

The Causal Pathways to Digital Teaching Competence: A Structural Analysis of Key Predictors of Teacher Education Programs in Karachi, Sindh

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ABSTRACT

The use of Pedagogical Digital Literacy (PDL) enhances the teaching of modern educators, with the integration of digital competency in Sindh, Pakistan. In developing countries, digital competency is often ineffective. Understanding the gap, the current study identifies the impact of PDL core competencies on the pre-service teachers' training efficiency in Karachi, Pakistan. The four key competencies are such as, Information & Data Literacy, Communication & Collaboration, Digital Content Creation, and Safety & Well Being. The study used a cross-sectional survey research design, where, based on a simple random sampling technique, 200 prospective teachers were selected for the distribution of the adapted research questionnaire on a five-point Likert scale. The findings indicate that these four core digital competencies significantly predict the Pedagogical Digital Literacy among the prospective teachers in the universities of Sindh, Pakistan. Contrary to that, the influence varies, the communication & collaboration strongly predict PDL of the prospective teachers with p value < 0.05 , and Beta at 0.727, and digital content creation significant but slightly weaker predictor to PDL of the prospective teachers with Beta 0.285 and p value < 0.001 . These results are evident to provide directives for the teacher education to reform the curricula in context to digital communication, collaboration skills, and competencies, developing a more effective teaching model for the future teachers of the education sector in Sindh, Pakistan. Indicating that future researchers are suggested to work on digital content creation, contextual barriers the access to digital resources, training in self-efficacy to pedagogical approaches, and sustainable development to address the resource-constrained situations in the higher education classrooms and practices.



Introduction

The use of digital technologies has transformed the global education pedagogical competencies (Rasskazova et al., 2020), where Pedagogical digital literacy is effective with the ability to integrate digital tools in classroom practices, despite the traditional teaching and learning processes (Falloon, 2020). The international frameworks, such as the European Union's DigCompEdu, are an effective structure and model for the educational curricula and pedagogical practices (Caena & Redecker, 2019), drawing key digital competencies in transforming the skills of the future graduates, educators, and teachers (Ghomi & Redecker, 2019). In developing countries, such models can become benchmarks to global standards, with an educational landscape to mark a significant digital competency (Santos & Pedro, 2024), while drawing a solution to pedagogical tension, and to application in practices. In Pakistan, PDL can be unrealistic for teacher trainings, a desperate gap between rural and urban higher education institutions (Soomro et al., 2020).

In the developing countries, emphasis on digital competency frameworks became popular during the Covid-19 pandemic, where the traditional approach of pedagogical practices was no longer needed, and to meet learning with distance was only possible with the training on the application of digital pedagogy in educational practices (Habib & Soomro, 2021). The policy initiatives such as Digital Pakistan Vision remained ineffective with the lack of implication mechanism (Shahzad, Ahmed & Khan, 2024), this led to a critical gap of identifying the digital competencies, with a contribution of the PDL as a framework to base the competency in the teacher training programs, especially for the pre-service and trainee teachers in Pakistan (Basal, 2022).

The digital competency gap in developing countries like Pakistan needs scientific studies to observe the impact of core digital competencies on the pedagogical digital literacy among the prospective teachers in the university classrooms and practices. The study aims to examine PDL into core competencies, developing the teaching skills of prospective teachers in higher education classrooms, practices in Karachi, Pakistan. This study can provide key informants about the digital teaching skills in effective teaching frameworks towards digital competency among the prospective teachers in Pakistan's higher education classrooms practices.

Literature Review

Theoretical Foundation

In connection with the study's nature and problem, the study was closely connected to the theoretical framework of Bandura's Social Cognitive Theory (SCT), which originated in 1986, laying a foundational stone of individual behavior dynamics, influences on the behavioral factors, and environmental conditions (Zhou et al., 2023). However, using this theory leads to understanding the teachers' digital competencies, and can trigger an effect on digital teaching practices with key competency forces. In line with Technological Pedagogical Content Knowledge (TPACK) (Nilsson, 2022) or any other framework such as DigCompEdu, can be more strengthened in practically executing the theoretical lens of SCT (Mishra & Koehler, 2006). This theoretical foundation possibly offers a base to the transformation of the knowledge via teachers to revolutionize the content, pedagogy, and technology as a triangular model in the teaching learning procedure. The theory SCT has a primary focus on behavior change, where core technologies can be integrated to have a foundational base for that social cognitive transformation among the university graduates (Li et al., 2024).

