

DIGITAL LITERACY AND INSTITUTIONAL DIGITAL TRANSFORMATION AS DETERMINANTS OF SERVICE QUALITY IN HIGHER EDUCATION: A CASE STUDY FROM AN EMERGING ECONOMY WITH IMPLICATIONS FOR INDUSTRY 4.0 WORKFORCE READINESS

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ABSTRACT

With the shifting of emerging economies to Industry 4.0 despite having low digital literacy, institutions of higher education are progressively incorporating new digital technologies into their learning institutions in order to improve learning outcomes and equip students with the demanded skills in the future. Here, institutional digital transformation as well as digital literacy of students has become significant determinants of perceived quality of service. Nonetheless, there is a dearth of empirical information on their relative contributions. This research paper focuses on the effects of digital transformation (DT) and digital literacy (DL) on the perceived quality of services by students in the conceptualized dimensions of SERVQUAL in higher education. It was a quantitative cross-sectional survey involving 164 diploma, undergraduate and postgraduate students. DT, DL and service quality standardized scales were used and data were processed with the help of SPSS 23. Cronbach alpha ranging from .877 to .971 was used to check reliability. Pearson correlation revealed a moderate association between DT and perceived service quality ($r = .39$, $p < .01$), but there was a stronger relationship with DL ($r = .51$, $p < .01$). The result of the multiple regression analysis indicated that both DT ($\beta = .216$, $p = .003$) and DL ($\beta = .420$, $p = .001$) had a significant predictive value on the service quality, but with a larger explanatory power of DL. The results indicate that institutional digital initiatives have a positive impact on the perceptions of the quality of services, but the contribution of the digital competencies of students is more significant. The research highlights the importance of higher education institutions to supplement technological investments with systematic building of digital skills to enhance service quality and the readiness of workforce in the industry 4.0 era.

Keywords: Digital Transformation, Digital Literacy, Service Quality, SERVQUAL, Industry 4.0, Higher Education, Emerging Economy, Digital Education.

INTRODUCTION

2.1 Background

In developing countries seeking to maintain a competitive edge in the global industrial economy, human resource development is increasingly

influenced by changing geopolitical and economic realities that both limit and enable possibilities. In South Asia, this has heightened the need for countries like Pakistan to strategically align human capital to seize emerging economic opportunities

(Cheema, 2025a). As a result, service quality (SERVQUAL) in higher education institutions - which are responsible for developing the workforce of the future - is now crucial. The digital skills of graduates are equally important as they act as the enablers for working in the industry 4.0 world (Cheema & Khalid, 2025c).

Industry 4.0 is defined by the adoption of cutting-edge technologies such as artificial intelligence, automation, big data analytics, and cyber-physical systems that are dramatically transforming work practices, skill sets and roles. This evolution is not only about technological progression, but also developing a workforce that can work with smart systems. In turn, companies need to build digitally empowered, agile and future-ready workforces to maintain their competitiveness and sustainability (Margherita & Braccini, 2021). In addition, empirical research also suggests that the level of digital and AI readiness plays a crucial role in determining productivity levels, which supports the need for human capital to be in sync with technological advancements (Cheema et al., 2025b).

In this regard, universities are crucial in preparing future professionals with the digital skills demanded by the professional world. Digital transformation in higher education involves the purposeful use of digital technologies to support teaching, learning and administration to improve efficiency, access and service provision (Dwivedi et al., 2021). This goes beyond digital content to include learning management systems (LMS), online student registration, e-libraries, and virtual labs that enhance teaching and administrative efficiencies (Ng, 2012). Such innovations help align higher education with Industry 4.0 by ensuring graduates are digitally literate to adapt to changing employment trends (Dwivedi et al., 2021).

The rise of internet and mobile technologies has also sped up the shift from analogue (paper-based) to digital environments. Traditionally, universities operated with manual registration processes, paper-based libraries and in-person teaching. But today, systems are increasingly incorporating LMSs like Moodle and Blackboard, online assessment tools, digital libraries and virtual laboratories that support online and on-the-go

learning (Hashim et al., 2022). In Pakistan, the Pakistan Education and Research Network (PERN) has been instrumental in this evolution by offering high-speed internet access and access to academic resources, which has improved research collaboration and technologically-mediated learning (PERN, n.d.).

