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Impact of Quality Management System on Student Satisfaction: Towards a Sustainable Quality Management Framework for Higher Education Institutions

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ABSTRACT

Higher education institutions (HEI) are striving to do more to maintain quality management and keep pace with the fast-paced nature of change that comes with Education 4.0. The growth of online technologies, artificial intelligence and automation is changing the academic systems and is forcing universities to rethink the traditional approaches to quality assurance. It is not a new concept that Total Quality Management (TQM) can improve performance and educational experience of institutions as it has long been considered as an essential strategy in the development of higher education, but its role and contribution to sustainability in quality practices have not yet been fully deployed.

This paper is aimed at examining the effects of TQM practices on student satisfaction and how the research outcomes might be used to create a Sustainable Quality Management Framework (SQMF) that would be applied in the universities operating in the Education 4.0 environment. The research problem of the proposed study is the investigation of engineering university in Pakistan with the idea of examining the relationship between specific TQM dimensions and student satisfaction. dependabilityonnaire was distributed among 500 students and results were analyzed

through the dependability and regression analyses.
The results show that TQM practices have enormous positive effect in student satisfaction. Continuous Improvement proved to be the most predictive factor (β = 0.25) then Strategic Planning and Process Approach. The results of this study suggest that college administration must be under permanent improvement and active policies that will improve their quality systems. The research provides practical suggestions on how institutional effectiveness can be improved and is useful in developing Digital and Sustainability-Oriented Quality Frameworks (DQMS/SQMF) and integrating them into the higher education policy and management practices in Pakistan.
Keywords: Total Quality Management (TQM), Student Satisfaction, Sustainable Quality Management Framework (SQMF), Education 4.0, Higher Education Institutions (HEIs)

INTRODUCTION

Global Perspectives on TQM in Higher Education

Sustainable quality management is one of the key priorities of institutions in the changing environment of higher education that attempts to accommodate the requirements of Education 4.0. It is necessary to have a new comprehensive approach to quality management in consideration of digital technologies, artificial intelligence (AI), and automation that are transforming the learning environments, as it has been so far. In this regard, Total Quality Management (TQM) has become one of the important determinants to the satisfaction of students, efficiency of the institution and sustainability in the long run. [1]

However, TQM is also being combined with Quality 4.0 principles using AI, learning analytics, and sustainability dashboards to drive evidence-based governance in the contemporary global literature. Total Quality Management (TQM) has gained wide acceptance in the world as a strategic model of enhancing performance of institutions, satisfaction of stakeholders, and relentless enhancement in institutions of higher education (HEIs). [2]

Studies conducted in the United States, the United Kingdom, and various European countries have indicated that Total Quality Management (TQM) can bring a lot of change to academic performance, provision of services and credibility of an institution Studies by Taylor and Wright [3] and others also support the notion that a good leadership style, effective management of processes, and stakeholder participation can lead to a sustainable quality enhancement in an academic institution. These strategies have been effective in the Western universities, but their effective usage in the developing areas is not assured. The cultural difference, institutional and governance structures could be limiting to the direct application of TQM in these settings.

TQM Adoption in Developing Countries

The latest research of such countries as Malaysia and India suggests that the digital quality assurance tools and sustainability scorecards may provide an opportunity to improve the relationship between TQM practices and the long-term

institutional resilience [4]. With the increasing efforts by higher education systems in an attempt to become competitive, accountable and in tandem with the international standards, TQM has become more relevant. According to research in Malaysia, India and Turkey, strategic planning, commitment by the leadership and constant improvement have proven to be critical in enhancing the performance of an institution and increasing the level of satisfaction of the students [5]. The implementation of TQM in many universities of the developing countries continues to face challenges, though. The causes of these problems are usually shortage in financial and human resources, insufficient quality assurance system and the ignorance of the TQM concept among the members of the faculty. Researchers also highlight that even with widespread implementation, the results of quality management initiatives within developing settings are most likely to differ based on organizational culture and country-level education policies [6].

Gaps in Pakistan's Higher Education Context

In Pakistan, quality assurance environment is slowly transforming into becoming digitized and in tandem with Sustainable Development Goal 4 (SDG 4) [7], which focuses on inclusive and equitable quality education. Nevertheless, to prove how this digital transformation is materializing in universities, there is a paucity of empirical studies on the issue particularly in quality management [8]. Even though the Higher Education Commission (HEC) has established a number of frameworks of quality assurance, the implementation of Total Quality Management (TQM) in higher education is still relatively new and is still going through development. The available research has put great emphasis on administrative enhancement and not the student outcomes. There is little information regarding the influence of various dimensions of TQM on the satisfaction of students in engineering institutions. Also, the latest trends, like digital quality management, the use of data in decision-making, or the involvement of universities in partnerships with industries have not been sufficiently investigated on the local level. This gap establishes the necessity to conduct research on the relationship between TQM practices and student satisfaction as well as institutional effectiveness in the Pakistani higher education. The given considerations are the foundation of the current research.

