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Service Quality in Higher Education: A Bibliometric Visualization and Prediction of Research Productivity and Thematic Evolution Using Biblioshiny and BERTopic

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Abstract

This study maps, models, and forecasts the evolution of service quality research in higher education using 951 articles indexed in Scopus and Web of Science (1993–2024). Biblioshiny was employed to analyze research productivity, collaboration patterns, influential authors, and keyword evolution, while BERTopic and Dynamic Topic Modeling (DTM) identified and tracked thematic developments over time. Topic interrelationships were examined through chord diagrams, and Prophet forecasting was used to predict topic prevalence through 2028. The findings reveal Malaysia as the most productive country and the UK and USA as leading collaborators, with Parvez Sultan emerging as the most prolific author. Keyword trends indicate a shift from quality assurance and student satisfaction toward digital learning, e-learning, and technology-enabled education. BERTopic identified 20 latent themes, with *service_quality_customer* as the dominant topic and *learn_system_learning_student* as the fastest-growing theme. Forecasts suggest continued expansion of student-centered, learning-focused, and technology-driven research, with the field expected to reach its publication peak around 2042. The study provides practical insights for higher education institutions and policymakers by highlighting the growing importance of student satisfaction, teaching quality, and digital learning infrastructure. By integrating bibliometric analysis, topic modeling, thematic evolution, and forecasting, this study offers a comprehensive and predictive understanding of service quality research in higher education.

Keywords: Service quality; Higher education; Bibliometric analysis; BERTopic; Dynamic Topic Modeling; Prophet forecasting.

1. Introduction

Quality education is a foundation of social development and economic growth, as it contributes to the formation of human capital and social development (Alexander, 1976). In democratic states, education is regarded as one of the basic rights because it ensures citizens' engagement in social affairs and democracy (Goodlad, 1997). Education is crucial to the development of ethics, health, politics, opportunities, empowerment, and well-informed decision-making (Carnoy, 2005; Domínguez et al., 2017). On the contrary, inadequate education results in poverty and social inequity, and thus, insufficient socio-economic development (Sittisom, 2020). Therefore, quality

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education is indispensable as it involves student satisfaction, creativity, and pedagogy (Lyubchenko, 2023). Despite its significance, quality education continues to face challenges such as gender inequality and resource disparities worldwide (Education, 2023).

Nevertheless, maintaining quality within higher education institutions proves to be quite difficult on account of infrastructural weaknesses, economic disparities, problems with governance, and out-of-date curriculum (Bates, 2015; Alvior, 2014; Marginson, 2016; Lakshmi & Ugandhar, 2023; Bwalya, 2023; Pramjeeth et al., 2023). Further, implementing quality assurance programs poses significant problems related to the effectiveness of applied models and insufficient participation of stakeholders (Pushpakumara et al., 2023). Moreover, the emergence of online learning and private education facilities, complicates the process of measuring educational quality (Harvey & Williams, 2010).

Service quality assessment within the realm of higher education has been an area of significant academic interest for the past four decades. Several service quality measurement tools such as SERVQUAL, SERVPERF, HEdPERF, EduQUAL, UNIQUAL, and HEISQUAL have been developed to assess students' perceptions, expectations, satisfaction, and performance (Abdullah, 2006; Abbas, 2020; Bartolo & Tınmaz, 2024; Sann et al., 2023; Esseh et al., 2024). Furthermore, systematic reviews show that the quality of services continues to be one of the most crucial factors that determine satisfaction, loyalty, reputation, and efficacy of education institutions (Sultan & Wong, 2010; Camilleri, 2021; Toscano-Hernández et al., 2024).

With the fast expansion of the literature base, bibliometric analysis has become a useful method to synthesize vast volume of literature, discover intellectual structures, find prominent authors, institutions, and countries as well as identify new themes that emerge (Brika et al., 2021; Ghaith et al., 2023). The existing bibliometric literature on higher education quality research has pointed to the dominance of models for measuring service quality, the increased relevance of digital transformation, students' satisfaction, stakeholders' involvement, and quality management in higher education (Brika et al., 2021). The above analysis has also shown that research efforts concentrate in only some countries and rely heavily on the use of Scopus/Web of Science databases while the focus continues to be on students alone and fails to consider faculty members, employers, and other interested parties (Kustiawan et al., 2024).

Notwithstanding all this, various bibliometric investigations have been conducted to establish a network of the study area concerned with higher education services. Nonetheless, majority of these studies depend on traditional measures such as performance indicators, citations, co-authorship, co-citation, and keyword co-occurrences (Donthu et al., 2021; Aria & Cuccurullo, 2017). While these measures successfully identify significant scholars, journal titles, and countries, as well as thematic groups, they are retrospective tools that do not shed any light on the future trends of the subject under consideration. Furthermore, traditional keyword-based analysis is limited by the term used by the researcher to describe the subject matter (Moro et al., 2023).

Furthermore, existing bibliometric investigations have seldom integrated advanced topic modeling techniques such as BERTopic, which combines transformer-based embeddings with clustering algorithms to uncover nuanced and evolving thematic structures within large textual datasets (Grootendorst, 2022). Consequently, the dynamic evolution of service quality research themes and the emergence of future research fronts remain insufficiently explored.

A significant limitation also revolves around the field of predictive bibliometrics. Even though the growth pattern of publications has been discussed widely in literature, very little effort is exerted in making predictions about future scholarly productivity based on such trends, despite its potential value for researchers, policymakers, and higher education administrators seeking to anticipate emerging areas of inquiry (Bornmann & Mutz, 2015). As a

result, the literature lacks an integrated framework that simultaneously maps the intellectual structure of service quality research, predicts future publication productivity, and anticipates emerging thematic directions.

To address these gaps, the present study combines Biblioshiny-based bibliometric visualization with BERTopic-driven topic modeling to provide a comprehensive analysis of service quality research in higher education. Beyond descriptive mapping, the study advances the field by incorporating predictive analyses of both research productivity and thematic evolution, thereby offering a forward-looking perspective on the future trajectory of scholarship in this domain.

2. Review of Literature

Service Quality in higher Education

The increasing privatization and marketization of higher education have elevated the importance of service quality as a key determinant of student satisfaction, loyalty, and institutional competitiveness. The foundation of service quality research was established by Parasuraman et al. (1988), who defined service quality as customers' perceptions of service excellence and introduced the SERVQUAL model comprising reliability, assurance, tangibles, empathy, and responsiveness. Recognizing the unique nature of educational services, scholars subsequently developed higher education-specific frameworks. Cronin and Taylor (1992) proposed SERVPERF, a performance-based alternative to SERVQUAL, while Abdullah (2005) introduced HEdPERF, incorporating academic aspects, non-academic services, access, reputation, and program issues. Later models such as EDUSERV (Ramseook-Munhurrun et al., 2010), SQM-HEI (Senthilkumar & Arulraj, 2011), HiEdQUAL (Annamdevula & Bellamkonda, 2012), HEDQUAL (Icli & Anil, 2014), HiEduQual (Latif et al., 2019), and HEISQUAL (Abbas, 2020) expanded the dimensions of service quality to include teacher quality, administrative support, infrastructure, employability, leadership, knowledge services, and student development. Despite these advancements, no universal consensus has emerged regarding the most appropriate framework for measuring service quality in higher education (Hussain & Birol, 2011).

From a geographical perspective, studies across diverse contexts consistently demonstrate a strong relationship between service quality, student satisfaction, loyalty, and institutional performance. Research conducted in Portugal (Sultan & Wong, 2012), Somalia (Ali & Mohamed, 2014), India (Subrahmanyam & Raja Shekhar, 2014), Pakistan (Khan & Alam, 2017), China (Mastoi et al., 2019), Spain (de la Cruz Del Río-Rama et al., 2021), and Nigeria (Borishade et al., 2021) highlights the growing need for context-specific quality frameworks that capture local educational realities while maintaining global relevance. Collectively, the literature suggests a gradual evolution from traditional service-quality measurement toward more comprehensive approaches integrating student outcomes, institutional reputation, employability, and long-term loyalty. This evolution reflects the increasing complexity of higher education environments and underscores the need for multidimensional models capable of capturing both academic and non-academic aspects of service quality.

Bibliometric Analysis

Bibliometric analysis is a quantitative method used to evaluate and classify scientific literature, authors and institutions within a specific field (Merigó and Yang, 2017; Lazarides et al., 2023; Passas, 2024). It involves data collection from databases, cleaning, and applying various Bibliometric techniques to extract meaningful insights and trends (Merigó and Yang, 2017). Further, Bibliometric analysis plays a crucial role in understanding research dynamics and trends across various fields. It offers insights into research productivity, influence, and thematic evolution. By analyzing publication trends, authorship patterns, citation impact, keyword occurrences, and

geographical origins of research, Bibliometric analysis provides a comprehensive view of the scholarly landscape (Moreira and Vidor, 2024; Hassan and Duarte, 2024; Rahman et al., 2024; Simion et al., 2023; Biju et al., 2024). This approach is increasingly popular in medical literature, operations research, management science, and artificial intelligence studies, allowing for the identification of influential papers, authors and emerging trends (Lazarides et al., 2023; Passas, 2024; Nur'aeni and Zalsahra, 2024). By utilizing tools like VOSviewer, Bibliometrix, CiteSpace and pyBibX researchers can visualize and analyze the data to understand the evolution and impact of research in various disciplines (Nur'aeni and Zalsahra, 2024). However, Bibliometric analysis plays a crucial role in technological forecasting, aiding in decision-making processes by assessing uncertainties and exploring future research directions in various areas (Yoshida, 2010).

BERTopic Modeling

BERTopic represents an advanced technique in the field of topic modeling. It integrates cutting-edge developments in natural language processing, machine learning, and information retrieval methods to discover hidden themes in large bodies of text. This approach has been developed by Maarten Grootendorst and aims at overcoming several deficiencies inherent to conventional topic modeling methods, including their failure to consider the contextuality and semantic connection between words and documents, which are key drawbacks of bag-of-words algorithms like Latent Dirichlet Allocation (LDA). BERTopic relies on pre-trained transformers and creates contextualized document vectors, which allows it to extract semantically meaningful topics (Grootendorst, 2022).