The digital innovation is strongly associated with perceived service quality (PSQ), also known as students' overall assessment of service quality (Parasuraman et al., 1988). In higher education, PSQ includes academic and administrative aspects, as well as the impact of digital technology. The SERVQUAL framework defines service quality in terms of five dimensions: tangibility (digital technologies and physical infrastructure), reliability (consistency and dependability), responsiveness (promptness in service), assurance (competence and trustworthiness of staff), and empathy (care and attention). Existing research shows that efficient digital services - like timely administrative platforms, LMS and access to e-libraries - improve student satisfaction, performance and the university's brand (Duarte et al., 2012).

But digital transformation is not just about infrastructure. Digital literacy, defined as the capacity to effectively harness digital technologies for learning, communication and problem-solving, is crucial in determining students' interaction with and use of these systems. For example, in the era of Industry 4.0, readiness for the workforce is not just about the availability of technology but also the ability to effectively use the systems (Cheema & Khalid, 2025c; Cheema et al., 2025d). Recent research also highlights the role of cognitive and adaptive skills in managing complex digital tasks, further underlining the role of human factors in digital transformation (Cheema et al., 2025e).

While investments in digital transformation in higher education continue to grow, few empirical studies have explored the relative and combined impacts of institutional digital transformation and individual digital literacy on perceptions of service quality, especially in developing countries. This research fills this gap by exploring the interactive effects of digital transformation and digital literacy on perceived service quality in the context of Industry 4.0-oriented higher education, providing

theoretical and empirical insights into workforce readiness in emerging markets.

2.2 Problem Statement

While the number of digital services available in higher education is increasing, many students are not able to maximize the benefits of them which will impact on the perceived quality of services. Lack of effective internet connectivity, complex LMS layouts, lack of technical support and effective integration of digital tools are still a constraint (Dwivedi et al., 2021). Crucially, lack of digital literacy will restrict the access of students to digital platforms such as e-libraries and virtual labs and this will hinder the success of digital transformation (Ng, 2012). There is evidence that digitally literate students have more positive attitudes towards services (Hashim et al, 2022). Insufficient infrastructure, uneven capacity and lack of training, which are more common in developing countries such as Pakistan, further exacerbate these problems (PERN, 2026).

2.3 Research Objectives

- To investigate the impact of Digital Transformation on SERVQUAL.
- To determine the impact of Digital Literacy on SERVQUAL

2.4 Research Questions

- Does Digital Transformation have an impact on SERVQUAL?
- Digital Literacy have an impact on SERVQUAL?

2.5 Hypotheses

- **H1:** Digital transformation has significant positive relation with SERVQUAL
- **H2:** Digital Literacy has significant positive relation with SERVQUAL

3. Literature Review

3.1 Digitalization in Higher Education

Digitalization in higher education is the strategic approach to the implementation of digital technologies in teaching, learning, evaluation, governance, and administration. Digitization is not only a process of changing analog resources

into digital ones, but also a process that focuses on the intentional application of information and communication technologies (ICT) to improve educational processes, accessibility, and outcomes. It involves the introduction of learning management systems (LMS), e-governance systems, mobile apps, and online assessment systems (Schuetze et al., 2024). LMSs, including Moodle, Blackboard, and institutional portals, combine course delivery, assessment, and communication, as well as academic records into single digital ecosystems, which enhances efficiency and flexibility in academic interactions. Digitalization has been influenced within the sphere of higher education by the fast technological development and the evolving needs in education. In the last twenty years, most of the world universities have shifted their conventional face-to-face learning towards blended and fully online education. The outbreak of COVID-19 also greatly contributed to the acceleration of this shift as it required virtual learning environments, cloud-based systems and digital assessment methods to be adopted quickly (Yin & Ying, 2025). Though developed countries developed faster with the help of more powerful infrastructure and policy facilitation, in most countries of the Global South, such as Pakistan, digitalization has proceeded at a slower pace due to resource limitations and a lack of strategic planning (Schuetze et al., 2024; Yin & Ying, 2025).