Research Gaps

Despite the fact that there is an emerging international literature emphasizing the importance of Total Quality Management (TQM) in terms of improving institutional performance and service provision, there is a scarcity of empirical studies on the role of individual dimensions of TQM in influencing satisfaction among students in Pakistan based engineering universities. A lot of current research has been done in industrial or general education contexts, and has frequently overlooked the changing demands of higher education systems that are influenced by Education 4.0, the digital transformation, and the sustainability challenges.

This paper addresses this gap by exploring the impact of certain TQM practices in bringing about student satisfaction and offer a framework of sustainable quality management that is realistic to the Pakistani higher learning institutions

(HEIs). As a result of the recent changes to the higher education quality assurance policies in the context of the Pakistan Precepts, Standards, and Guidelines PSG-2023 [9] there is a new focus on data-based decision-making, sustainability, and digitalization. In this context, the classical dimensions of TQM may be redefined in terms of the basic components of Digital Quality Management System (DQMS) [10] which meets the Education 4.0 priorities and helps to develop the institution in the long run. This can help universities to shift towards the simpler quality practices to innovative evidence-based systems that promote sustainability and growth.

Research Objectives

Based on the reviewed literature and the research gaps, this study aims to test the empirical nature of Total Quality Management (TQM) dimensions on student satisfaction in engineering universities in Pakistan. Specific objectives are to:

1. Assess the contribution of TQM practices in student satisfaction in engineering higher education.
2. Trace the TQM areas such as Leadership, Strategic Planning, Process Approach, Continuous Improvement, Factual Evidence, and External Partnerships, which are the major determiners of the quality of education.
3. Test the connections between these TQM dimensions and the general student satisfaction.
4. Determine the effectiveness of TQM implementation in eliminating quality gaps in institutions of higher learning.
5. Make any practical suggestions on how the institutional quality management systems and decision-making models can improve under Education 4.0.

Significance of the Study:

This paper provides valuable information on the realization of TQM practices in higher education to enhance the satisfaction of the students and overall performance of the institution. Higher education institutions can improve the quality of the academic services offered by recognizing and meeting the needs of students and by inculcating the culture of continuous improvement. This, therefore, fosters improved learning results, employability and better professional readiness of the engineering graduates.

The findings of this research paper present a realistic guideline that any institution of higher learning can employ to ensure that the strategic endeavors are aligned to the principles of TQM and that student satisfaction is not a single aspect in institutional performance. This approach will help the HEIs to enhance the quality assurance systems, and encourage long-term teaching and learning excellence and student engagement.

METHODOLOGY:

This paper focus on how Total Quality Management (TQM) practices have influenced student satisfaction in the Universities of Engineering. The study design assumes the use of six TQM dimensions as independent variables:

- **Leadership (X1):** The role of institutional leaders in fostering a culture of quality and continuous improvement.

- **Strategic Planning (X2):** The alignment of institutional goals with long-term quality objectives.
- **Process Approach (X3):** The optimization of academic and administrative workflows for efficiency.
- **Continuous Improvement (X4):** Ongoing enhancements in policies, teaching methods, and services.
- **Factual Evidence (X5):** Data-driven decision-making for quality assurance.
- **External Partnerships (X6):** Collaborations with external stakeholders, such as vendors and internship providers.

Student Satisfaction (Y) is the dependent variable that is used to measure the overall experience of the students in the course of education.

Figure 1: Conceptual Model of TQM Dimensions and Student Satisfaction Source: Author(s)' own work

Based on the framework of Figure 1, the research investigates the correlation of TQM factors as the independent variables and student satisfaction as the dependent factors. The framework demonstrates the ways in which six dimensions of Total Quality Management (Leadership, Strategic Planning, Process Approach, Continuous Improvement, Factual Evidence, and External Partnerships) are used in combination to increase student satisfaction. These TQM aspects also help to establish Digital and Sustainable Quality Management Framework (DQMS/SQMF) based on Education 4.0 and PSG-2023 guidelines of HEC.

Research Hypotheses

The study tests the following hypotheses:

- **H1:** Effective leadership practices positively impact student satisfaction.
- **H2:** Strategic planning initiatives enhance student satisfaction.
- **H3:** Efficient academic and administrative processes improve student satisfaction.
- **H4:** Continuous improvement efforts positively affect student satisfaction.
- **H5:** Data-driven decision-making strengthens student satisfaction.
- **H6:** External partnerships contribute to student satisfaction.