Connection of Pedagogical Digital Literacy & Innovation to Core Competencies

The Pedagogical digital literacy (PDL) is a complex digital competency with basic technical skills, where critical abilities in the integration of digital tools are often under operation. However, this includes practice of teaching, learning, and assessment with digital sources (Guitert, Romeu & Baztán, 2021). Studying the global framework, DigCompEdu in connection to PDL for the digital competency model context of Pakistan (Vuorikari, Kluzer & Punie, 2022). The DigCompEdu framework is further illustrated by Cabero-Almenara et al. (2023) as in the following figure, which indicates professional competences, Pedagogical competence, and learners' competences. This offers digital competencies to transform teaching, learning, and assessment in classroom practices at higher education or adult education.

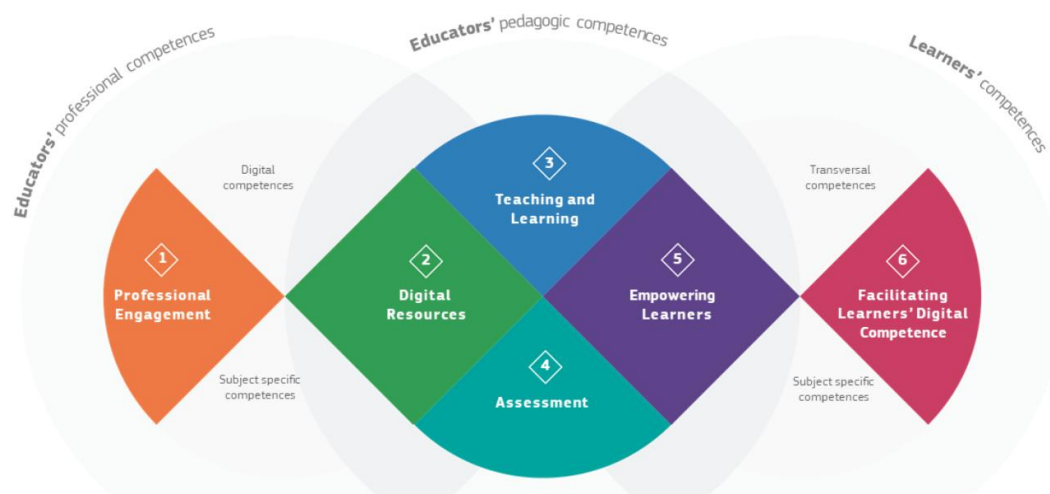


Figure 1: DigCompEdu Framework

Information and Data Literacy for Prospective Teachers

The digital competencies, such as information and data literacy (IDL), are a core ability of PDL to recognize, discover, assess, and manage any digital information (Redecker & Punie, 2017). Digital competence is important towards pedagogical transformation, while crucial to strengthen the educators, i.e., prospective teachers, with the information of digital tools, in connection to pedagogical transformation, dealing with content, teaching methods, and assessment at undergraduate and postgraduate classrooms (Ala-Mutka, 2011). Teachers with IDL skills can change the students' learning behavior with digital literacy skills, providing information and integration skills. Hence, the study made efforts to test hypothesis 1:

H1: Information and data literacy has a significant effect on pedagogical digital literacy among the prospective teachers in university classrooms.

Communication and Collaboration: Transformation of Digital Pedagogy

Communication and collaboration are effective sources for digital tools application, interaction for the social construction of learning, as directed by Vygotsky in the constructivist approach (Vygotsky, 1978), and in connection to the social cognitive theory of Bandura. In developing a socio-constructivist approach, which directs academic practices, for instance, emails, online or virtual classrooms, collective and collaborative learning, students' engagement, and educators' digital teaching competencies (García-Vandewalle García et al., 2023). The study was conducted to test the hypothesis in this regard, such as:

H2: Communication and collaboration have a significant effect on the pedagogical digital literacy among the prospective teachers in university classrooms.