In Pakistan, the national initiatives and institutional reforms to modernize the education systems have been motivated by the digitalization. The Higher Education Commission (HEC) has established numerous digital governance projects such as the establishment of centralized data, digitized student services, and improved inter-university connectivity to facilitate research and collaboration (HEC, 2025; Schuetze et al., 2024). Moreover, higher education institutions like the Virtual University of Pakistan have led the way in ICT-enabled education by providing online and mobile learning, and has been made accessible to students in both cities and rural regions (Virtual University of Pakistan, 2025).

The advantages of digitalization in higher education are not a secret. To start with, it

improves accessibility by eliminating temporal and geographical barriers, which offers flexibility and learning to diverse student groups, such as working people and remote areas (Yin & Ying, 2025). Second, the automation and the ability to communicate in real-time and to store records centrally result in a reduction in delays and human error, as well as enhancing administrative efficiency and transparency (Schuetze et al., 2024). Third, the personalized and interactive learning is enabled by the digital platforms through the use of adaptive technologies and multimedia content, which meet different learning needs.

Nevertheless, there are still several challenges that are very serious. The inability to implement effectively due to infrastructural constraints, including poor internet connectivity, outdated equipment, and fragmented digital systems, persistently impedes effective implementation, especially in under-resourced institutions (Schuetze et al., 2024). Difficulty in adoption by faculty and administrative staff is also a limitation as traditional practices tend to hinder digital transformation initiatives. Besides, a weak digital governance system and poor access to emerging technologies inhibit the scale and sustainability of digital programs (Schuetze et al., 2024; Yin & Ying, 2025).

Thus, to enhance successful digital transformation in higher education, it is not only necessary to invest in technology but also to plan, build capacity, and align policies. Altogether, digitalization is a paradigm change that alters the way institutions work and students learn. Its success is eventually determined by its ability to deal with technological and people challenges by having powerful leadership and infrastructure building.

3.2 Perceived Service Quality in Education

The concept of perceived service quality (PSQ) in higher education can be defined as assessment of the total quality of the institutional services by the students, which is based on the difference between expectations and experiences (Parasuraman et al., 1988). It includes academic support, administrative services, teaching effectiveness, and learning facilities, which all have an impact on

student satisfaction, engagement, and institutional reputation (Musandiwa & Rokhotso, 2024).

The most popular model to measure PSQ is SERVQUAL created by Parasuraman et al. (1988) that incorporates five dimensions, namely, tangibility (physical facilities and resources), reliability (consistent and accurate service delivery), responsiveness (timely support), assurance (trust and competence of staff), and empathy (personalized attention). These dimensions measure both concrete and non-concrete elements of service quality, and the data show that reliability and responsiveness are some of the most impactful dimensions in the sphere of higher education (Musandiwa & Rokhotso, 2024).

Digitalization has greatly transformed PSQ by allowing greater accessibility, efficiency and responsiveness. Learning management systems (LMS), e-registration systems, and online libraries are all technologies that allow access to academic and administrative services 24/7, eliminating the time delays and enhancing the user experience (Hashim, 2022). Additional characteristics like real-time communication, automatic feedback, and the delivery of digital content enhance service quality with timeliness and customized support.

There is empirical evidence that there is a positive correlation between digitalization and PSQ, and digital tools enhance student satisfaction and institutional effectiveness perceptions (Puriwat & Tripopsakul, 2021). The advantages of digital services, however, are determined by usability, accessibility, and digital literacy of students. The perceived quality may also be poor when there are advanced technologies with poor system design or user competence (Ng, 2012).

In general, the traditional and digital service dimensions influence PSQ in higher education. Its successful implementation based on alignment of technological systems to digital competencies empowers the digitalization to increase reliability, responsiveness, and satisfaction.

3.3 Digital Literacy

Digital literacy is the capacity to work in digital settings in an effective, safe, and responsible manner to access, evaluate, create, and share

information (Meyers et al., 2023). It goes further beyond technical-only to cognitive and socio-emotional abilities that are needed to have meaningful interaction with digital content. Digital literacy in higher education allows students to engage with academic technologies like learning management systems (LMS), e-libraries, online tests and other collaborative tools, which are crucial to academic success.