Research Design

The paper uses descriptive survey design, which assists in setting the existing condition of TQM implementation and its correlation to student satisfaction.

Descriptive research can be good in offering statistical information that can be used by policymakers.

Target Population and Sampling

The study sample includes students of ten Pakistani engineering universities, chosen due to their similarity in operations, the form of governance, and the academic conditions.

The participants were chosen through a stratified random sampling method where they were represented at the various levels of studies:

- Undergraduate Students
- Postgraduate Students (Master & PhD)

Despite the fact that Cochran formula showed that the minimum sample size required is 384 students at 95 percent confidence level, 500 responses were obtained to increase data reliability and generalizability. The reason behind this oversampling method was to cover cases of non-responses or failure to fill questionnaires as well, which is a sufficient statistical power of regression and correlation analyses. The 500 questionnaires that were distributed were only 308 that remained after data cleaning as valid responses. Cases that had missing values more than 30 percent, duplication, and straight-lined answers were eliminated. To guarantee the reliability, correlation, and regression analyses, the final sample size (N = 308) was determined to be accurate and of quality data. Before analysis, the data were tested in terms of normality, linearity, and homoscedasticity. The standardized residual values were between ± 3, Durbin Watson was 2.16, and all VIF were lower than 5. These tests proved that the assumptions of parametric regression were met.

Data Collection Procedure

A structured questionnaire consisting of two sections was used in primary data collection.

1. Demographics: Gender, age, school of study.
2. TQM Dimensions: The questionnaire questions evaluate the TQM factors on a 5-point Likert scale (1= Strongly Disagree, 5 = Strongly Agree).

Data Analysis

The data was analyzed using both quantitative and qualitative methods.

- Descriptive (frequencies, percentages) were used to describe demographic.
- Cronbach's Alpha Reliability Testing was done to establish internal consistency of questionnaire items.
- Correlation and Regression Analysis was used to analyze relationships between TQM factors and student satisfaction.
- ANOVA was used to establish the statistical significance of the independent variables.
- Variance Inflation Factor (VIF) verified the presence of multi-collinearity between predictors.

Though in this paper, the traditional measurement of TQM dimensions was based on surveys, each of the constructions can be operationalized using digital KPIs in a DQMS setting. For instance, Leadership may be tracked through dashboard

review frequency, Continuous Improvement through automated PDCA cycles, and Strategic Planning through goal-achievement analytics. The sustainability, transparency and real-time evidence-based decision making is guaranteed by such digital mapping.

Validity and Reliability

Validity: A pre-test was carried out on 10 students in the University of Wah to determine the clarity of the questionnaires and the accuracy of the responses obtained. Changes were done according to feedback.

Reliability: The Cronbachs Alpha coefficient ($\alpha = 0.89$) was used to test internal consistency, which indicates that there is a high level of reliability.

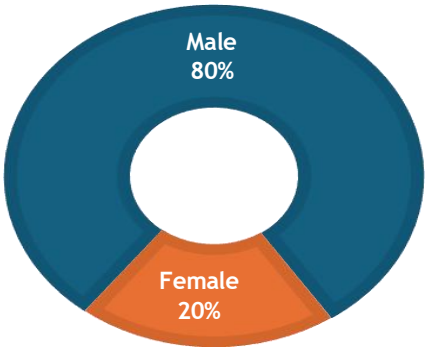
Ethical Considerations

Informed Consent: The respondents were briefed about the fact that it was an academic exercise and voluntary.

Confidentiality: Strict anonymity standards were maintained, ensuring data privacy.

RESULT:

