An Empirical Study on the Impact of Digital Transformation on Teacher Education Institutions

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Abstract

The rapid development of digital technologies has radically transformed teacher education institutions, transforming the pedagogical practise, operations of the institutions and faculty competencies. Based on these five main dimensions, which are investigated in this empirical study to understand how digital transformation affects quality of teacher education by usung variables like digital infrastructure, faculty digital competence, technology-enabled teaching-learning practises, institutional digital support and leadership, and digital learning resources & content. To use a quantitative, descriptive-analytical research design, a structured questionnaire was used to collect primary data with 200 teachers that were chosen with the help of simple random sampling method. The answers measured on a 5 level Likert scale and the instrument exhibited a satisfactory degree of reliability with the Cronbachs coefficients of alpha being higher than 0.70. The SPSS was used in data analysis, and such statistical methods as descriptive statistics& Inferential statistics were applied.

The results show that the five dimensions of digital transformation have significant impact on the quality of teacher education at the 5% level of significance. Digital competence in faculty was the strongest predictor (50.7) with technology enabled teaching learning practises at number two (47.5), digital learning resources and content (41.6) and digital infrastructure (40.2) followed by digital support and leadership in institutions (35.8). There was a large practical significance, as all effect sizes were large, based on Cohen f 2. As a result, all the null hypotheses were rejected and the alternative hypotheses accepted.

The paper concludes that digital transformation, as a whole, i.e., infrastructure, trained faculty, innovative approaches to teaching, a supportive administration and quality digital content is a key to improving the quality of teacher education. The results present powerful suggestions to policymakers, institutional administrators, and educators who would like to enhance teacher education by introducing digital programmes with a well-calculated strategy.

Introduction

The rapid growth of digital technologies has introduced the concept of change at all levels of education, and the institutions of teacher training are one of the most affected fields. Digital transformation in teacher education is not only the adopting of technology but also includes the adoption of digital infrastructure, the emergence of new pedagogical practises, faculty competencies, and institutional leadership, all of which are directed towards improving the quality of education. As the future teachers prepared to respond to the needs of the technology

driven classroom, teacher education institutions are under increasing pressure to match their methods of instruction and their structures with the modern digital developments.

The technology role in pedagogy and learning has evolved over the past years regarding it being an additional support mechanism in education to forming the core part of the delivery process. The digital infrastructure such as learning management systems, smart classrooms, high-speed internet and online assessment tools has enhanced access, efficiency and flexibility of teacher training programmes. Simultaneously, the faculty digital competence has become one of the key variables of an appropriate technology integration, affecting the design of instruction, interaction with learners, and the development of pedagogical competencies by teacher trainees. Learning experiences and educational outcomes are also enriched by technology-based teaching-learning practises alongside high-quality availability of digital learning resources, which enhances the educational process.

In spite of the increasing investments in digital endeavours, differences still exist in the effectiveness by which teacher education institutions adopt and utilise digital transformation strategies. Digital support in institutions, leadership dedication, and the policy frameworks are critical in maintaining and expanding the technology integration exercise. However, there is little empirical examination that is to determine the collective effect of these digital dimensions on the quality of teacher particularly in the background of the developing education systems. In this respect, the current research paper attempts to empirically investigate the effects of digital transformation on teacher schools, consider major digital variables that determine the effectiveness of teaching, institutional performance, and the general quality of teaching.

Literature review

The (TPACK) framework has been proposed by Mishra and Koehler (2006) and the scholars believe that successful teacher learning and instruction cannot be achieved without combining knowledge of technology with pedagogical & knowledge. Their case study highlighted the role of teacher educator digital competence in preparing the future teacher to work in technology-intensive classrooms.

Ertmer and Ottenbreit-Leftwich (2010) also examined the obstacles to the implementation of technology and established that faculty perceptions, institutional backing and access to digital architecture play a significant role in determining the use of technology-based teaching approach in institutions of teacher education.

Fullan (2013) stated that strong institutional leadership, favourable policies and ongoing professional growth are key components of achieving sustainable digital change in education. His authorship highlighted leadership as one of the sources of streamlining digital efforts to fit institutional objectives.

Selwyn (2016) critically discussed the reforms in digital education and claimed that integration of technology should be considered as an organisational and cultural change, not just a technical upgrade, especially in the educational context of teachers.

Redecker (2017) created the DigCompEdu model that identified some key digital competencies of the educators and emphasised that the ability to access high-quality digital learning materials and content would improve instruction quality and professionalism.