This construct consists of a number of dimensions that are interrelated. Technical skills refer to the possibility to use digital tools and programs, such as LMS and productivity tools (Elcic et al., 2022). The skills of critical thinking help students to analyze the validity and applicability of digital information in the information world that grows more complicated (Rafiq uz Zaman, 2023). Digital communication is the ability to be an ethical and effective digital Communicator, and problem-solving in digital contexts is the ability to make informed decisions using data and digital tools (Elçiçek & Kahyaoglu, 2022).

Digital literacy has become a necessity in higher education and not an option but a pre-condition to successful learning. Digital competent students are in a better position to navigate through LMS platforms, gain access to scholarly resources, undertake online assessments, and work with peers and instructors. It has empirically been identified that the more digital literate students are, the more they are prone to enhanced learning experiences, increased engagement, and self-efficacy in online and blended learning (Qinglin & Zainal Abidin, 2024; Getenet et al., 2024).

Additionally, digital literacy has a great influence on the quality of services perceived by students. Learners who have greater digital proficiency are more likely to access LMS platforms successfully and feel more satisfied with them, and individuals

with a low level of digital skills are more prone to frustration and disengagement (Alkhuzaimi et al., 2025). Digital literacy leads to better academic performance and more favorable perceptions of institutional services by improving the capacity of students to effectively use digital academic resources.

3.3 Theoretical Framework

The current research is based on the Technology Acceptance Model (TAM) and Information Systems (IS) Success Model (DeLone and McLean, 2003). TAM assumes that perceptions of usefulness and ease of use determine how individuals adopt and use technology, and thus it is applicable in understanding how students adopt and utilize digital technology like e-libraries and learning management systems (LMS) (Venkatesh and Davis, 2000). It stresses that the adoption of technology is not just based on its availability but the perception of its effectiveness and usability by the users too.

To complement this, the IS Success Model lists the system quality, information quality, and service quality as the major determinants of user satisfaction and system outcomes (DeLone and McLean, 2003). In this context, digital literacy can be characterized as a key factor because the skills of students to effectively utilize digital systems impact their perception of service quality and their overall satisfaction.

Based on these theories, the study conceptualizes the digital transformation and digital literacy as the independent variables, perceived service quality as the dependent variable. The hypothesis is that the perceived service quality is positively affected by both digital transformation and digital literacy.