Figure 2: Gender Distribution of Respondents



Source: Author(s)' own work

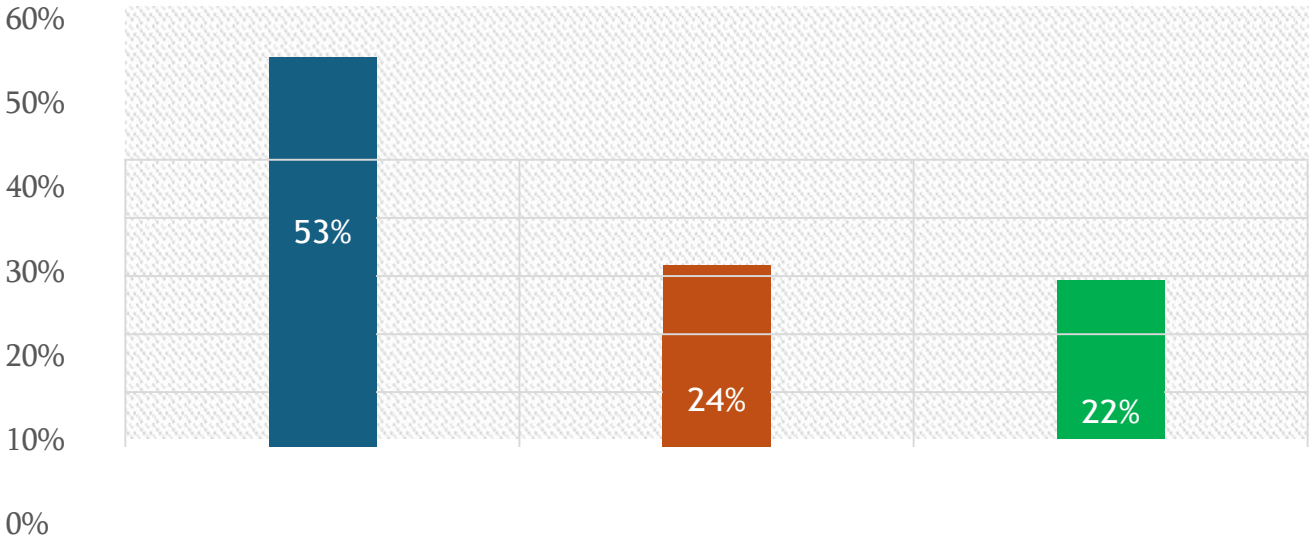
It can be observed in Figure 2 that 80 percent of the respondents were male and 20 percent were female, which was indicative of the current gender imbalance in the engineering education sector in Pakistan. This is in line with the national trends in STEM fields whereby there has been low participation among females. The fact that male respondents are dominating implies that the perception of Total Quality Management (TQM) practices and student satisfaction in the research falls more on the student experience of the male gender. This result highlights the necessity of adoption of gender inclusive policies, special scholarships and outreach programmes to motivate more women to join engineering universities.

This finding underscores the need for gender-inclusive policies, targeted scholarships, and outreach programs to encourage greater female enrollment in engineering universities.

Figure 3: Age Group Distribution of Respondents

As it can be seen in Figure 3 the greatest number of participants (53%) fall within the 22-25 age bracket. 24% aged 26-28 years and 22% above 29 years. This

age distribution implies that the majority of them is between 22-25.

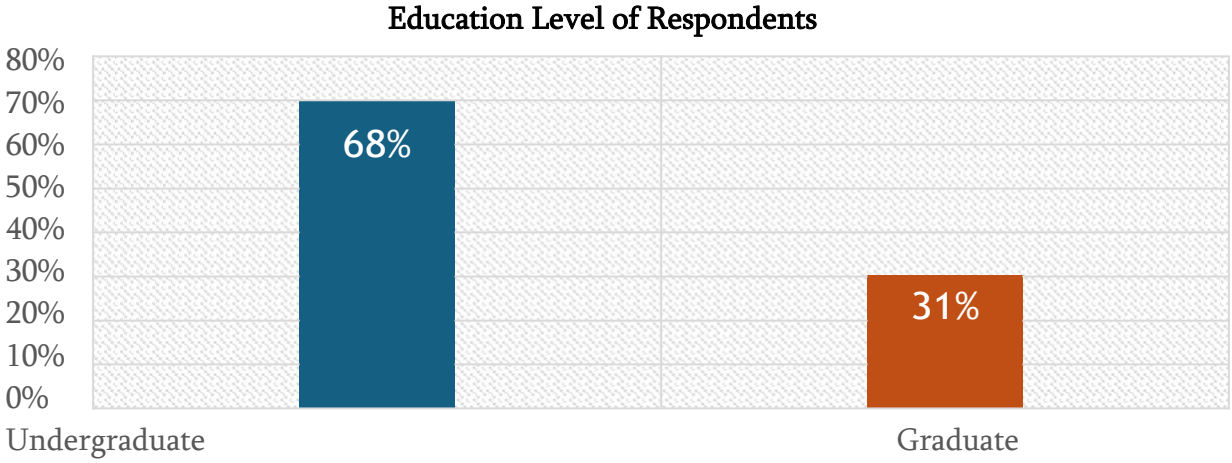


Age group distribution of Respondents

Source: Author(s)' own work

The respondents are undergraduate students who are about to graduate, and the fact that there were older respondents suggests that post graduate students who have undertaken advanced degrees were included. The age diversity increases the validity of the findings as it will represent the views of different academic levels. This equal representation assists in assessing the perceived institutional quality management practices among the early-stage and mature learners.