The underlying theory behind BERTopic is based on four inter-related fields, namely, contextual language representations, manifold learning, density-based clustering, and term weighting theories. First, documents are converted into high-dimensional semantic vector spaces through the application of transformers such as BERT and Sentence-BERT. Unlike frequency-based approaches, transformers use the context in which a particular word is used in generating meaningful semantic relations between documents (Devlin et al., 2019; Reimers & Gurevych, 2019). Second, since document representations are generated using high-dimensional spaces, BERTopic makes use of the UMAP technique to convert document representations into lower dimensional representations while ensuring that their manifold structure remains intact. The theory behind UMAP is founded on manifold learning theory and focuses on the maintenance of the relative position of neighboring documents in the new dimensionally-reduced space (McInnes et al., 2018). Third, the reduced dimensional embedding is clustered using HDBSCAN, a density-based algorithm that can effectively group together different clusters irrespective of shape and size. Finally, a class-based TF-IDF process is used to extract relevant terms for each cluster to label them as topics (Grootendorst, 2022).

Mathematical Formulation of BERTopic

Let a corpus contain N documents: D = {d1, d2, d3…….,dN)

Each document is transformed into a dense embedding vector using a transformer model.

$$f_{embed} : d_i \rightarrow e_i \in \mathbb{R}^H$$

Where H is the hidden state dimensionality (typically H = 384 or 768).

$\boldsymbol{e_i}$ retains semantic word order, preserving the context of complex scientific terms

Step 2: Dimensionality Reduction Using UMAP

UMAP minimizes topological distortion by preserving local neighbourhood structure

The Similarity between points is estimated using:

$$p_{ij} = exp\left(-\frac{d(x_i,x_j)-\rho_i}{\sigma_i}\right)$$

Where:

$d(x_i, x_j) - \rho_i$ = Distance between documents

ρ_i = Local connecgtivity parameter

σ_i = Scaling factor

Step 3: Density-Based Clustering (HDBSCAN)

BERTopic identifies thematic clusters without forcing spherical restrictions, allowing the discovery of uneven research fields. Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN) uses mutual reachability distance to find core regions

Mutual Reachability Distance

For two low-dimensional document vectors y_i, y_{ij}:

$\boldsymbol{d_{mreach,k}(y_i, y_j)}$ = max $\{core_k\ (\boldsymbol{y_i}), core_k\ (\boldsymbol{y_j}), d(\boldsymbol{y_i}, \boldsymbol{y_j})\}$

$Core_k\ (\boldsymbol{y})$ is the distance from point y to its k-th nearest neighbor

Step 4: Topic Representation Using c-TF-IDF

After clustering, all documents within a cluster are combined into a single class document.

The term frequency is:

$TF_{t,c} = \frac{f_{t,c}}{\sum_{w\ \epsilon\ c} f_{w,c}}$, Where $f_{t,c}$ = Frequency of term **t** in cluster **c**

3. Research Methodology

Research Objective

The primary objective of this study is to systematically map, model, and forecast the thematic evolution of service quality research in higher education over a three-decade period (1993–2024) and project emerging trends to 2028. Specifically, the study aims to: (1) identify latent topic structures and their temporal trajectories using advanced natural language processing; (2) quantify the growth, decline, and inter-relationships of key service quality dimensions and (3) generate evidence-based forecasts to inform future research agendas and institutional quality strategies.

Research Design

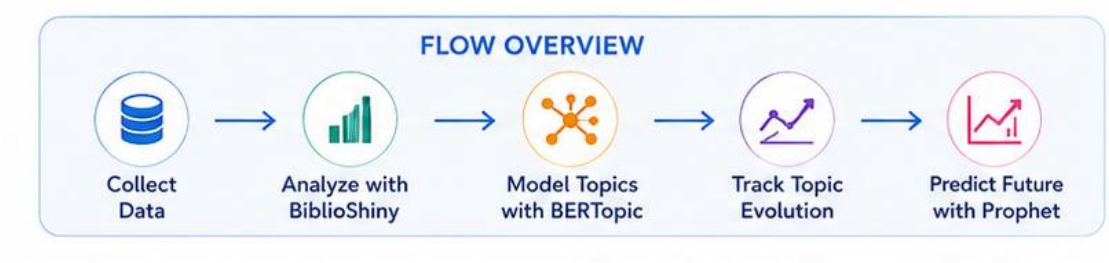

Figure 1. Research Work-flow

The study adopts a longitudinal, mixed-methods bibliometric and text-mining design, comprising five sequential stages (Figure 1):

Data collection – A systematic retrieval of peer-reviewed articles on service quality in higher education from indexed databases (e.g., Scopus, Web of Science) covering 1990–2020.

Descriptive bibliometric analysis – Using BibliShiny (R package) to perform initial bibliometric mapping (annual scientific production, source dynamics, author collaboration networks) and to obtain a cleaned corpus of titles, abstracts, and keywords.

Topic modeling – Applying BERTopic (a transformer-based topic modeling technique) to the pre-processed textual corpus. This step extracts latent thematic clusters and generates document-topic probability distributions.

Temporal topic tracking – Analysing the evolution of each BERTopic-derived topic over time by calculating annual prevalence (proportion of documents per topic per year) and identifying emerging, stable, and declining discourses.

Forecasting – Employing Prophet (a time-series forecasting model developed by Meta) on the historical annual topic prevalences (1990–2020) to predict future trends (2025–2030). Forecasts are then validated through back-testing and, where necessary, bounded (e.g., via logit transformation) to ensure non-negative prevalence values.

4. Result and Discussion

Bibliometric data Searching Strategy

The bibliometric analysis conducted using the query TITLE-ABS-KEY ("Service Quality" AND "Higher Education"), limited to articles (ar), conference papers (cp), and book chapters (ch) published in the English language, offers a focused and comprehensive view of scholarly contributions in the field of service quality within higher education. As shown in **Figure 2** the analysis spans from 1993 to 2024, covering over three decades of academic inquiry and knowledge generation. It includes 951 documents from 491 sources, showing a strong annual growth rate of 15.28%, indicating rising interest in service quality within higher education.

With 2,489 authors and an average of 2.95 co-authors per document, the field reflects high collaboration, including 21.14% international co-authorship. Only 123 documents are single-authored, underscoring the cooperative nature of this research domain.

Figure 2. Main Information Retrieved

The documents reference over 40,000 citations, with an average citation rate of 20.02%, highlighting strong academic impact. The average document age is 6.7 years, suggesting a mix of foundational and recent contributions. The presence of 1,987 unique keywords indicates thematic diversity, covering areas like student satisfaction, institutional performance, and quality assurance.

Analysis of productivity, Country and Sources

The examination of the trends in publications during 1993-2024 uncovers tremendous insights into the development of scholarly work contained in **Table 1.** The average number of publications over these years was 29.72 based on the standard deviation of 31.64, showcasing tremendous variation in the number of publications annually. The overall percentage of relative growth in publications across these years was 27.69%. It is significant that the highest productivity in 2023, where there was a total of 100 publications, accounting for 9.51% of the overall production for the year, and the lowest productivity in 1994, with no publications.

Table 1. Overall Scientific Productivity

Year	Frequency	Cumulative Total	Loge W	AGR	RGR
1993	1	1	0	0	0
1994	0	1	0	-1	0
1995	2	3	1.1	-	1.1
1996	5	8	2.08	1.5	0.98
1997	7	15	2.71	0.4	0.63
1998	4	19	2.94	-0.43	0.24
1999	3	22	3.09	-0.25	0.15
2000	2	24	3.18	-0.33	0.09
2001	3	27	3.3	0.5	0.12
2002	3	30	3.4	0	0.11
2003	5	35	3.56	0.67	0.15
2004	3	38	3.64	-0.4	0.08
2005	5	43	3.76	0.67	0.12
2006	14	57	4.04	1.8	0.28
2007	5	62	4.13	-0.64	0.08
2008	10	72	4.28	1	0.15
2009	25	97	4.57	1.5	0.3
2010	21	118	4.77	-0.16	0.2
2011	29	147	4.99	0.38	0.22
2012	34	181	5.2	0.17	0.21
2013	36	217	5.38	0.06	0.18
2014	45	262	5.57	0.25	0.19
2015	26	288	5.66	-0.42	0.09
2016	48	336	5.82	0.85	0.15
2017	42	378	5.93	-0.12	0.12
2018	65	443	6.09	0.55	0.16
2019	78	521	6.26	0.2	0.16
2020	79	600	6.4	0.01	0.14
2021	92	692	6.54	0.16	0.14
2022	77	769	6.65	-0.16	0.11
2023	100	869	6.77	0.3	0.12
2024	82	951	6.86	-0.18	0.09

The extracted Bibliometric information (**Figure 3**) of service quality in the context of higher education places strong emphasis on disparities in scientific research across different countries, indicative of their varied research production and cooperative outcomes. The country with the highest contribution is Malaysia with 7.89% of all 951 articles, hence cementing its leading position in research into service quality within the context of higher education. Coming next to Malaysia are Indonesia, India, and China, each holding 7.3%, 5.6%, and 4.8% respectively of the total number of articles, proving high-level research activity in the vital field. As, being at number three, India's contribution proves the increasing role of India in worldwide scientific output pertaining to educational service quality.