According to OECD (2019), institutions of teacher education that have well-established digital infrastructure and institutional support systems have a higher quality of teaching, engagement with learners, and professional readiness.

The digital readiness of teacher educators was studied by Konig et al. (2022), who discovered that digital competence and institutional support were key predictors of effective teaching practises online and using blended teaching methods in teacher education programmes.

Based on their review of digital competence models, Rakisheva and Witt (2023) concluded that teacher education institutions have to contextualise the development of digital skills to make sure that they align with the pedagogical objectives and the needs of their institutions.

The study by Dang (2024) empirically showed that faculty digital competence significantly affects teaching effectiveness and perceived learning value in a positive way, which supports the necessity of ongoing acquisition of digital skills by teacher educators.

Wagner (2024) analysed the issue of digital transformation in teacher education and stated that, despite the growth of the integration of technologies, there is still a lack of pedagogical integration and support of institutional leadership, which, in turn, leads to the need to plan digital changes strategically.

All in all, the literature analysis has shown that digital infrastructure, faculty digital competence, technology-enabled teaching practise, institutional support and leadership, and digital learning resource, all play a role in the overall quality of teacher education. The studies form a solid theoretical and empirical basis on which the effects of the digital transformation dimensions can be studied in the current research.

Research Gap

Most of the existing literature on digitization in education has concerned the adoption of digital technologies at an abstract institutional or policy level, with much of the literature addressing the outcome of student learning, online education platforms or the integration of ICTs in higher learning in general. But there are still few systematic empirical studies that clearly and exclusively focus on teacher education quality based on a number of digital dimensions. Majority of the previous research is more likely to conceptualise digitization as a unit, thus ignoring the differentiated contribution of digital infrastructure, faculty digital competence, technology-enabled pedagogical practises, institutional digital leadership, and digital learning resources on teacher competence.

Moreover, despite the fact that a number of studies recognise the significance of faculty digital competence, a gap in the comprehension still exists on how faculty competence works in isolation of other digital enablers to impact the outcome of teacher education. The studies that discuss the technology-enabled teaching-learning practises tend to be abstract or qualitative whereby, little reliance is made on firm statistical models to establish the extent to which they actually influence pedagogical effectiveness. On the same note, institutional digital support and leadership have been represented primarily in an administrative or policy lens, and empirical data on their primary role in teacher education quality and instructional enhancement is very limited.

Secondly, little focus has been laid on the quality, relevance and accessibility of online learning materials and text in the teacher education, especially in developing and transitional education systems. Most of the available literature is based on qualitative observations or small sample sizes which means that a generalisation cannot be done. Thus, the necessity to conduct a hypothesis-based, quantitative study, analysing the personal and relative influence of various dimensions of digitization on the teacher education's quality is evident.

General Objective

This paper aims at discussing how digitization affects the competence of Teacher's in educational institutions

Specific Objectives

- To investigate how digital infrastructure affects teaching, especially the efficiency of its operations and pedagogical results it facilitates.
- In order to examine the role of faculty digital competence in teacher education.
- To determine the effect of technology-depends teaching-learning practises on teacher education
- To examine the use of institutional digital support and leadership to improve teacher education, the policy frameworks and resource allocation should be assessed.
- To assess the effects of digital learning materials and content on teacher education, assessing the relevance, accessibility and alignment to the instructions.

Hypotheses (H_0)

H_{01}: There is no substantial impact of **digital infrastructure** on teacher education.
H_{11}: There is a substantial impact of **digital infrastructure** on teacher education.
H_{02}: There is no substantial impact of **faculty digital competence** on teacher education.
H_{12}: There is a substantial impact of **faculty digital competence** on teacher education.
H_{03}: There is no substantial effect of **technology-enabled teaching–learning practices** on teacher education.
H_{13}: There is a substantial effect of **technology-enabled teaching–learning practices** on teacher education.
H_{04}: There is no substantial effect of **institutional digital support and leadership** on teacher education.
H_{14}: There is a substantial effect of **institutional digital support and leadership** on teacher education.
H_{05}: There is no substantial effect of **digital learning resources & content** on teacher education.
H_{15}: There is a substantial effect of **digital learning resources & content** on teacher education.

Research Methodology

A quantitative and descriptive-analytical research design was used in the current research in an attempt to investigate the effect of the variables of digital transformation on teacher education quality. The survey methodology used was cross-sectional survey and gathered primary data with teacher educators who are working with teacher education institutions. Under the simple random sampling structure, 200 respondents were sampled, which seemed adequate in the

further correlation and regression studies. Quality of teacher education was the dependent variable, with digital infrastructure, digital competence of the faculty, teaching learning practises technology enabled, institutions with digital support and leadership, and digital learning resources and content as independent variables.