Figure 4: Educational Level of Respondents



Source: Author(s)' own work

According to figure 4, 68% of the respondents are studying undergraduate programs, as compared to 31% graduate students. This validates that the research sample is undergraduate based but the graduate respondents are also very helpful in offering valuable information on such quality aspects of post-graduate experiences as research supervision and academic support. This two-level representation enhances

the external validity of the results, providing a more profound insight into the way TQM dimensions affect student satisfaction in various degrees of academic levels.

Table 1: Demographics Profile of Respondents:

Variables	Categories	Frequency	Percentage
Gender	Male	250	81%
	Female	58	19%
	22-25	166	54%
	26-28	74	24%
	Above 29	68	22%
Program	Undergraduate	210	68%
	Graduate	98	32%

Source: Author(s)' own work

The demographic information of the respondents as shown in Table 1 is; 250 males, 58 females which reflects the gender trends in engineering programs, 166 of the respondents are aged between 22 and 25, so the majority of the respondents are still in early university years, and 210 are the undergraduate and 98 are the graduates.

Reliability Testing:

Table 2: Reliability of TQM Dimensions (Cronbach's Alpha)

Study Variables	Number of Items	Cronbach's Alpha
Leadership (X1)	2	0.82
Strategic Planning (X2)	2	0.86
Process Approach (X3)	2	0.83
Factual Evidence (X4)	2	0.80
Continuous Improvement (X5)	3	0.84
External Partnership (X6)	2	0.81

Source: Author(s)' own work

Based on Table 2 Cronbach Alpha test was done to determine the reliability of the instrument of the study. Nunnally and Bernstein examined the good measurement of internal consistency of 0.80 or more. The Alpha of all variables was above 0.80, which is a strong internal consistency and reliability of measurement.

Correlation Analysis

Table 3: Correlation Matrix of TQM Dimensions and Student Satisfaction

	X1	X2	X3	X4	X5	X6
Leadership (X1)	1					
Strategic Planning (X2)	.728**	1				
Process approach (X3)	.718**	.694**	1			
Continuous Improvement (X4)	.705**	.752**	.765**	1		
Factual Evidence (X5)	.694**	.615**	.818**	.683**	1	
External partnership (X6)	.421**	.530**	.501**	.565**	.434**	1
Overall Student Satisfaction (Y)	.850**	.866**	.891**	.900**	.833**	.645**

- Dark Green/Light Green → Strong Positive Correlation
- Lighter Colors → Moderate Correlation
- Red or Weak Colors → Low or No Correlation **Source:** Author(s)' own work

Table 3 shows that All TQM dimensions were significant with positive correlations to student satisfaction ($r > 0.80$). Continuous Improvement and Student Satisfaction had the highest correlation ($r = 0.90$) indicating that students believed in continuous improvement of teaching and institutional services greatly.

Analysis of Variance:

Table 4: ANOVA Results for Regression Model

Model	Sum of Squares	Degrees of freedom	Mean Square	F	Sig.
Regression	53327.131		8887.855	4230.292	.000[b]
Residual	632.402	01	2.101	-	-
Total	53959.532	07	-	-	-

Source: Author(s)' own work

Table 4 indicates the ANOVA results ($F = 4230.29$, $p < 0.001$) demonstrate that the total regression model is statistically significant. This supports the fact that the aggregate predictors of TQM, Leadership, Strategic Planning, Process Approach, Continuous Improvement, Factual Evidence as well as External Partnerships are reliable predictors of student satisfaction in engineering universities. That is, the difference in the satisfaction of the students between the two groups is not due to mere chance, but rather on the combined effect of the two TQM dimensions.

Regression Analysis

Table 5: Regression Coefficients Predicting Student Satisfaction

Predictor	β (Standardized)	t	P	95% CI (Lower, Upper)	VIF
External Partnership	.127	16.39	.000	[.935, 1.190]	1.55
Process Approach	.199	15.51	.000	[1.153, 1.488]	4.23
Leadership	.194	18.44	.000	[1.214, 1.504]	2.85
Continuous Improvement	.256	22.17	.000	[1.142, 1.365]	3.42
Factual Evidence	.169	14.94	.000	[0.869, 1.132]	3.28
Strategic Planning	.223	20.77	.000	[1.172, 1.418]	2.96

Source: Author(s)' own work

The regression model explained **98.8% of the variance** in student satisfaction ($R = 0.994$, $R^2 = 0.988$, Adjusted $R^2 = 0.988$).