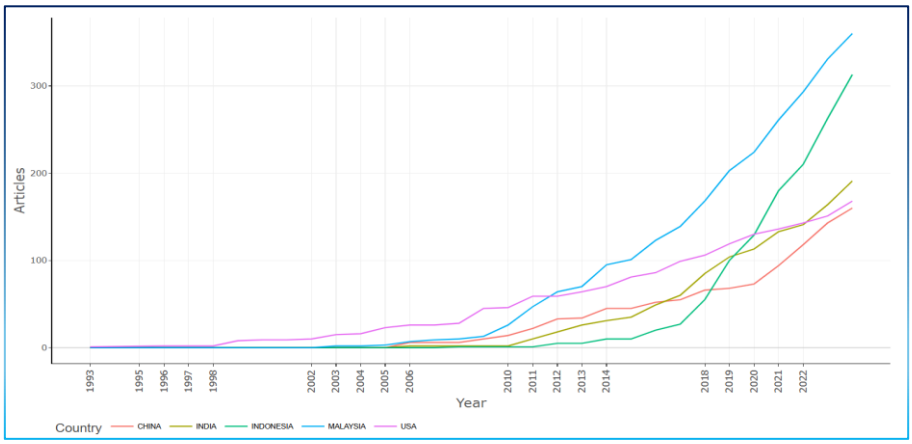

Figure 3. Country's Productivity

On the context of collaborative research (**Table 2** and **Figure 4)**, The USA and The United Kingdom, although writing fewer articles (2.94% and 3.05%, respectively), have established research environments that continue to inform discourse regarding service quality in higher education. Nations such as Saudi Arabia and Turkey also show significant contributions at 2.10% and 2.10%, respectively, with strong international collaboration rates as seen in their Multiple Country Publications (MCP) rates of 45% and 15%, respectively. At the lower side, nations such as Colombia, Egypt, the Philippines, and Romania each contribute weakly at 0.53%, suggesting a weak presence in this dataset on service quality research.

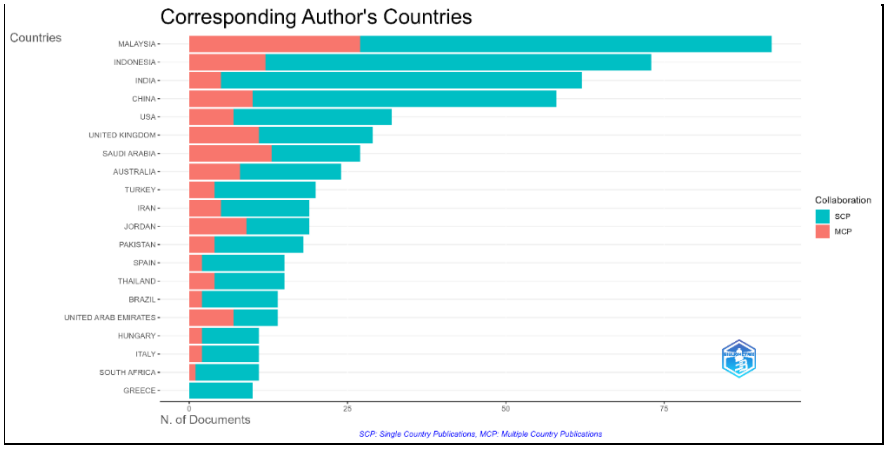

Figure 4. Collaborative Research Work

Malaysia shows a remarkable leadership role with a stunning 74.7% in Single Country Publications (SCP), marking a strong focus on in-country research projects aimed at enhancing service quality in higher educational institutions. Indonesia, being the second-largest contributor, produced 46 such articles identified as SCP with a Multiple Country Publication (MCP) rate of 14.5%, hence showing a regard for research done in its own country. India, in the third rank among contributions, made 50 such articles recognized as SCP and has 5.7% of MCP, revealing an avid participation in international collaborations; there is, however, much needing to be done to increase collaborative work in this arena.

United Kingdom, despite contributing fewer articles (29), shows a robust global collaborative network, which is defined by an MCP of 41.4%. Similarly, UAE, having 45% of MCP, follows Saudi Arabia's higher international collaborative levels. These measures of MCP underscore their international integration despite much lower article productivity. On the contrary, Ghana and Portugal show negligible contributions, having article percentages of as low as 0.5%, which speaks about reduced research activity. The spread of SCP and MCP percentages of countries indicates their different methodologies, offsetting in-country activity by international collaborations to increase scientific productivity. Conversely, Saudi Arabia and UAE focus much more upon international collaborations to increase scientific visibility as seen by higher percentages of MCP.

Table 2. Productivity and Collaborative Work

Country	Articles	Articles %	SCP	MCP	MCP %
MALAYSIA	75	7.9	56	19	25.3
INDONESIA	69	7.3	59	10	14.5
INDIA	53	5.6	50	3	5.7
CHINA	46	4.8	38	8	17.4
UNITED KINGDOM	29	3	17	12	41.4
USA	28	2.9	22	6	21.4
AUSTRALIA	21	2.2	15	6	28.6
SAUDI ARABIA	20	2.1	11	9	45
TURKEY	20	2.1	17	3	15
JORDAN	18	1.9	11	7	38.9
IRAN	16	1.7	11	5	31.3
PAKISTAN	16	1.7	12	4	25
BRAZIL	13	1.4	11	2	15.4
SPAIN	13	1.4	12	1	7.7
THAILAND	12	1.3	8	4	33.3
UAE	11	1.2	6	5	45.5
ITALY	9	0.9	7	2	22.2
GREECE	8	0.8	8	0	0
SOUTH AFRICA	8	0.8	7	1	12.5
HUNGARY	7	0.7	7	0	0
PORTUGAL	7	0.7	6	1	14.3
GHANA	6	0.6	5	1	16.7
KOREA	6	0.6	4	2	33.3
COLOMBIA	5	0.5	5	0	0
EGYPT	5	0.5	4	1	20
PHILIPPINES	5	0.5	5	0	0
ROMANIA	5	0.5	5	0	0

The Bibliometric evaluation of scholarly journals that relate to research of service quality in higher education shows a variety of influences and centers (**Table 3, Figure 5**). Quality Assurance in Education emerges as the leading journal, with an h-index of 31, g-index of 53, and highest TC of 3,770, indicating its core influence in the field since its launch in 1995. The journal's sustained contributions have formulated a sound base of scholarship in terms of quality assurance methodologies. The Journal of Marketing for Higher Education, marked by a moderate h-index of 16 and TC of 949, focuses on marketing strategies, indicating a significant though more

specialized impact since 1997. Similarly, Total Quality Management and Business Excellence (h-index: 14, TC: 839) has forged a distinctive role by applying principles of business excellence in the educational field since 2007.

New ones such as Sustainability (Switzerland) exhibit the maximum m-index of 1.286, which indicates a remarkable research history despite its relatively new inception in 2018. Yet, being low in total citations (247) indicates that its work remains yet to gain much traction. International Journal of Educational Management (h-index: 11, TC: 529) and TQM Journal (h-index: 9, TC: 353) exhibit steady contributions to management and quality paradigms but miss out in terms of more widespread influence as in upper-level journals.

It must, however, be pointed out that journals like Quality in Higher Education (h-index: 6, TC: 394, from 1996) show sustainability, but based on their relatively low research figures, this suggests a limited reach compared to the leading journals in the field. The International Journal of Quality and Service Sciences (h-index: 9, TC: 340) and Services Marketing Quarterly (h-index: 6, TC: 107) also show that while they have a specialized orientation, such influence is constrained by a niche readership population.

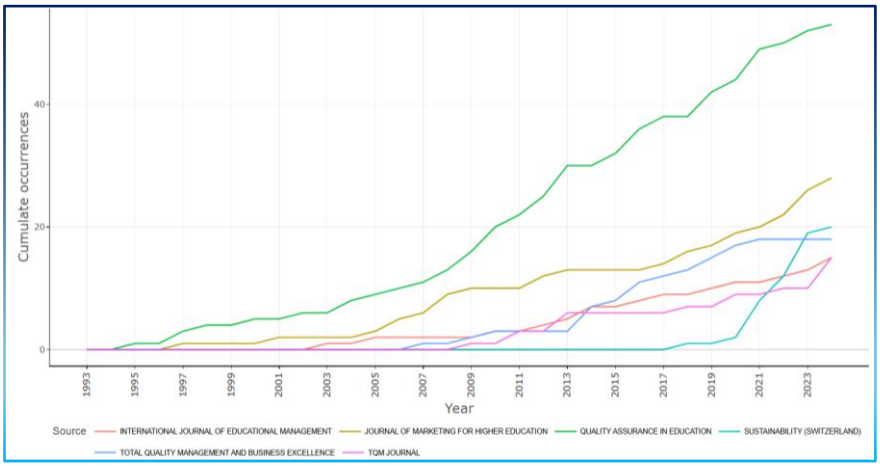

Figure 5. Journals on Trend

Table 3. List of Most Impact full Journals

Source	h_index	g_index	m_index	TC	NP	PY_start
QUALITY ASSURANCE IN EDUCATION	31	53	1.033	3770	53	1995
JOURNAL OF MARKETING FOR HIGHER EDUCATION	16	28	0.571	949	28	1997
TOTAL QUALITY MANAGEMENT AND BUSINESS EXCELLENCE	14	18	0.778	839	18	2007
INTERNATIONAL JOURNAL OF EDUCATIONAL MANAGEMENT	11	15	0.5	529	15	2003
INTERNATIONAL JOURNAL OF QUALITY AND SERVICE SCIENCES	9	11	0.563	340	11	2009
SUSTAINABILITY (SWITZERLAND)	9	15	1.286	247	19	2018
TQM JOURNAL	9	15	0.563	353	15	2009
INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH	7	7	1	122	7	2018
JOURNAL OF APPLIED RESEARCH IN HIGHER EDUCATION	6	9	0.75	161	9	2017
QUALITY IN HIGHER EDUCATION	6	8	0.207	394	8	1996
SERVICES MARKETING QUARTERLY	6	7	0.375	107	7	2009
ASIA PACIFIC JOURNAL OF MARKETING AND LOGISTICS	5	5	0.263	271	5	2006
JOURNAL OF SERVICES MARKETING	5	5	0.192	340	5	1999
MANAGING SERVICE QUALITY: AN INTERNATIONAL JOURNAL	5	5	0.167	291	5	1995
STUDIES IN HIGHER EDUCATION	5	7	0.333	198	7	2010

The productivity Prediction

The **Figure 6** demonstrates the fitting curve for research life cycle which comprises the historical data points (blue dots) and a theoretical bell-shaped curve (blue line). The model has attained a very high level of fit,