Digital Content Creation in Pedagogical Approaches

Digital content creation is a skill in designing, editing, producing media, illustration, and instructional materials. Using the theory of Cognitive Multimedia learning can be an effective theoretical lens, in connection to SCT (Çeken & Taşkın, 2022), drawing materials in using multimedia projections for effectively promoting educators as prospective teachers, drawing a foundational base for the content, pedagogy, and assessment procedures, teaching the prospective teachers with the triangulation framework, having critical teaching pedagogies, and evaluation models. Enabling prospective teachers with digital content creation skills can connect them with the digital cognitive transformation, integrating digital tools with teaching approaches in the teaching-learning processes. This has led to testing the association between DCC and PDT among prospective teachers, i.e.:

H3: Digital content creation has a significant effect on the pedagogical digital literacy among the prospective teachers in university classrooms.

Safety and Well-being for Digital Ethics

The studies indicate that in the digital transformation, the requirements for safety and well-being are important to follow the digital ethics towards cybersecurity, data privacy, and considerably integrating a Digital Citizenship model (Mattson, 2024). The digital ethical behaviors with a DC model can manage to protect personal information, with an effective digital engagement, and a transformative, healthy learning environment for the trainee teachers in the university (Lachheb et al., 2023), and teacher training programs in Pakistan (Ameer & Hukamdad, 2025). Following the ethical digital environment, the study made efforts to test hypothesis 4, such as:

H4: Safety and well-being towards digital ethics have a significant effect on the pedagogical digital literacy among the prospective teachers in university classrooms.

Conceptual Framework

The study in nature to investigate the impact of core digital competencies on the Pedagogical digital literacy among the prospective teachers, integrating the theoretical frameworks such as SCT and TPACK, positing the DigCompEdu model, with the specific competencies effectively illustrated in Figure 02. Considerably, the conceptual framework illustrates the digital competencies as the independent variables, such as information and data literacy, communication & collaboration, digital content creation, and safety & well-being, as demonstrated further:

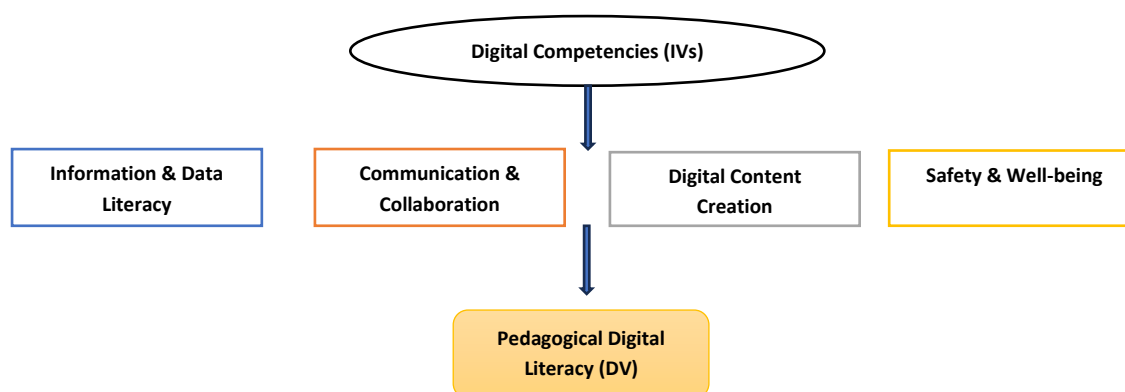


Figure 2: Conceptual Model

Research Methods

The study adopted a quantitative cross-sectional survey research design, which is an appropriate method for efficiently collecting numerical data from a larger sample size. This helps to enable the relationships of key constructs as measurable variables (Saunders, Lewis & Thornill, 2009). The research was conducted using the natural setting, approaching the participants from the university campuses, assuring the academic excellence of the prospective teachers' digital transformation into Pedagogical skills.