Regression Model Specification

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon$ Where:

(Y) = Student Satisfaction (dependent variable) (X_1) = Leadership

(X_2) = Strategic Planning (X_3) = Process Approach

(X_4) = Continuous Improvement (X_5) = Factual Evidence

(X_6) = External Partnerships (β_0) = Intercept term

(ε) = Random error term

This regression model measures the relative contribution of each of the TQM dimensions in predicting the variation in student satisfaction.

The regression statement showed that the six dimensions of Total Quality Management (TQM) had significant importance on student satisfaction with different degrees of strength. Of these, the strongest predictor was Continuous Improvement ($\beta = 0.25$, $p < 0.001$), meaning that students attach a great value to the institution that constantly enhances teaching and learning practices, administrative procedures, and support services. Strategic Planning ($\beta = 0.22$, $p < 0.001$) was the second-most influential factor, which depicted the significance of institutional goals and long-term vision in forming positive perceptions in students. Leadership ($\beta = 0.19$, $p < 0.001$) and Process Approach ($\beta = 0.19$, $p < 0.001$) show the importance of managerial dedication and smooth workflows in service excellence. The role of data-informed decision-making in quality assurance was supported by Factual Evidence ($\beta = 0.16$, $p < 0.001$), whereas External Partnerships ($\beta = 0.12$, $p < 0.001$) had the least effect, though statistically significant. This implies that although the practice of cooperation with industry and external stakeholders is still regarded as useful, it is still not completely embedded in the quality management practice of the engineering universities in Pakistan. In general, these findings suggest that the institutional attempts targeted at the continuous improvement, strategic planning,

and leadership involvement have the greatest likelihood to bring significant advancements to the student satisfaction rates and perceived educational quality. These quantitative trends give a data base upon which DQMS alignment is made, and Continuous Improvement and Strategic planning become priorities of digital transformation.

Multicollinearity Assessment

The values of Variance Inflation Factor (VIF) of the independent variables are between 1.54 and 4.23, which are much lower than the conservative limit of 5.0 that is recommended in regression diagnostics. This supports the fact that there was no issue of multicollinearity and each TQM dimension made its own individual contribution and influence on the variations in student satisfaction.

Model Diagnostics and Assumption Testing

Table 6: Assumption Testing

Assumption	Diagnostic Test	Result	Interpretation
ormality of Residuals	ov–Smirnov (p > 0.05)	ally distributed residuals	Assumption met
pendence of Errors	Durbin–Watson = 2.16	ıtocorrelation detected	Assumption met
oscedasticity	Scatterplot of residuals	tant variance observed	Assumption met
ırity	Residual vs. predicted value plot	ır relationship confirmed	Assumption met
icollinearity	VIF < 5	ılticollinearity	Assumption met

Source: Author(s)' own work

Regression assumptions were verified and met. Linearity and homoscedasticity were also met since the residuals were approximately normally distributed, with the standardized residuals falling within the range of ±3, and no obvious patterns in scatter plots. Durbin Watson value (2.16) showed that the residual values were independent. Multicollinearity diagnostics confirmed VIF < 5 and Tolerance > 0.2, ensuring the stability of parameter estimates.

Study Limitations

The research was also limited to Pakistani engineering universities and this could compromise the extrapolation of results in other fields of study. Moreover, self-reported Likert-scale data might result in the bias of response as a participant might not have the complete perception of the objective institutional performance. In the future, the research might be extended to other fields and mix methodological techniques might be utilized in proving these results. [11]

Research Discussion:

The findings of this research confirm the main importance of Total Quality Management (TQM) practices related to the improvement of student satisfaction in the context of higher education, especially in the engineering institutions. Such observations are in line with other current studies in the international arena that have indicated that well-established TQM systems contribute to the enhancement of the quality of academics, institutional accountability and service delivery [12]. As an example, [13] emphasized that the benefits of TQM implementation in terms of teaching and research quality in Nigerian universities improved significantly, and [14] found that the implementation of the TQM in conjunction with sustainability and social responsibility led to the increased levels of stakeholder satisfaction.

As a part of the current research, Continuous Improvement proved to be the strongest predictor of student satisfaction. This implies that universities that focus on curriculum changes, development and effective performance review systems are in a better position to address the changing needs of students. Strategic Planning and Leadership is also an important factor that highlights the value of visionary management and participatory institutions cultures. Such results correlate with the efforts of [15], who stated that the leaders commitment and evidence-based planning are the most important enablers of quality improvement in higher education.

Conversely, External Partnerships had the least relationship with student satisfaction. This can be the case of low exposure to the industry or insufficient internship or lack of formal collaboration plans in most of the engineering universities in Pakistan. Such partnerships in developing situations may be informal or randomly established initiatives; they do not form part of an institutionalized strategy. More effective solutions by extending the academic programs and enhancing graduate employability can be achieved through building up stronger relationships with industry partners, alumni networks and professional organizations.