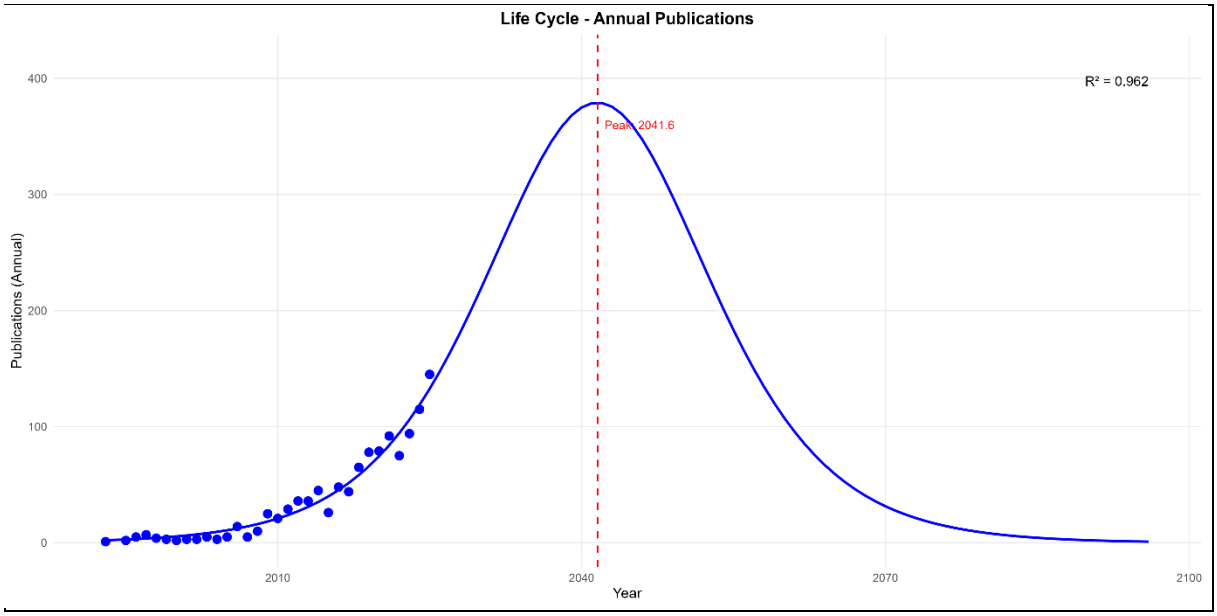

Figure 6. Life Cycle Model of Predicted Productivity

R^2 =0.962, which means that 96.2% of the variations in the historical data points can be accounted for by the curve. Historical data (1993 to 2024) reveal slow growth at the start and then sudden exponential increase—putting this research into a fast expansion stage. Projected data is similar to that of Hubbert or Bass diffusion models and reflects the whole life cycle until 2100. The vertical red dashed line indicates the forecasted research peak year which is expected in 2041.6. According to the model, it is expected to have almost 400 publications per year. After that point, the forecast will follow a downward trend to zero.

Analysis of Author's productivity, Collaborative work and the context

This literature review encompasses 2,489 distinct authors, illustrating extensive collaboration in research studies. Each study involved an average of 2.62 researchers on average, while each researcher on average published 7.72 articles. **Table 4** depicts the details on the number of authors involved, overall productivity, and the Collaboration Index (CI). The mean number of authors per document rose from 2.62 during 1993–2024 to 3.74 during 2011–2023. This upward trend is statistically significant ($R^2 = 0.26$, *p* = 0.012), indicating a growing tendency toward multi-authored research and stronger scholarly collaboration within the field.

Table 4. Authors Scientific Productivity

Year	Total Authors	Avg TA	Single Authored Pubs	Multi Authored Pubs	Authors in Single-Authored Pubs	Authors in Multi-Authored Pubs	Collaboration Index
1993	1	1	1	0	1	0	-
1994	*	*	*	*	*	*	*
1995	2	1	2	0	2	0	-
1996	7	1.40	3	2	3	4	2.00
1997	9	1.29	5	2	5	4	2.00
1998	7	1.75	1	3	1	6	2.00
1999	7	2.33	0	3	0	7	2.33
2000	4	2.00	0	2	0	4	2.00
2001	7	2.33	0	3	0	7	2.33
2002	5	1.67	1	2	1	4	2.00
2003	8	1.60	2	3	2	6	2.00
2004	7	2.33	0	7	0	7	1.00
2005	12	2.40	2	3	2	10	3.33
2006	27	1.93	6	8	6	21	2.63
2007	13	2.60	1	4	1	12	3.00
2008	17	1.70	5	5	5	12	2.40
2009	51	2.04	6	19	6	45	2.37
2010	53	2.52	4	17	4	49	2.88
2011	78	2.69	4	25	4	74	2.96
2012	82	2.41	7	27	7	75	2.78
2013	84	2.33	9	27	9	75	2.78
2014	114	2.53	6	39	6	108	2.77
2015	59	2.27	4	22	4	55	2.50
2016	130	2.71	9	39	9	121	3.10
2017	114	2.71	8	34	8	106	3.12
2018	185	2.85	6	59	6	179	3.03
2019	238	3.05	10	68	10	228	3.35
2020	222	2.81	12	67	12	210	3.13
2021	352	3.83	8	84	8	344	4.10
2022	267	3.47	8	69	8	259	3.75
2023	350	3.50	7	93	7	343	3.69
2024	289	3.52	4	78	4	285	3.65

Figure 7 highlights the most prolific contributors to service quality research in higher education. Parvez Sultan emerges as the leading author with seven publications, making significant contributions through the development and validation of the Performance-Based Service Quality (PBSQ) model and integrated frameworks that combine SERVQUAL and SERVPERF approaches. Rasli and Wong , with six publications each, have further advanced the field through research on international student satisfaction, institutional performance, and cross-cultural validation of service quality constructs. Joseph and Yeo (five publications each) have contributed to strategic service management and student-centered quality improvement, while Abdullah , Ahmad , Chong , Gruber , and Hassan (four publications each) have enriched the literature through regional studies, quantitative assessments, and quality assurance research. Collectively, these scholars have shaped the evolution of higher education service quality from traditional input-based evaluations toward student-centered, performance-oriented, and globally applicable quality frameworks.

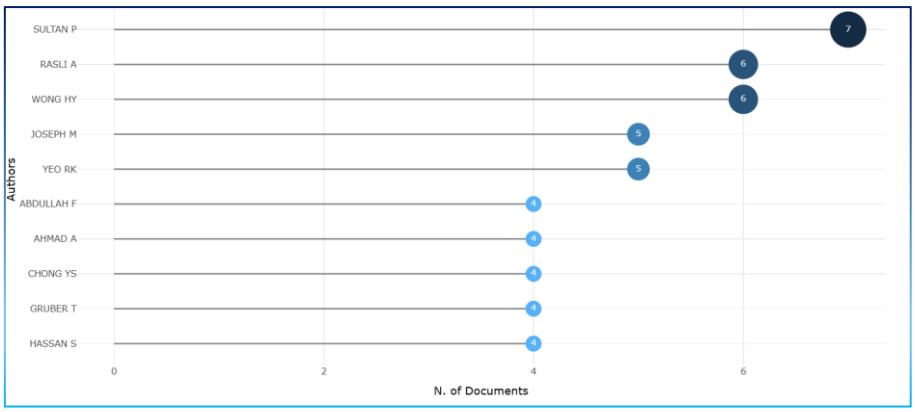

Figure 7. Top 10 Authors on Service Quality in Higher Education

Keywords, Topic, and Trend Analysis and the Prediction

Figure 8 and **Figure 9** reveals the dominant themes and emerging directions in higher education service quality research. The prominence of "service quality" and "higher education" confirms the field's primary focus on evaluating educational services using frameworks such as SERVQUAL, SERVPERF, and HEdPERF. The frequent occurrence of "students" highlights the strong student-centered orientation of the literature, with particular emphasis on satisfaction, loyalty, and educational experiences. Keywords such as "quality of service," "quality control," and "education" reflect continued interest in quality assurance, accreditation, and institutional performance. Meanwhile, the emergence of "education computing" and "e-learning" underscores the growing influence of digital technologies and online learning on perceptions of service quality, especially in the post-pandemic era. The presence of terms such as "female" and "human" further suggests increasing attention to demographic diversity and human factors in educational service delivery. Overall, the keyword structure indicates a dynamic field that has evolved from traditional service-quality assessment toward broader concerns encompassing student outcomes, digital transformation, quality assurance, and inclusivity.