The collection of data use of a structured questionnaire which was developed through a profound examination of the relevant literature. To quantify the perceptions of respondents the instrument used a five-point Likert scale, that is, strongly disagree (1) to strongly agree (5) scale. The expertise was used to assure content validity and internal consistency reliability was acceptable with all constructs having a Cronbach alpha value of more than 0.70. The ethical issues, i.e. voluntary participation, informed consent and confidentiality of the responses, were strictly ensured during the data-collection process.

The collected information was evaluated through the SPSS software. The data were summarised using descriptive statistics followed by the Pearson correlation analysis of the data to determine the strengths and direction of the inter-variable relationships. Each hypothesis was tested by means of simple linear regression and thus established the predictive effect of each digital factor on teacher education quality. The significance of models was determined by R, F statistic, t-test, and p-test, and Cohen f^2 was determined to determine the strength of the effects. Each of the hypotheses was tested with a 5%significance threshold, which gave solid and trustworthy empirical results.

Hypothesis-Wise Statistical Analysis for Research Paper

HYPOTHESIS 1 (H_{01} & H_{11}): Digital Infrastructure

Table 1.1: Descriptive Statistics - Digital Infrastructure

Variable	N	Mean	SD	Std. Error	Min	Max	Variance
Digital Infrastructure	200	3.52	0.72	0.051	1.5	5	0.518
Teacher Education Quality	200	3.45	0.68	0.048	1.2	5	0.462

Table 1.2: Correlation Analysis - Digital Infrastructure

Variables	Digital Infrastructure	Teacher Education Quality
Digital Infrastructure	1	.634**
Teacher Education Quality	.634**	1

Table 1.3: ANOVA - Digital Infrastructure

Model Summary	SS	DF	MS	F-value	Significance
Regression model	37.184	1	37.184	133.42	0
Residual model	55.184	198	0.279		
Total	92.368	199			

Table 1.4: Regression Coefficients - Digital Infrastructure

Variable	B	Std. Error	β (Beta)	t	Sig.	95% CI
(Constant)	1.324	0.196	-	6.755	0	[0.938, 1.710]
Digital Infrastructure	0.604	0.052	0.634	11.551	0	[0.501, 0.707]

Interpretation: As a result of the analysis, digital infrastructure has a significantly positive effect on the quality of teacher education (b = 0.634, t =11.551, p = 0.001). The model explains 40.2 percentage of total variation by the quality of teacher-education (R^2=0.402). The magnitude of the observed effect size, Cohen's f^2 = 0.672, indicates that it is large, which highlights significance.

HYPOTHESIS 2 (H_{02} & H_{12}): Faculty Digital Competence

Table 2.1: Descriptive Statistics - Faculty Digital Competence

Variable	N	Mean	SD	Std. Error	Min	Max	Variance
Faculty Digital Competence	200	3.38	0.65	0.046	1.8	5	0.423
Teacher Education Quality	200	3.45	0.68	0.048	1.2	5	0.462

Table 2.2: Correlation Analysis - Faculty Digital Competence

Variables	Faculty Digital Competence	Teacher Education Quality

Faculty Digital Competence	1	.712**
Teacher Education Quality	.712**	1

Table 2.3: ANOVA - Faculty Digital Competence

Model Summary	SS	DF	MS	F-value	Significance
Regression model	46.821	1	46.821	203.82	0
Residual model	45.547	198	0.23		
Total	92.368	199			

Table 2.4: Regression Coefficients - Faculty Digital Competence

Variable	B	Std. Error	β (Beta)	t	Sig.	95% CI
(Constant)	0.834	0.182	-	4.582	0	[0.475, 1.193]
Faculty Digital Competence	0.745	0.052	0.712	14.277	0	[0.642, 0.848]

Interpretation: There is a significantly positive influence of faculty digital competence on the quality of teacher education (b = .712, t = 14.277, p =.000). The model explains 50.7 0 of the variances (R^2 =.507), which is more explained by any of the remaining predictors. The effect size is very large (Cohen f^2 =1.028), which highlights an important and commanding role. Hypothesis H_{02} is debated away in favour of H_{12}.

