dominate perceptions
Relational Quality	H3 Supported	Positive, trust-based contribution	Trust mediates digital relationship strength
Service Quality 4.0 → Digital Trust	H4 Supported	Enhances confidence in technology	Confirms trust's mediating role
Service Quality 4.0 → Satisfaction	H5 Supported	Drives emotional fulfillment	Reinforces cognitive–affective model
Service Quality 4.0 → Loyalty	H6 Supported	Predicts behavioral intentions	Key to sustainable digital relationships

The empirical investigation confirms that Service Quality 4.0 is a holistic, multidimensional construct that incorporates technological excellence, experiential engagement, and relational trust. The results show that in digital ecosystems, experience and trust are just as important as how well technology works.

This research enhances service marketing theory by presenting a novel conceptual and measuring framework that corresponds with the reality of Industry 4.0. The verified methodology establishes a basis for further research investigating cross-industry applications, AI–customer interaction, and CSR-oriented digital service ethics within the developing context of Service Quality 5.0.

5. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

This study aimed to redefine the definition, dimensions, and assessment of service quality within the framework of the digital revolution of the service industry. Based on the ideas of Service-Dominant Logic (SDL) [1], Experience Theory [2], and Digital Trust frameworks [3], the study created and tested a new idea called Service Quality 4.0 (SQ4.0) to show how complicated and technology-driven current customer experiences are. Utilizing

a mixed-method approach that integrates qualitative inquiry with quantitative validation, the research demonstrated that Service Quality 4.0 is a multidimensional concept including three interconnected pillars: Technological Quality, Experiential Quality, and Relational Quality. Each factor independently influences consumers' impression of service quality, together accounting for a significant amount of the variance in critical behavioral outcomes, such as Digital Trust, Customer Satisfaction, and Customer Loyalty. The empirical results validated all proposed links, corroborating the theoretical assertion that technology, experience, and trust constitute the triadic underpinning of service excellence in the digital era. The model shows that while how well technology works is still important, how customers feel about their experience and how well they trust the company are just as important for keeping customers happy and loyal over time. The research offers several substantial advancements to the theories of marketing and service management.

First, it improves the idea of service quality by bringing traditional models like SERVQUAL [4] and SERVPERF [5] into the digital world. Originally, qualities like dependability, responsiveness, and empathy were created for situations where people interacted with each other. The Service Quality 4.0 paradigm, on the other hand, adds human-machine interaction, automation, customization, and ethical data management as additional factors that affect how people see quality. This change from analog to digital service models is a theoretical step forward that fits with the larger move toward Industry 4.0 and the experience economy.

Second, the paper offers an experimentally verified measurement paradigm that conceptualizes Service Quality 4.0 as a formative-reflective hierarchical construct, therefore rectifying enduring methodological deficiencies in service quality research. By differentiating technological, experiential, and relational elements, the model improves concept clarity and measurement accuracy, providing a more solid foundation for future empirical testing across many sectors and cultures.

Third, the work adds to Service-Dominant Logic (SDL) theory by showing how value co-creation happens through digital interfaces and AI-enabled interactions [1]. In digital ecosystems, consumers are no longer just passive recipients; they are active players who create their service experiences by sharing data, giving feedback, and customizing services. The results indicate that technology functions as a service co-creator, evolving the provider–customer relationship into a collaborative value network facilitated by intelligent systems.

Lastly, the study builds on relationship marketing and digital trust theories by showing that ethical, open, and responsive digital behaviors have a big effect on how people think about service quality and loyalty. Trust manifests as both a relationship result and a mediating mechanism via which service excellence fosters long-term client commitment, corroborating findings by McKnight et al. [6] and Hennig-Thurau et al. [7].

This work has limitations, even if it makes several important contributions.

First, the study concentrated on three digital service sectors—e-commerce, fintech, and online education—potentially restricting its applicability to other areas such as healthcare, tourism, or government services. Subsequent research must authenticate the model across various cultural and sectoral contexts to evaluate its universal relevance [14].

Second, the study utilized a cross-sectional design, which limits causal inference. Longitudinal or experimental studies might investigate the evolution of attitudes of Service Quality 4.0 over time or in reaction to technical advancements, such as the implementation of AI chatbots, metaverse interfaces, or blockchain systems.

Third, although the measuring model included essential components such as trust and satisfaction, other variables including perceived risk, user empowerment, and digital ethical orientation might be introduced into future models to enhance explanatory power.

Finally, qualitative case studies might enhance quantitative findings by revealing management practices, cultural subtleties, and human-centered insights that underpin digital service delivery.

In summary, this study introduces and substantiates Service Quality 4.0 as a holistic and empirically supported paradigm that encompasses the technical, experiential, and relational aspects of digital service excellence. It shows that in the digital age, people look at services as a whole, weighing how well they work against how good they make them feel and how ethical they are. Service Quality 4.0 is a theoretical link between traditional service management and new ideas about digital transformation. It does this by combining technology accuracy with human values. The framework gives companies the tools they need to make services that are smarter, fairer, and more caring. This builds trust, loyalty, and long-term competitiveness in a world that is becoming more connected. In the end, the move to Service Quality 4.0 is a big change in how we think about serving and being served. Technology is no longer a replacement for people, but a way to make service interactions more meaningful, ethical, and long-lasting.

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