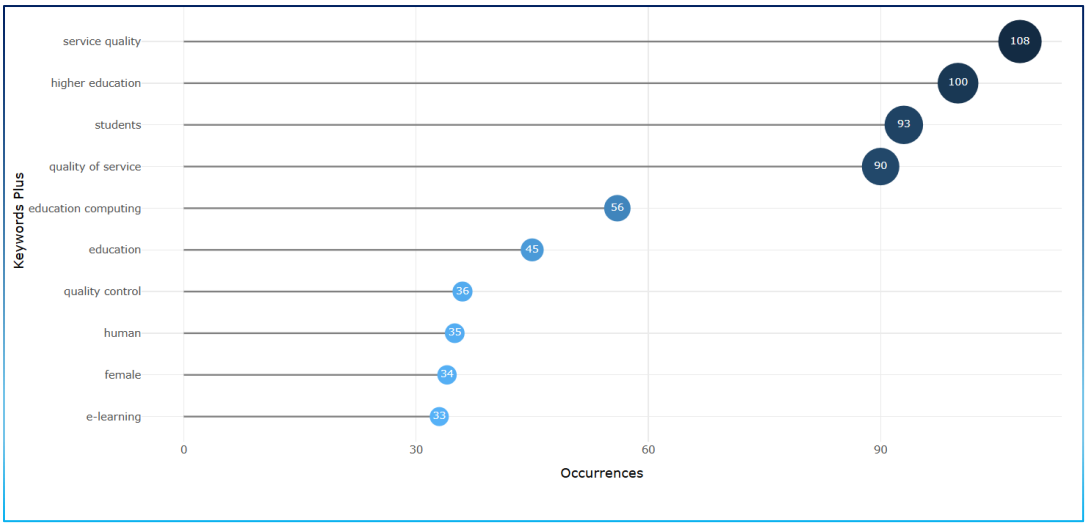

Figure 8. Top Ten Keywords Analysis

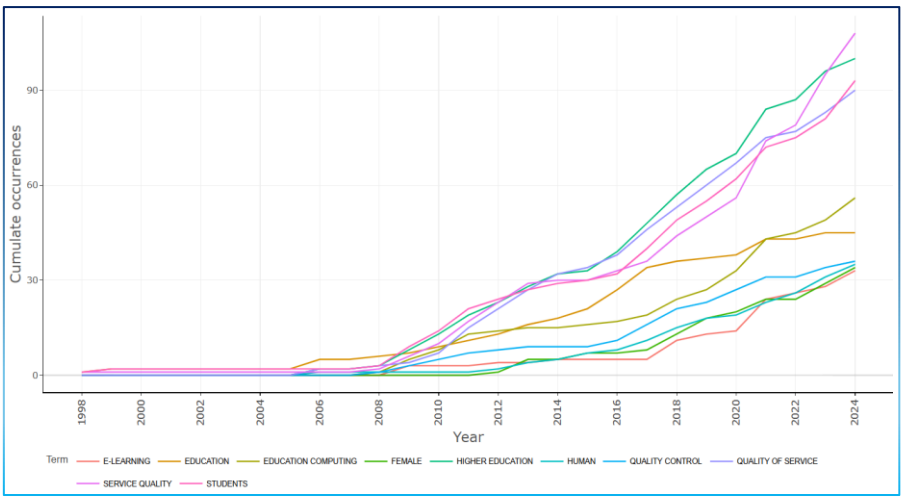

Figure 9. Cumulative Trend of Keywords

More Specific on the keywords trends the Sankey diagram (**Figure 10**) provides a temporal visualization of the evolution of research themes related to service quality in higher education across four distinct time periods: 1993–2012, 2013–2016, 2019–2021, 2022–2024. In the earliest phase (1993–2012), the research focus was relatively broad and foundational, with keywords like "students," "education," "quality control," "societies and institutions," and "management." This reflects an early attempt to position service quality within the broader framework of educational systems and institutional management, with "students" already emerging as key stakeholders in service delivery.

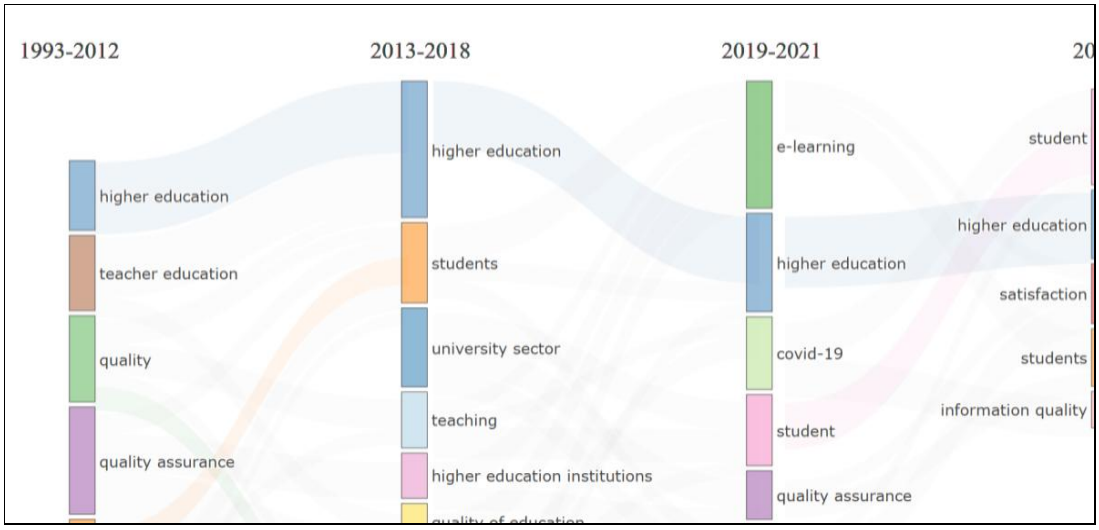

Figure 10. Temporal evolution of Keywords

From 2013 to 2016, the field started to gather around more specific ideas such as "quality of service," "University sector," "questionnaire," and "education computing." This time marked a methodological shift that highlighted the use of empirical tools like surveys and increased focus on technological aspects. It laid the groundwork for applying service quality frameworks in higher education. The term "human" as a keyword points to a growing interest in user-centered or behavioral views of service perception (Figure 2.9).

In 2017 to 2019, the themes became more focused. They consolidated around the main ideas of "service quality" and "higher education." These two terms act as key links for future periods, showing that the field is maturing and building a solid research base. During this time, the connection between academic service quality and the environment of higher education was strongly highlighted.

The 2020 to 2021 phase shows a dramatic change due to global disruptions, especially with the rise of "COVID-19" as a key theme. Alongside COVID-19, terms like "curricula" and "teaching" became more prominent, highlighting a strong research focus on how pandemic-related disruptions impacted service delivery, content delivery, and instructional quality. The ongoing importance of "service quality" during this time indicates that assessing institutional responsiveness and effectiveness remained a major concern.

In 2022 to 2023, research became more varied and in-depth. Terms like "higher education institutions," "customer satisfaction," and "quality control" grew in importance. The continued impact of COVID-19 and the introduction of "blended learning" show an evolving research focus on hybrid education models and what they mean for service quality and student experience. There was also a clear shift towards strategic decision-making and institutional resilience.

Finally, in the latest period (2024 to 2024), themes such as "e-learning," "decision making," "service quality," and "higher education institutions" are prevalent. This reflects the complete integration of digital technologies and changes in institutions after the pandemic. The ongoing themes like "quality control" and "customer satisfaction" show a continued emphasis on measuring performance, ensuring accountability, and improving the student experience in a rapidly changing educational environment.

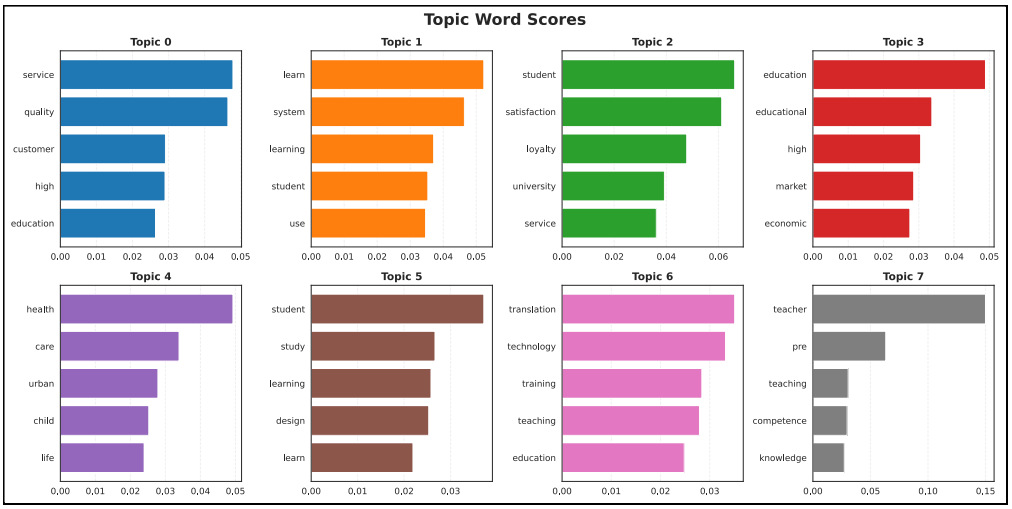

Figure 11. Topic Word Scores

Figure 12 presents the top-five keyword scores for eight latent topics extracted from the corpus of higher education service quality literature. These word clusters reveal the underlying thematic structure of the research

field. Topic 0 (service, quality, customer, high, education) captures the core customer-centric service quality paradigm, directly applying classic frameworks such as SERVQUAL to higher education by treating students as customers. Topic 2 (student, satisfaction, loyalty, university, service) shifts the focus to the attitudinal and behavioural outcomes of service quality, emphasising student satisfaction and loyalty as key dependent variables. Topic 3 (education, educational, high, market, economic) introduces an economic and market lens, linking educational quality to graduate employability, return on investment, and institutional competitiveness. Together, Topics 0, 2, and 3 form the traditional core of the field, centred on perceived service quality, its consequences, and its economic justification. A second conceptual layer addresses learning and pedagogical effectiveness. Topic 1 (learn, system, learning, student, use) focuses on learning management systems and technology-enhanced learning. Topic 5 (student, study, learning, design, learn) emphasises instructional and curriculum design, while Topic 7 (teacher, pre, teaching, competence, knowledge) highlights pre-service teacher competence and pedagogical knowledge. These three topics mark a shift from perceiving service quality solely as a customer-service encounter towards defining it as the effectiveness of learning processes and inputs. A third layer comprises cross-cutting and analogical themes. Topic 6 (translation, technology, training, teaching, education) captures the role of translation technologies and digital training tools, particularly relevant to multilingual and international classrooms. Topic 4 (health, care, urban, child, life) is the most distinctive: it signals a cross-sector borrowing of service quality frameworks from health and social care, likely applied to university-based health services, counselling, or community engagement programmes. In summary, the topic word scores confirm that service quality in higher education is a multi-faceted domain, integrating customer-service logic, learning effectiveness, teacher competence, educational technology, and even analogies with human services such as health care.

To investigate how service-quality research in higher education has evolved, we compared two computational text-analysis methods: a temporal topic model (Topics over Time) and conventional keyword-frequency analysis. The temporal topic model was fitted to a corpus covering 1993–2024 and produced twelve coherent thematic topics (**Figure 13**). In parallel, Thematic keyword analysis tracked the incidence of terms (**Figure 11**) across the same period.