HYPOTHESIS 3 (H_{03} & H_{13}): Technology-Enabled Teaching–Learning Practices

Table 3.1: Descriptive Statistics - Technology-Enabled Practices

Variable	N	Mean	SD	Std. Error	Min	Max	Variance
Tech-enabled Teaching Practices	200	3.41	0.7	0.05	1.4	5	0.49
Teacher Education Quality	200	3.45	0.68	0.048	1.2	5	0.462

Table 3.2: Correlation Analysis - Technology-Enabled Practices

Variables	Tech-enabled Practices	Teacher Education Quality
Tech-enabled Teaching Practices	1	.689**
Teacher Education Quality	.689**	1

Table 3.3: ANOVA - Technology-Enabled Practices

Model Summary	SS	DF	MS	F-value	Significance
Regression model	43.862	1	43.862	179.31	0
Residual model	48.506	198	0.245		
Total	92.368	199			

Table 3.4: Regression Coefficients - Technology-Enabled Practices

Variable	B	Std. Error	β (Beta)	t	Sig.	95% CI
(Constant)	1.128	0.189	-	5.968	0	[0.756, 1.500]
Tech-enabled Practices	0.67	0.05	0.689	13.39	0	[0.571, 0.769]

Interpretation: The effect of the technology-enabled practises of the teaching-learning on the quality of teacher education is shown to have a strong positive effect with a standardised coefficient of b =.689, t =13.390, and p-value less than.001. To this end, the model explains 47.5 per cent of the variance (R^2 =.475). Cohen f^2 = 0.905 that is calculated and falls under the large effects threshold is an indicator of a significant effect.

HYPOTHESIS 4 (H_{04} & H_{14}): Institutional Digital Support and Leadership

Table 4.1: Descriptive Statistics - Institutional Support

Variable	N	Mean	SD	Std. Error	Min	Max	Variance
Institutional Support	200	3.29	0.74	0.052	1.3	5	0.548
Teacher Education Quality	200	3.45	0.68	0.048	1.2	5	0.462

Table 4.2: Correlation Analysis - Institutional Support

Variables	Institutional Support	Teacher Education Quality
Institutional Support	1	.598**
Teacher Education Quality	.598**	1

Table 4.3: ANOVA - Institutional Support

Model Summary	SS	DF	MS	F-value	Significance
Regression model	33.062	1	33.062	110.35	0
Residual model	59.306	198	0.3		
Total	92.368	199			

Table 4.4: Regression Coefficients - Institutional Support

Variable	B	Std. Error	β (Beta)	t	Sig.	95% CI
(Constant)	1.635	0.203	-	8.054	0	[1.235, 2.035]
Institutional Support	0.55	0.052	0.598	10.504	0	[0.447, 0.653]

The leadership and the provision of the digital support role by the institution has a demonstrable significant positive effect on the quality of teacher education (b =.598, t = 10.504, p -.001). This model explains 35.8 percent of the variance (R^2 =.358). The size of the effect, the coefficients f^2 = 0.558, has an impressive practical scale.

HYPOTHESIS 5 (H_{05} & H_{15}): Digital Learning Resources and Content

Table 5.1: Descriptive Statistics - Digital Learning Resources

Variable	N	Mean	SD	Std. Error	Min	Max	Variance
Digital Learning Resources	200	3.48	0.69	0.049	1.6	5	0.476
Teacher Education Quality	200	3.45	0.68	0.048	1.2	5	0.462

Table 5.2: Correlation Analysis - Digital Learning Resources

Variables	Digital Learning Resources	Teacher Education Quality
Digital Learning Resources	1	.645**
Teacher Education Quality	.645**	1

Table 5.3: ANOVA - Digital Learning Resources

Model Summary	SS	DF	MS	F-value	Significance
Regression model	38.425	1	38.425	141.14	0
Residual model	53.943	198	0.272		
Total	92.368	199			

Table 5.4: Regression Coefficients - Digital Learning Resources

Variable	B	Std. Error	β (Beta)	t	Sig.	95% CI
(Constant)	1.188	0.194	-	6.124	0	[0.806, 1.570]
Digital Learning Resources	0.636	0.054	0.645	11.88	0	[0.530, 0.742]

Interpretation: The empirical study indicates that the application of digital learning facilities and content has a significant impact on the quality of teacher education since the higher index (0.645) exhibits a statistically significant value (t=11.880, p=.001). Regression model would explain 41.6 percent of the variation in the outcome variable (R^2 =.416). The effect size is huge, as Cohen f^2 is 0.712, which thus dictates a significant effect.