Policy and Administrative Implications

Based on the findings, the leaders of higher education and policymakers must take into account the following strategies:

- Make curriculum development and review process align with changing needs of the industry and technology. [13]
- Offer frequent professional development among faculty with an emphasis on TQM, outcome-based education, and quality assurance.
- Institutionalize the use of data-based decision-making tools by creating digital dashboards and real-time quality monitoring tools.
- Establish sustainable industry alliances models that enhance internships, applied research, and innovation collaborations.

TQM in the Era of Education 4.0:

By placing TQM in the larger context of the transition to Education 4.0, this paper shows that the process of quality sustainability development needs to involve the combination of human and technical aspects. Beyond the compliance-driven quality assurance, institutions of higher learning need to follow proactive, data-driven, and student-focused initiatives that keep promoting the excellence of the institution. This alignment does not only make the student experience a better one,

but also guarantees institutional sustainability in a fast changing educational landscape.

Strategic Implications

The empirical findings indicate priority areas of institutional action. In order to apply these findings into policy and operational actions, we provide a brief SWOT analysis and a step-by-step practical roadmap that will be specific to the engineering universities in Pakistan.

SWOT Analysis of TQM Implementation

The SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is used to summarise the results of the study and situational issues in the implementation of TQM in the engineering HEIs. The analysis sums up the institutional capabilities and exterior limitations and points out strategic entry points to correct quality.

Table 7. SWOT Analysis of TQM Implementation in Engineering Universities (Pakistan)

Strengths	Weaknesses
Strong leadership commitment in several institutions (evidenced by strategic plans and QA units).	Limited digital quality-assurance infrastructure (few institutions use integrated DQMS).
h student engagement in feedback mechanisms (regular surveys).	ow female representation and gender imbalance in engineering programs.
shed quality assurance cells and accreditation awareness.	eak industry linkages and ad-hoc internship placement systems.
Opportunities	**Threats**
Adoption of Education 4.0 tools (learning analytics, dashboards, AI) to strengthen evidence-based QA.	Resource constraints in public HEIs (budget cuts, limited investment in QA tech).
Potential to establish structured industry partnerships and applied research centers.	Policy instability and administrative turnover that can disrupt long-term QA plans.
laborations and accreditation incentives.	Resistance to change among some academic staff; cultural barriers to TQM adoption.

Source: Author(s)' own work

Interpretation.

Table 7 SWOT analysis points out that institutional leadership and QA structure offers a basis to the realisation of the benefits of TQM but technical and relational

gaps particularly in digital QA systems and industry connection inhibit full attainment of the benefits of TQM. The prudent application of Education 4.0 technologies and consistent political support may help to turn some of the weaknesses and threats into the opportunities of sustainable improvement of quality.

Table 8: Mapping TQM Dimensions to DQMS-Aligned Key Performance Indicators (KPIs)

TQM Dimension	Traditional Indicator	Digital / DQMS-Aligned KPI
Leadership	Vision communication	% of QA meetings utilizing dashboard analytics
Strategic Planning	Annual QA plan existence	Goal attainment rate via KPI monitoring
Process Approach	Documented SOPs	% of academic processes digitized
Continuous Improvement	PDCA cycle reports	Number of PDCA cycles completed through DQMS annually
Factual Evidence	Manual reports	Data quality index generated from DQMS
External Partnerships	Industry MoUs	% of partnerships contributing to SDG-oriented learning outcomes

Source: Author(s)' own work

Table 8 shows how the traditional, document based TQM indicators will be replaced by contemporary, digitally compatible measures within a Digital Quality Management System (DQMS). Although the traditional methods are usually based on the usage of fixed or manual reporting, DQMS allows real-time performance monitoring via the digital dashboard, learning analytics, and institutional KPI trackers. [16] The KPIs that are aligned to the DQMS concentrate on the measurable indicators such as the process digitization rates, data quality levels, and the percent of goals that are achieved all of which enhance institutional transparency, enable fast decision-making, and maintain the process of constant improvement. These KPIs are completely consistent with the PSG-2023 framework of the HEC and contribute to higher education institutions shifting to the wider goals of the Education 4.0 (digitally enabled learning, sustainability, and adaptive quality assurance).

Practical Roadmap for Implementing TQM in Higher Education

The roadmap below translates the empirical findings of the study into the action plan of higher education institutions. It focuses on both short- term and long-term sustainability, which forms a foundation for the development of a Sustainable Quality Management Framework (SQMF).