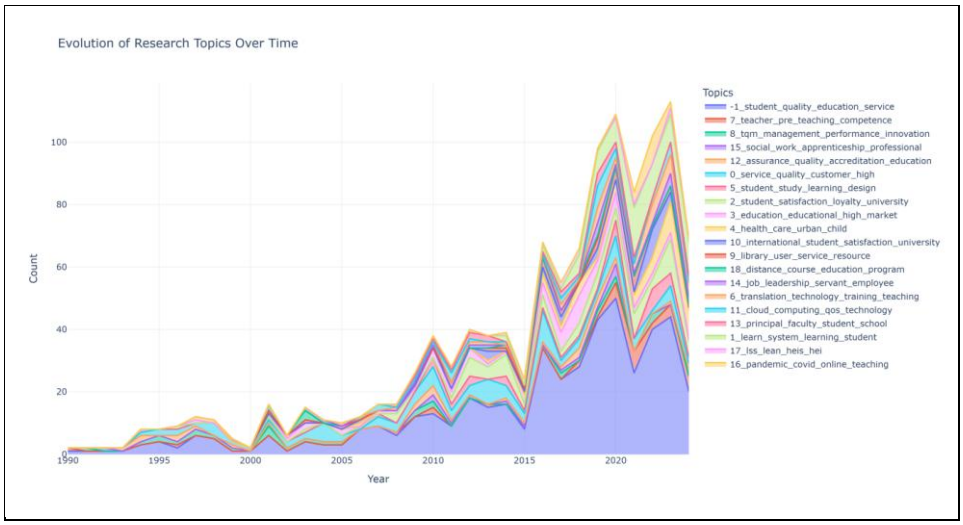

Figure 12. Temporal topic model

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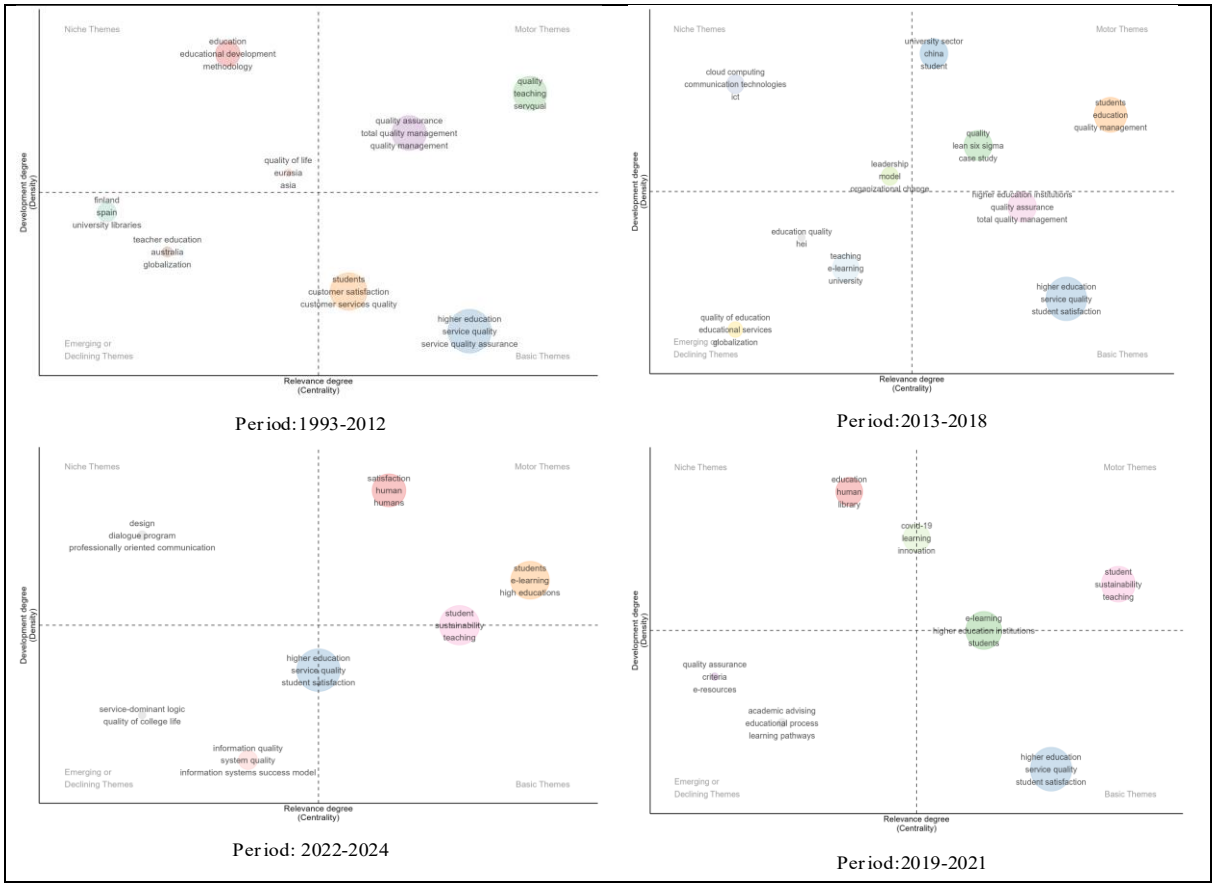

Figure 13. Thematic Evolution (1993-2024)

The temporal topic model revealed latent, multidimensional constructs that keyword counts do not capture. For example, topic 0 integrates student, satisfaction, loyalty, and service into a single, semantically coherent discourse, whereas keyword analysis treats these terms independently and therefore loses their interdependence. The model also detected early (pre-2000) attention to teacher competence and library services—signals that a keyword search for the single phrase "service quality" would likely miss because of lexical sparsity. Importantly, the model's temporal component let us trace the lifecycle of entire research themes (for instance, the post-2010 emergence of cloud_computing_qos_technology, topic 12), a pattern that isolated keyword counts cannot reveal because they lack thematic aggregation.

Keyword analysis, however, retains practical strengths: it is transparent, easy to validate, and free from choices like the number of topics or probabilistic parameter tuning. Terms such as SERVQUAL or STUDENTS can be counted directly with minimal inferential overhead. Its main drawback for higher-education service-quality research is loss of conceptual context: an uptick in the frequency of "quality" can reflect service quality, data quality, or program quality—each implying different substantive interpretation.

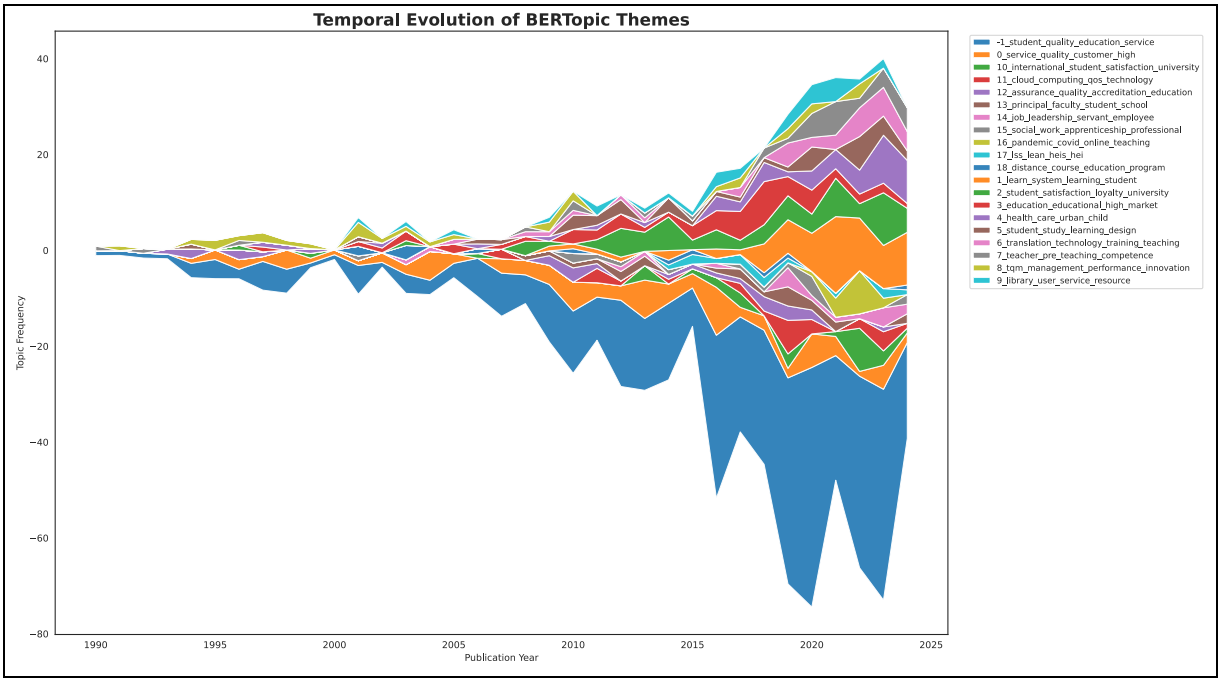

Figure 14. Temporal topic trends Analysis

Temporal topic trends reveal a clear evolution in how service quality in higher education has been conceptualised and researched from the 1990s through 2025. Early in the record (1990–1995) topic activity is negligible, indicating that service quality had not yet emerged as a distinct research domain. From 2000–2005 the discourse shifted toward assurance and accreditation concerns, as external quality frameworks and compliance issues consolidated in policy and scholarship; however, this assurance-centred strand does not dominate long term and stabilises as a baseline concern after 2010.

The period 2010–2015 marks the field's high-growth phase. Core customer-centric constructs (Topic 0: service quality / student satisfaction and loyalty) and international student-satisfaction metrics (Topic 10) register pronounced positive peaks, while technology-related service dimensions (Topic 11: cloud computing/QoS) also surge. Together these trends evidence a reorientation toward student experience, internationalisation, and digitally mediated delivery as primary vectors of service-quality scholarship.

Emerging and technology-driven dimensions continue to shape the 2010s: learning systems and pedagogical inputs move from peripheral to central concerns, and measurement-focused research becomes tightly coupled with outcome-oriented studies. The COVID-19 pandemic produced a short, intense spike in pandemic-labelled research (Topic 16) around 2020, reflecting urgent attention to online teaching quality; by 2024 this explicit pandemic discourse subsides, with its substantive lessons appearing absorbed into continuing conversations on ed-tech, distance education, and teacher competence.

Several topics remain peripheral or negative throughout the period (e.g., leadership in K–12 contexts, vocational apprenticeship, some health-education analogies), indicating the corpus includes broader educational research but that these strands do not drive the higher-education service-quality agenda.

Service quality research in higher education has moved from a niche, assurance-oriented concern to a mature, multi-faceted field centred on student experience, learning effectiveness, and technology-mediated delivery. Peaks around 2010–2015 reflect the consolidation of customer-centric and internationalisation themes; the pandemic created a transient but impactful focus on online teaching quality. By 2024, topic activity largely normalises, suggesting service quality has been mainstreamed into general higher-education scholarship rather than remaining a separate, rapidly changing frontier.