SUMMARY TABLE: All Hypotheses Testing Results

Table 6: Comprehensive Hypothesis Testing Summary

Hypothesis	Variable	r	R^2	β	t-value	p-value	F	Cohen's f^2	Decision
H_{01}	Digital Infrastructure	.634**	0.402	0.634	11.551	< .001	133.42	0.672 (Large)	Reject H_{01}

H_{02}	Faculty Digital Competence	.712**	0.507	0.712	14.277	< .001	203.82	1.028 (Large)	Reject H_{02}
H_{03}	Tech-enabled Practices	.689**	0.475	0.689	13.39	< .001	179.31	0.905 (Large)	Reject H_{03}
H_{04}	Institutional Support	.598**	0.358	0.598	10.504	< .001	110.35	0.558 (Large)	Reject H_{04}
H_{05}	Digital Learning Resources	.645**	0.416	0.645	11.88	< .001	141.14	0.712 (Large)	Reject H_{05}

Findings

The results of the empirical study make it clear that digitization process has a determinative impact on teacher education standards in various aspects. The quantitative data support the fact that the strong digital infrastructure, that is, the presence of high-quality internet connectivity, a variety of digital gadgets, and advanced learning management systems, improve the efficiency of instruction and pedagogical results considerably. Regression analyses support the fact that the influence of digital infrastructure on the teacher-education quality is statistically significant and warrants considering it as the basis of the conditions under which digital teaching and learning may take place today.

We find that teachers who have superior digital proficiency, technological efficacy as well as instructional adaptability exhibit an increased ability to include digital tools in their pedagogical arsenal and, therefore, create high-quality educational results. The significant positive effect of the technological-mediated teaching learning practices also confirms the vitality of successful implementation of digital platforms, interactivity resources, and blending learning modalities in improving the teaching learning process and enhancing learner engagement. Besides, it was observed that institutional digital support and strategic leadership have a significant impact on teacher-education quality; proactive policies, specific resource allocation, and visionary leaders are inevitable in building a digitally accommodating academic environment.

Also, digital learning resources and content were found to be important predictors of quality of teacher education. The results can imply that the ability to access high-quality, relevant, and curriculum-based digital materials will improve the effectiveness of the teaching process and assist teachers and educators in their professional development. The general idea of this research is that the quality of teacher education is not predetermined by one particular digital

variable, but a complex system of ecosystem that incorporates infrastructure, faculty capacity, pedagogical creativity, institutional support, and learning materials.

Suggestions

According to the results, the article recommends that schools must focus on building and constantly upgrading the digital infrastructure in order to have constant access to digital tools and platforms. The high-speed internet, smart classrooms, and learning management system should be invested in to facilitate successful digital teaching and learning. The institutions also need to pay attention to family digital competence by developing faculty members on a regular basis using professional development programmes and hands-on training workshops as well as continuous mentoring programmes that will help improve the technological and pedagogical abilities of teachers.

Moreover, by implementing blended learning approaches, interactive online resources, and creative evaluation plans into the teacher training programmes, institutions are advised to advance teaching learning application with the help of technology. The leaders within the institution will have to be proactive in promoting digital innovation by developing clear digital policies, equal distribution of resources, and creating a culture to enhance the use of digital innovation. Good leadership dedication is a key building block to the long-term digital transformation in teacher education institutions.

Lastly, the research advises institutions to invest on the creation and upkeep of high quality digital learning resources that are affordable, pertinent, and centrally on the goals of instruction. The possible results are improved instruction and learning by educators through collaboration, open educational resources, and digital repositories.

Conclusion

The current research finds that the effects of digitization have a significant and beneficial impact on teacher education quality in institutions. Empirical evidence shows conclusively that the digital infrastructure, faculty digital competence, technology-enabled teaching-learning practises, institutional digital support and influence, and digital learning resources all play important roles in enhancing teacher education outcomes. These factors yielded a significant relationship between faculty digital competence as the most powerful predictor, which is a core and central attribute to the significance of digital competence of teachers in the successful application of technology in the pedagogical process.

The research also confirms that teacher education effectiveness is informed by an integrated digital ecosystem as opposed to a technological intervention. Although effective digital infrastructure is the key to the required framework, other elements such as skilled staff, innovative teaching-learning processes, effective institutional management, and access to quality digital learning resources are what enhance its effectiveness. The large variance of each of the digital dimensions is a testament that strategic digital integration improves teaching effectiveness, pedagogical competence, and professional growth in institutions of teacher education.

In general, the research offers good empirical evidence of the need to conduct systematic digital transformation of teacher education. When the process of digitization is holistic, the

educational institution can improve the competence of teachers, the teaching quality, and the effectiveness of the institution.

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