Moreover, the study used the simple random sampling method to draw the sample size from the target population, who were prospective teachers of B.Ed. Hons. Programs were targeted at the public and private universities in Karachi, Pakistan. The use of probability sampling, where the SRS method is used to give every individual participant an equal chance of selection. Four universities' teacher education programs from the department of education were targeted, and a list of department students' number was received from which, randomly, the participants were selected, targeting the University of Karachi, Sindh Madressatul Islam University, Iqra University Gulshan Campus, and Greenwich University in Karachi, Pakistan. From each university, 50 prospective teachers enrolled in B.Ed. Honors programs were randomly selected for a total sample size of 200 from four universities' selected departments and teaching programs. The sample size was considered adequate to lead correlation and regression analysis for the testing of research hypotheses (Nanjundeswaraswamy & Divakar, 2021).

The study adapted a research scale from the digital competency frameworks, such as DigCompEdu using the TPACK framework (Mishra & Koehler, 2006), which instructed to measure five constructs, as key variables to study the relationships, considering the 05-point Likert scale, using the ranges such as Strongly Disagree to Strongly Agree, scaling 01 to 05 (SDA, D, UD, A, SA) scoring. Hence, the operationalization of the scale constructs as described in Table 1:

Table 1: Operationalization of Constructs and Reliability

Constructs	Operational Definition	No. of Items	Sample Item	Measurement Scale	References of Scale Adaption	Pilot Study Reliability (Cronbach's Alpha)
Information & Data Literacy	Ability to locate, evaluate, and manage digital information.	3	"I can evaluate the credibility and reliability of different digital data, information, and content."	1 Strongly Disagree to 5 Strongly Agree	DigCompEdu framework (Redecker & Punie, 2017) & (Caena & Redecker, 2019)	0.85
Communication & Collaboration	Proficiency in using digital tools for academic interaction and teamwork.	6	"I can recommend suitable digital tools and technologies for collaboration and teamwork."	1 Strongly Disagree to 5 Strongly Agree	TPACK framework (Mishra & Koehler, 2006)	0.89
Digital Content	Skills to	4	"I can create	1 Strongly	Adapted from	0.83

Creation	create and edit multimedia content.		and edit content using text, video, graphic design, and presentation software."	Disagree to 5 Strongly Agree	digital pedagogy instruments (Pongsakdi et al., 2021)	
Safety & Well-being	Knowledge of cybersecurity, data privacy, and digital ethics.	4	"I can protect my personal information and privacy while using digital technologies."	1 Strongly Disagree to 5 Strongly Agree	Ribble's Digital Citizenship framework, applied in Pakistani context (Ameer & Hukamdad, 2025)	0.81
Pedagogical Digital Literacy & Innovation	Using digital tools to solve academic and technical problems.	4	"I can use digital technologies to create knowledge and collaborate on innovative projects."	1 Strongly Disagree to 5 Strongly Agree	DigCompEdu (Redecker & Punie, 2017) & TPACK (Mishra & Koehler, 2006) & (Ghomi & Redecker, 2019)	0.86

Before the distribution of the questionnaire scale to the targeted sample size, a separate sample of 30 prospective teachers was distributed to measure the instrument's reliability and validity, to be used further in the research study. However, the Cronbach's Alpha was calculated in the pilot study, and the internal consistency between the constructs was in the range of 0.80, good enough to be considered in the study data collection and drawing key findings. With a zero-order correlation matrix calculation, measured to indicate that study instrument shows a p value < 0.05 (or 0.01), resulting in a significant instrument in observing the core relationships, and good construct validity measures (Pallant, 2020).

Data Analysis

Demographic Information

University Type

The sample size of respondents belonged to both public and private universities of Karachi, in Sindh, Pakistan, where the majority of the respondents who participated in the data collection process were from public sector universities, covering 80.5% of the sample size as described in Figure 3, while the private sector respondents were very less, covering 19.5%. This shows that most of the private prospective teachers did not provide their consent to provide the data on the digital competencies with core digital potentials in respect to pedagogical digital literacy at a university level classroom, and training of the trainee teachers in teacher education programs in Karachi, Sindh.