The Principal Component Analysis (PCA) of BERTopic loadings (**Table 5**, **Figure 15**) reveals a clear intellectual divide within higher-education service-quality research: Component 1 separates a dominant student-centric, learning-experience paradigm from a process and compliance-oriented paradigm. Strong positive loadings cluster on student satisfaction and loyalty (T0), learning systems (T1), and outcome/market perspectives (T2), indicating that contemporary scholarship increasingly frames quality in terms of student experience, learning effectiveness, engagement, and institutional outcomes rather than solely administrative procedures (Harvey & Green, 1993).

Table 5. Topic Modeling and Principal Component Analysis

Topic	Label	PCA Score (Comp 1)
T0	student_satisfaction_loyalty_service	+12
T1	learn_system_learning_student	+10
T2	education_educational_high_economic	+8
T3	health_care_urban_child	+6
T4	service_quality_servqual_measure	+4
T5	teacher_pre_teaching_competence	+2
T6	translation_technology_teaching_educat...	+1
T7	library_user_academic_service	0
T8	tqm_management_performance_innovation	–1
T9	assurance_quality_education_accreditat...	–2

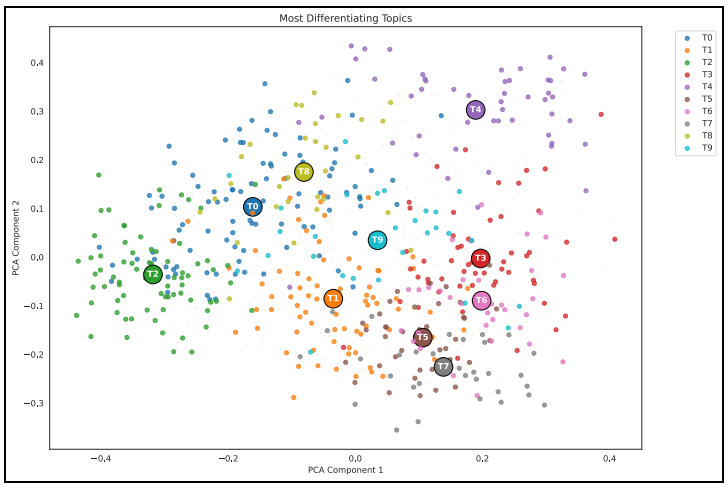

Figure 15. Principal Component Analysis

The positive position of teacher competence, service-quality measurement, and educational technology further suggests that pedagogical effectiveness and digital learning environments are integral determinants of perceived quality (Bond et al., 2021). By contrast, negative loadings on TQM and accreditation reflect a distinct, process-driven paradigm focused on accountability and formal assurance mechanisms (Harvey & Williams, 2010; Stensaker, 2008). Library services' neutral placement implies a baseline support role rather than a differentiating perspective. Overall, the PCA documents a structural shift from institution-centred quality assurance toward student-centred value creation and learning outcomes; bridging these paradigms, by linking student-level outcomes with institutional assurance systems, represents a high-value agenda for future research and policy (Ewell, 2010).

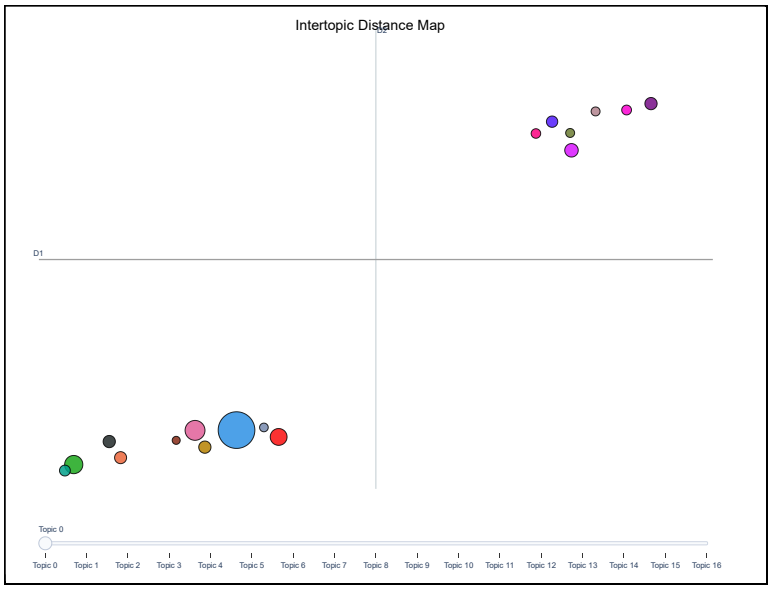

Figure 16. Inter-topic Distance Map

Intertopic distance map (**Figure 16**) illustrates the intellectual structure of studies about service quality in higher education based on the semantic similarity between topics (Sievert & Shirley, 2014). The fact that the topics about student satisfaction and service-quality concepts occupy central positions proves that they are the dominating core of the research area. The dominance of such topics is explained by the influence of the SERVQUAL approach and student-as-customer paradigm (Parasuraman et al., 1988; Abdullah, 2006). The dense cluster of learning systems, student satisfaction, and quality measurement topics shows a trend towards the combination of educational outcomes, student experience, and quality assessment associated with outcome-based approaches (Harvey & Green, 1993; Ewell, 2010).

Likewise, the proximity of teacher competence and educational technology issues emphasizes the emerging importance of educational and technological aspects as determinants of the concept under discussion (Selwyn, 2016; Bond et al., 2021). The isolated position of the remaining topics, including accreditation, TQM, healthcare-oriented quality improvement models, and lean higher education, reflects the specialized nature of such streams of research (Harvey & Williams, 2010; Donabedian, 1988).

Overall, the map demonstrates a transition from a predominantly customer-oriented paradigm toward a broader framework encompassing learning effectiveness, digital transformation, student well-being, and institutional quality, thereby corroborating trends identified in recent higher education quality research (Teeroovengadum et al., 2019; OECD, 2021).

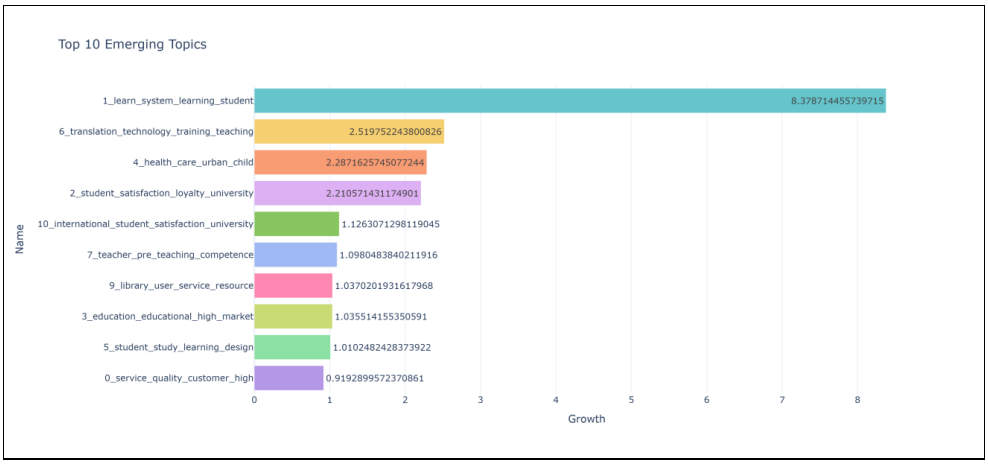

Figure 17. Top 10 Emerging Topics

The emergence and growth of topics (**Figure 17**) within the framework of growth rates suggest a noticeable transition from research related to service quality and customer services towards topics associated with learning and technology-enhanced education. Indeed, the topic with the highest growth rate is *learn_system_learning_student*, which growth equals 8.38, indicating a growing interest in learning systems, students' learning outcomes, and learner-centric quality frameworks.

The other rapidly developing areas concern technology usage, with such topics as *translation_technology_training_teaching*, which growth rate amounts to 2.52, referring to the increased focus on digital technologies, artificial intelligence-driven learning, and cross-language education. In addition, a growing interest in *health_care_urban_child* with the growth rate of 2.29 indicates an increasing number of publications about the use of service quality principles and approaches from healthcare within higher education settings (Donabedian, 1988).

Meanwhile, while the publication count of the topic *student satisfaction_loyalty_university* with the growth rate of 2.21 increases, it can be assumed that student satisfaction and loyalty are no longer emerging topics, but the areas that have become quite well-researched already (Hemsley-Brown & Oplatka, 2006).

The forecasted topic composition (**Appendix 1**) suggests that higher education service quality research is evolving around a persistent customer-centric core and several emerging themes. Topic 0 (service_quality_customer_high) remains dominant through 2028 (44.12%), reaffirming the centrality of student satisfaction, loyalty, and SERVQUAL-based frameworks in the field (Parasuraman et al., 1988). Among secondary themes, Topic 2 (student_satisfaction_loyalty_university; 14.29%) shows the strongest growth, indicating increasing emphasis on student retention, institutional reputation, and loyalty outcomes (Hemsley-Brown & Oplatka, 2006). Topic 3 (education_educational_high_market; 4.48%) reflects the continued integration of employability and market-oriented perspectives into quality research (Marginson, 2016).

Technology-related topics, including Topic 6 (translation_technology_training_teaching; 4.18%), Topic 11 (cloud_computing_qos_technology; 2.28%), and Topic 18 (distance_course_education_program; 2.37%), exhibit steady growth, highlighting the institutionalization of digital learning and technology-enabled quality assessment (Selwyn, 2016). Meanwhile, Topic 7 (teacher_pre_teaching_competence; 5.06%) remains an important and expanding dimension, emphasizing the role of pedagogical competence in perceived educational quality (Brophy, 2017). In contrast, accreditation, library-service, and lean-management themes show limited growth, suggesting reduced prominence within the broader service-quality discourse.

Overall, the forecasts indicate a transition from traditional service-quality measurement toward a more integrated framework combining student outcomes, employability, teaching competence, and digital learning environments. Future research is therefore likely to emerge at the intersection of student satisfaction, technology-enhanced learning, and institutional performance.