Table 9. Practical Roadmap for TQM Implementation (Phased Actions)

Phase	Timeline (Suggested)	Key Actions	Responsible Parties	Expected Outcome
Phase1: Initiation	0–6 months	Gain senior leadership commitment; form cross-functional QA steering committee; conduct QA audit.	Vice Chancellor, Deans, QEC	Institutional buy- in and clear strategic mandate for TQM adoption.
Phase2: Standardization	6–12 months	Define quality indicators and KPIs; standardize data collection; initiate faculty QA training.	QEC, Department Heads, HR	Establishment of common QA metrics and initial staff capacity-building.
Phase 3: Digital Enablement	12–24 months	Develop or deploy a digital QA dashboard; integrate student feedback portals and analytics tools.	IT Division, QEC, Registrar	Real-time monitoring and data-informed decision-making.
Phase4: External Integration	18–36 months	Develop industry partnerships; co-design internships; expand applied research collaborations.	Careers Office, Research Office, Industry Partners	Enhanced employability, skill relevance, and collaborative learning environments.
Phase 5: Continuous Improvement	Ongoing	Institutionalize PDCA (Plan–Do– Check–Act) cycles; conduct external reviews and	QEC, Academic Units	Self-sustaining culture of quality and transparency supported by periodic evaluation.

		prepare for accreditation.		

Source: Author(s)' own work

Phases 3 and 5 of the roadmaps correspond directly with DQMS integration in PSG-2023, which allows a transition to predictive, data-driven quality cycles in line with sustainability and institutional excellence. Timelines are estimated and must be adjusted to the capacity of the institutions. Significant attention to leadership participation and standardization develops the governance and data base of a successful digital enablement and industry integration. The iterative improvement cycles and evidence-based policymaking will be enabled by constant monitoring using DQMS dashboards.

Practical Roadmap for Implementation

According to the results of the study, the action roadmap proposed to higher learning institutions and policymakers is as follows:

- Institutionalizing Continuous Improvement
- Strengthen Strategic Planning
- Enhance Leadership Commitment
- Integrate Data Analytics in Decision-Making
- Promote University–Industry Collaboration
- Develop Faculty Competence in Quality Management **[17] Theoretical and Policy Implications**

The results of the study are highly aligned with the PSG-2023 principle of evidence-based continuous improvement. The hegemony of Continuous Improvement and Strategic Planning proves that information-based feedback and online planning dashboards are the keys to institutional resilience and sustainability. The research results add to the theoretical content of TQM as it illustrates the relationship between the main dimensions of TQM and the enhancement of its quality of service and experience of students in the higher education. The research provides a piece of evidence to the policymakers that TQM could be used as the basis of coming up with a Sustainable Quality Management Framework (SQMF) specific to the higher education sector in Pakistan. Also, by harmonizing these practices with a DQMS, universities would be able to track sustainability KPIs, including the relevance of the curriculum, carbon-neutral operations, and gender equity in STEM programs, turning quality assurance into a sustained learning process.

The results are useful to university administrators and policymakers. Through leadership, digital quality dashboards must be institutionalized so that they constantly monitor the key performance indicators concerning student satisfaction, curriculum relevance, and faculty development. Data-driven decision models should be embraced by Strategic Planning units to align the academic objectives with the results of sustainability. A high level of transparency and accountability can be

promoted with the help of Continuous Improvement mechanisms with the support of regular feedback analytics. By embedding the practices into a Digital Quality Management System (DQMS), it will be possible to secure uniform monitoring, policy changes based on evidence, and the overall institutional sustainability in the long term.

Future Research Directions

The future research can be focused to the implementation of the digital TQM tools, i.e., AI, learning analytics, and monitoring with dashboards to assess the effectiveness of real-time quality tracking in the institutions enhancement. [18] Some comparative and qualitative research is also required to understand the influence of institutional situations and internal obstacles in determining the success of TQM implementation. Moreover, longitudinal studies based on DQMS-created data sets will be able to offer further understanding of how the constant improvement initiatives will result in sustained results in higher education over time.

Final Remark

The findings highlight that Continuous Improvement, Strategic Planning, and Leadership are key drivers of institutional change. These dimensions can be viewed as a foundation of a Digital and Sustainable Quality Management System (DQMS/SQMF) in higher education, interpreted through the prism of the new PSG-2023 framework operations. By embedding sustainability indicators, and reinforcing leadership accountability, universities can achieve evidence-based, future-ready excellence aligned with Education 4.0 and SDG 4.

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Conflict of Interest

The author(s) affirm that this study has no financial, professional, or personal conflicts of interest that may affect the research findings or inferences discussed in this research study.

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