3.4 Conceptual Framework:

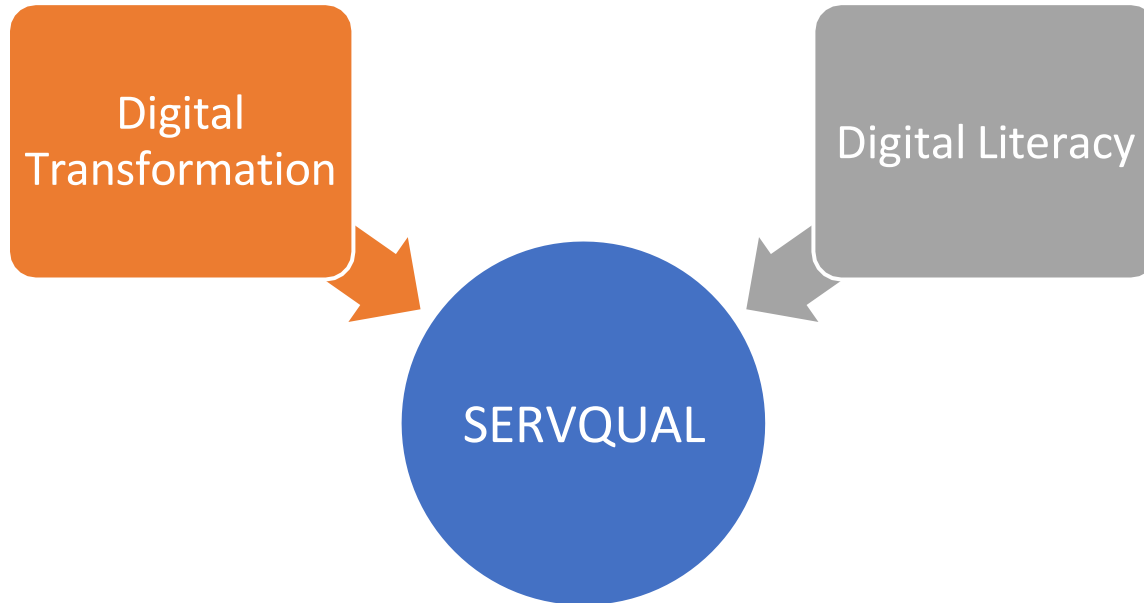


Figure 1: Conceptual Framework

Methodology

4.1 Research Design

The research design used in the study was quantitative and cross-sectional survey research design. This design suited well since it was meant to identify the relationships between digital transformation, digital literacy, and service quality (SERVQUAL) with regard to perceptions of the participants at a specific time.

4.2 Population and Sample

The sample included higher education institutions students who use digital systems (e.g., LMS and online portals). One hundred and sixty-four students were picked through predefined criteria. The convenience sampling was used because of accessibility and time limits, which is a common methodology in a survey study and appropriate when studying a perceptual construct like digital transformation, digital literacy, and service quality, although it has limited generalizability.

4.3 Operational Definitions

4.3.1. Digital Transformation

Digital Transformation refers to the extent in which an institution has strategically embraced,

implemented and used digital technologies to redesign its academic, administrative and service delivery processes. The operationalization of digital transformation in the study is based on the Digital Transformation Scale that was created by Zincirli & Polat and reflects the perceptions of institutional digital change among respondents in terms of such dimensions as digital strategy, process digitalization, technological infrastructure, and innovation orientation (Zincirli & Polat, 2025).

4.3.2. Digital Literacy

Digital Literacy describes the capability of an individual to utilize digital technologies in a way that he or she is able to access, communicate, create, solve problems, and indulge in ethical digital interactions in higher learning institutions. The Digital Literacy Scale (DLS) created and tested by Amin, Malik, and Akkaya to measure digital literacy competences in technical skills, information literacy, communication, critical thinking, and digital responsibility operationalizes digital literacy in this study (Amin, Malik, & Akkaya, 2021).

4.3.3. SERVQUAL

A Service Quality is described as the general rating of effectiveness and reliability of information system-based services by the users of an institution. Service quality in the present study is operationalized with the help of the adapted

SERVQUAL instrument of Information Systems by Van Dyke, Kappelman, and Prybutok, which is used to measure perceived service quality, in terms of five dimensions, namely: tangibility, reliability, responsiveness, assurance and empathy within an information system-enabled service setting (Van Dyke, Kappelman, & Prybutok, 1997).

Table 1
Demographic Characteristics of the Sample N (164)

Variable	f	%
Age		
18-22	105	64
23-26	54	32.9
26 onwards	5	3
Year of Study		
1 st year	15	9.1
2 nd year	44	26.8
3 rd year	42	25.6
4 th year	49	29.9
1 st year (Postgraduate)	12	7.3
2 nd year (Postgraduate)	2	1.2
Degree		
ADP	28	17
Undergraduate Programs	120	73.2
Postgraduate Programs	16	9.7

Note: f= Frequency; %= Percentage

A total of 164 participants were surveyed, and most (64%) were between 18-22 years old. A further 32.9% of respondents were aged 23-26 years, with a minority (3%) over 26 years, suggesting a young population. As for the academic year, the sample was fairly spread across the years of study, with fourth-year students being the highest (29.9%), followed by second year (26.8%) and third year students (25.6%). Only 9.1% were first-year undergraduates, and there was a smaller representation of postgraduate students (7.3% first year and 1.2% second year). In terms of course types, most students were studying

undergraduate degrees (73.2%), with advanced diploma (17%) and postgraduate degrees (9.7%) being the next most represented. In general, the sample consisted of mostly undergraduate students, with few diploma and postgraduate students.

4.4 Assessment Tools

4.4.1 Digital Transformation Scale

We measured digital transformation using the Digital Transformation Scale proposed by Zincirli and Polat (2025) which measures the degree to which institutions embrace and incorporate digital

technologies into their processes. The scale measures perceptions of digital strategy, digital process, technology infrastructure and innovation. It was rated on a Likert scale, with higher scores implying a higher perceived digital transformation. The scale has been shown to have adequate reliability and validity in previous studies.