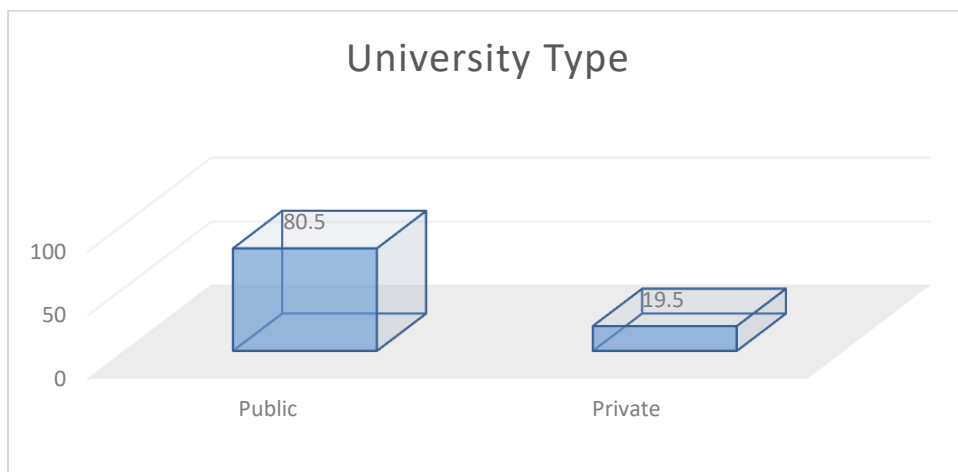


Figure 3: University Type

Age

The age distribution in the research scale in the collection of data was 18-21 years, 22-25 years, 26-29 years, and 30 years or above. Most of the respondents age category fall at 18-21 years old, studying in their early B.ED hon's program at 77%, and other age category of respondents are less following 22-25 years were 16.5%, 30 years or above covering 4.5% and least from 26-29 years old respondents in studying as prospective teachers in the public and private universities in Karachi, Sindh, with the skills of digital competencies via digital pedagogical literacy in classrooms practices. It indicates most of the respondents were in early semesters of their Bachelor of Education degree program.

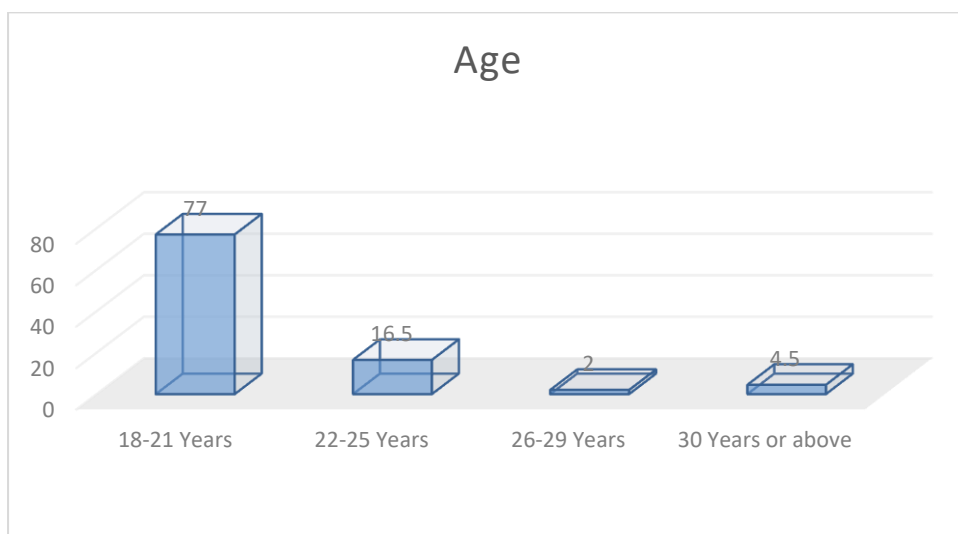


Figure 4: Age of Respondents

Teaching Experience

The respondents had teaching experiences where most of the prospective teachers mentioned having 01 year of teaching experience, most were in the process of training in the B.Ed. Honors program at the university level. This covers 53% of the participants, where 18% had teaching experience, and 0.5% with 0% of teaching experience. However, less but second second-highest range of teaching experience indicated 02 years, at 12.5%. Others 5.5% both at 05 & 03 years of teaching experience, and 04 years with 05% of experience. This shows that most of the teaching

experience ranges from 01 and 02 years, studying in their first or second year of graduation at the university level.