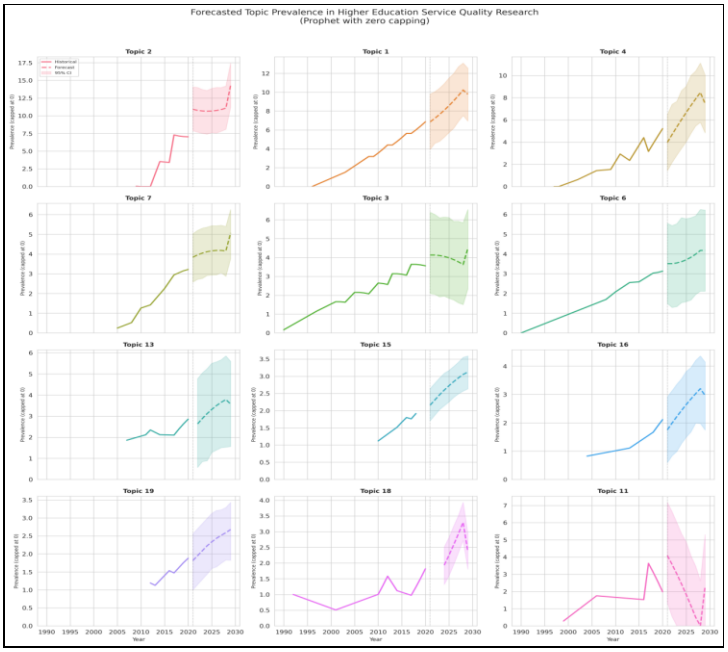

Figure 18. Prophet-based forecasted Topics

Figure 18 presents Prophet-based forecasts of eight major research topics in higher education service quality, with 95% confidence intervals. The forecasts reveal continuity and transformation in the field.

Dominant Future Themes

Topic 2 (student_satisfaction_loyalty_university) is projected to rise sharply from ~11% (2023) to ~15% (2030), indicating student satisfaction, loyalty, retention, and institutional reputation will remain central evaluation criteria (Hemsley-Brown & Oplatka, 2006). Topic 1 (learn_system_learning_student) shows consistent growth to ~10% by 2030, reflecting emphasis on learning systems, engagement, and outcome-based education (Harvey & Green, 1993).

Emerging Themes

Topic 4 (health_care_urban_child) exceeds 8% by 2030, signaling increased focus on student well-being and healthcare-quality principles in education (Donabedian, 1988). Topic 7 (teacher_pre_teaching_competence) grows steadily, underscoring pedagogical competence as a key quality determinant.

Technology-Related Themes

Topics 6 (translation_technology_training_teaching), 16 (pandemic_covid_online_teaching), and 18 (distance_course_education_program) show moderate, sustained growth, indicating digital learning, AI-assisted education, and distance/hybrid models are now permanent research components (Selwyn, 2016).

*Stable and Leadership Theme*s

Topic 3 (education_educational_high_market) remains stable with moderate growth, suggesting employability and market perspectives persist but are no longer primary innovation drivers. Topics 13 (principal_faculty_student_school) and 19 (job_leadership_servant_employee) show gradual upward trajectories, reflecting interest in leadership and organizational effectiveness.

High Uncertainty

Topic 11 (cloud_computing_qos_technology) exhibits the highest uncertainty (wide confidence interval), implying cloud-service quality research may become a specialized niche or merge into broader digital-learning discussions.

Overall Shift

Forecasts indicate a shift from traditional service-quality measurement toward a multidimensional framework integrating student satisfaction, learning effectiveness, teacher competence, digital transformation, and well-being. Future research will prioritize value creation through effective learning ecosystems rather than solely assessing institutional service performance.

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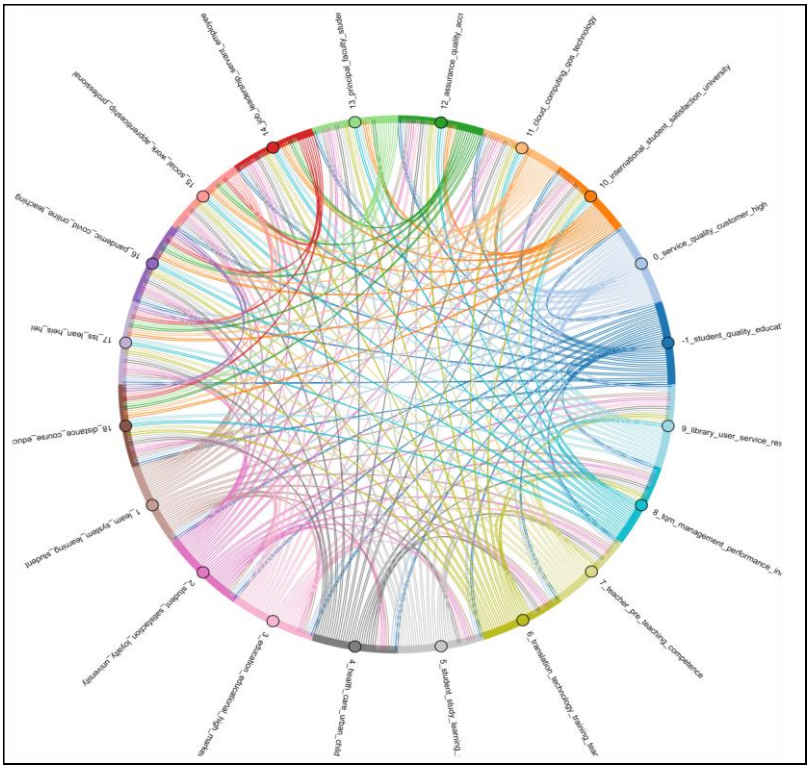

Figure 19. Chord Plot of Interconnected Topics

Examining the interconnections and overlapping themes, **Figure 19** shows among 20 research topics obtained from the corpus of higher education service quality literature. In the figure, each coloured sector (node) located on the circle's edge represents a unique multiple-word theme (e.g., *0_service_quality_customer_high*), where the length of the arc shows its degree of connectivity with others. The coloured chords inside the circle represent the linkage between any two themes; the width of each chord measures the frequency of the co-occurrence, while its colour reflects that of the category node (source). The chord diagram highlights the existence of an extremely integrated system, since the centre contains many chords spread evenly throughout, indicating that the knowledge base does not consist of disconnected domains but has a high degree of thematic overlap. Indeed, two main hubs have emerged from the dense network, including the dark blue node (*0_service_quality_customer_high*) and the cyan node (*1_student_quality_education*). Their thick chords and numerous connections make them the key pillars upon which the entire interconnected framework depends, proving that concepts related to customer-focused service quality and student achievement outcomes lie at the heart of the field. The additional classification by perimeter labels further breaks down the themes into three distinct categories. The first category revolves around themes related to performance of students and institutions, which includes the labels (*0_service_quality_customer*, 1*_learn_system_learning_student*, and *2_student satisfaction_loyalty_university*). The second group of categories deals with technology adaptation and innovation (*11_cloud_computing_technology*, *16_pandemic_online_teaching*, and *18_distance_course_education_program*, where thick chords lead to the center, showing how digital infrastructure and forced adoption of online learning because of the pandemic have become an indispensable part of the service quality concept. Finally, the third category revolves around themes associated with the faculty and professional development, particularly *7_teacher_pre_teaching_competence* and *6_translation_technology_training_teaching*, which have a strong connection with the central hubs,

demonstrating how teacher competence and learning technologies are regarded as vital determinants for achieving perceived service quality. Overall, the chord plot visualizes a mature, systems-oriented research domain where student satisfaction, learning effectiveness, and technological adaptation are not competing paradigms but mutually reinforcing dimensions of service quality in higher education.

5. Implications, Conclusions, Limitations, and Future Research Scope

Theoretical Implications

This study advances conceptualization of service quality in higher education by demonstrating the field is highly integrated rather than fragmented. The chord diagram reveals pervasive thematic connectivity, showing that customer-centric service quality, student satisfaction and loyalty, learning systems, teacher competence, and technology-mediated services function as mutually reinforcing paradigms rather than competing dimensions. This challenges earlier dimensional models (SERVQUAL, HEdPERF, HiEduQual) that treat dimensions as separate, warranting a systems perspective. The emergence of digital infrastructure and crisis-resilience themes indicates service quality frameworks must now explicitly incorporate these as core dimensions, not peripheral add-ons.

Practical Implications for Higher Education Institutions

Institutions should adopt multi-pronged strategies. The forecasted dominance of customer-focused service quality and student satisfaction confirms traditional satisfaction measurement remains essential. However, rapid growth in learning systems, learning design, and teacher competence signals that learning effectiveness and faculty development are equally critical. Administrators should invest in learning analytics, instructional design units, and pre-service teacher training programs. Strong connectivity of technology-related topics implies quality assurance must include IT service reliability, platform usability, and support for online/distance education. The declining trajectory of accreditation and total quality management themes suggests compliance-based approaches are losing relevance; student-perceived quality should take precedence.

Policy Implications

Accreditation bodies and quality assurance agencies should revise criteria to emphasize student-perceived service quality, learning system performance, and teacher competence. The cross-sector analogy with health care recommends modeling student support services (counseling, health clinics) on proven health-sector service quality frameworks.

Conclusions

Service quality research in higher education has evolved from fragmented, compliance-focused dimensions toward an integrated, student-centered paradigm. The field now prioritizes learning effectiveness, digital transformation, teacher competence, and student well-being alongside traditional satisfaction metrics. A systems-oriented framework best captures the multidimensional nature of contemporary service quality.

Limitations

This study relies on topic modeling and time-series forecasting, which may not fully capture thematic interdependencies or exogenous shocks. Conservative adjustments to forecast values compress low-end variability. The analysis is limited to the available corpus and may not represent all disciplinary or geographical perspectives.

Future Research Scope

Future work should: (1) employ multivariate compositional time-series models to capture thematic interdependencies; (2) incorporate covariates such as policy changes, funding shifts, and technology adoption rates; (3) validate findings across diverse geographical and disciplinary contexts; (4) develop integrative frameworks linking student outcomes with institutional assurance systems; and (5) examine emerging themes like AI-assisted education, hybrid learning models, and student well-being in greater depth.

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