4.4.2 Digital Literacy Scale

The Digital Literacy Scale (DLS) created by Amin, Malik, and Akkaya (2021) for higher education was used to assess digital literacy. It measures skills related to the effective use of digital technologies for learning, such as technical, information, communication, critical thinking and ethical digital technology use. The scale's responses were measured on a Likert scale, with higher scores denoting higher digital literacy. The scale has been shown to be reliable and valid for university student samples.

4.4.3 Service Quality (SERVQUAL)

A modified SERVQUAL scale for information systems designed by Van Dyke, Kappelman and Prybutok (1997) was used to measure perceived service quality. The questionnaire assesses perceptions of tangibility, reliability, responsiveness, assurance and empathy in technologically mediated services. The scale was rated on a 0-4 Likert-type scale, with higher values indicating higher service quality. The scale is extensively employed and validated in information systems and service quality studies.

4.5. Procedure

The cross-sectional survey design was used to collect data on students studying in institution of higher learning that used the digital systems actively. Once the institutional consent was given, the participants were briefed on the purpose of the study and informed consent was taken. Digital Transformation, Digital Literacy, and Service Quality (SERVQUAL) questionnaire that includes the demographic information was carried out using a structured questionnaire in English. The data were gathered using an online self-administered survey that was distributed via the institutional platform and student communication media. The involvement was voluntary and anonymous and no personal identifiable data were obtained. The responses were filtered on missing data and inconsistencies, and questionnaires that were not completed were not included in further analysis.

Results

After the completion of data collection, the data was entered in SPSS version 23.00 for further analysis. The psychometric properties and descriptive statistics of assessment measures was used to assess study variables including digital transformation, digital literacy and SERVQUAL which were sought using Cronbach's alpha and mean, standard deviation, ranges, skewness and kurtosis. The values were sought and are presented in table 1.

Table 2

Psychometric properties of Digital Transformation, Digital Literacy and SERVQUAL

Variable	n	Min	Max	M	SD	Skewness	Kurtosis	α
Digital Transformation	164	8	40	32.15	4.81	-1.25	4.04	0.877
Digital Literacy	164	96	184	131.75	15.60	0.53	0.66	0.905
SERVQUAL	164	75	190	143.14	20.01	0.02	0.56	0.971

Note. SERVQUAL = Service Quality; M = Mean; SD = Standard Deviation; SE = Standard Error. Cronbach's α indicates internal consistency reliability. The study variables were psychometrically analyzed, and the results revealed that the reliability and normality were satisfactory. There was strong internal consistency of all scales with Cronbach alpha of between 0.877 (Digital Transformation) and 0.971 (SERVQUAL), and this test shows strong reliability. The descriptive statistics revealed that the mean scores were

between 32.15 (Digital Transformation) and 143.14 (SERVQUAL), and the standard deviation was the measure of moderate variability in responses. The values of skewness and kurtosis indicated that the Distributions of Digital Literacy and SERVQUALCOMP were roughly normal, whereas Digital Transformation displayed minor negative skew implies that the majority of the scores are large, and the tail is pulled towards the left. In general, the findings allow one to assume that these tools are quite reliable and suitable to conduct further analyses.

Table 3

Pearson Product Moment Correlation between scales of Study Variables (N=164)

Variable	1	2	3
1. Digital Transformation	—	.41**	.39**
2. Digital Literacy		—	.51**
3. SERVQUAL			—

Note: * $p < .05$, ** $p < .01$

Pearson correlation analysis showed that all the variables of the study were significantly positively correlated. Digital Literacy ($r = .41$, $p < .01$) and overall perceived service quality, SERVQUAL ($r = .39$, $p < .01$) had a positive relationship with Digital Transformation, indicating that the higher the digital transformation, the higher the level of the digital literacy and the perceptions of the service quality among students. Digital Literacy showed a

positive correlation with SERVQUAL more ($r = .51$, $p < .01$) and this means that the digital competency of students is more positively correlated with their perception of service quality as opposed to digital transformation. On the whole, these results indicate that not only digital transformation but also digital literacy affects the perceived quality of services by a student, although the impact of digital literacy is a little more significant.

Table 4

Regression Coefficient of Digital Transformation, Digital Literacy

Predictor	B (Unstandardized)	SE B	β (Standardized)	t	p
Constant (Intercept)	43.257	8.533	—	5.073	< .001
Digital Transformation	0.900	0.301	0.216	2.988	.003
Digital Literacy	0.539	0.093	0.420	5.803	< .001

It was a multiple regression analysis to examine the prediction of perceived service quality by digital

transformation (DT) and digital literacy (DL). The model indicated that both DT ($B = 0.90$, $SE =$

0.30, $\beta = .22$, $t(161) = 2.99$, $p = .003$) and DL ($B = 0.54$, $SE = 0.09$, $\beta = .42$, $t(161) = 5.80$, $p < .001$) were significant positive predictors. Digital literacy showed a greater contribution to the model. The collinearity diagnostics were in reasonable range ($VIF = 1.20$), which means that there is no multicollinearity issue. On the whole, the results indicate that digital transformation and digital literacy increase the perceived service quality and the impact of digital literacy is stronger.

Discussion

This paper examined in context of emerging economies where digital literacy is alarmingly low, how institutional digital transformation, student digital literacy, and perceived service quality correlate, and had an additional interest in the role of higher education in preparing the workforce to Industry 4.0. In addition to the SERVQUAL framework, the results also indicate the impact that universities have on not only making digital technologies available to students, but also form their capacity to use it effectively. Previous studies highlight that digital transformation is not only about infrastructure but also about how students and faculty are developed into digital competencies and that the former is the key to successful learning outcomes (Tinmaz et al., 2022; Abnoulgid et al., 2025).

Findings show that digital literacy is more likely to influence the perceived quality of services, compared to institutional digital transformation. This implies that although universities invest in digital platforms and infrastructure, the effectiveness of these technologies in enhancing student performance depends heavily on the capabilities of students to access and utilize the technologies meaningfully. The existing literature supports the notion that digital competence (including abilities, knowledge, and attitudes) is essential not just to academic success but also to the future workability in digital settings (Rahmat et al., 2024). Therefore, institutional transformation opens opportunity and digital literacy defines how effective it can be in supporting learning and Industry 4.0 preparedness. In theory, the research locates digital literacy as one of the main factors to determine the readiness of Industry 4.0 (Tinmaz et

al., 2022).

Universities are facilitators of technological exposure, although the real preparedness lies in the capacity of the students to translate the exposure to practical competence (Abnoulgid et al., 2025). In practice, the results highlight the importance of comprehensive measures, combining digital infrastructure and selected skill training. This also involves training, simulations, and problem-based learning that are aligned with Industry 4.0 requirements, so that digital transformation can be transformed into competencies that are measurable and lead to better employability (Rahmat et al., 2024).

All in all, the research expands the literature by connecting the perceptions of service quality to Industry 4.0 readiness, indicating that the perceived service quality is not only a reflection of institutional efficiency but also the digital-capability of students to utilize and enjoy digital systems. It makes a conclusion that student-centered development of digital literacy and technological investments should be prioritized in universities to guarantee the achievement of meaningful results of transformation (Tinmaz et al., 2022; Rahmat et al., 2024).

Implications

- Digital literacy programs should be broadened to include Industry 4.0 skills such as data literacy, cybersecurity and digital tools.
- Technology infrastructure development should be aligned with pedagogies to ensure technology usage improves engagement and perceived quality of services.
- Universities should foster flexibility, problem solving and continuous learning to equip students for technology jobs.
- Both qualitative and quantitative indicators need to be created to better measure digital literacy and the impact of digital transformation.
- Institutions should collaborate across borders to learn and share best practices in digital literacy for global competition.
- Alumni tracking should be undertaken to assess digital skills and employability in Industry 4.0 jobs like smart manufacturing.

Limitations

- Cross-sectional analysis does not allow for causal inference of digital transformation, digital literacy and service quality; longitudinal research is advised.
- Results could be affected by self-report and social desirability bias; objective measures of digital literacy are recommended.
- The research is confined to one Pakistani university and may not be generalizable; studies encompassing multiple institutions are required.
- Factors such as digital self-efficacy, motivation and engagement were not tested.
- Employability and organizational performance outcomes of digital skills were not directly examined

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