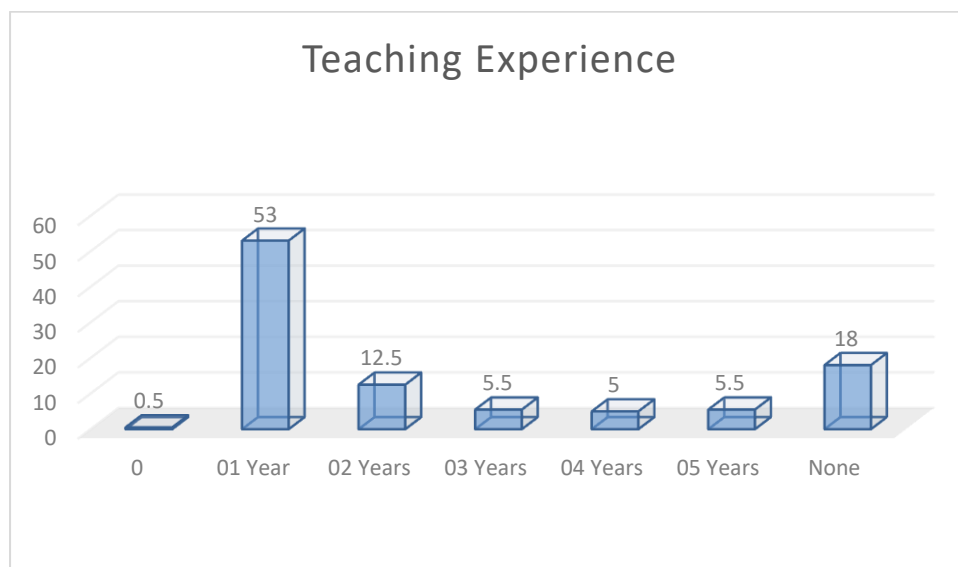


Figure 5: Teaching Experience of Respondents

Correlation Analysis

In the analysis of the relationship of key variables of the study, the Pearson correlation was used to evaluate the association between the variables. However, the ranges of analysis can be measured either -1 or +1, which shows that if the relationship falls with +1, a strong positive relationship, and -1 demonstrates a strong negative relationship. This measures if one variable increases, the other decreases. If the value is 0, it means no correlation or association between the variables. In this process, the p-value shows how significant the correlation is with a value less than 0.05 or 0.01. Table 02 shows different variables, Pearson correlation, and p-value from a sample size of N=200.

Table 2: Correlation Analysis of Constructs

Variable	Pearson Correlation (r)	p-value
IDL	0.579	<0.01
CC	0.792	<0.01
DCC	0.285	<0.01
SWB	0.562	<0.01

Note. All correlations are significant at the * $p < .01$ level (2-tailed). $N = 200$

In observing the table of Pearson correlation (r), which illustrates that there is a statistically significant association between all independent variables with the dependent variable PDL, at $p < 0.01$. This shows that each independent variable positively and significantly associates with the dependent variable, i.e., pedagogical digital literacy among the prospective teachers in the university classrooms. Hence, the strength of the relationships positively varies.

Regression Analysis

The linear regression was used to analyze the effects of independent variables (IDL, CC & SWB) on a single dependent variable (PDL) among the prospective teachers in the university classrooms in Karachi, Sindh. The process was used to calculate how the independent variable statistically affects the dependent variables, observing all independent relationships separately via a linear

regression procedure. This analysis measured the correlation coefficient (R value), Beta, t value, and the significance of the p-value at 0.05.

IDL → PDL

The linear regression analysis was processed to check the impact of IDL on PDL among prospective teachers in university classrooms. This showed that the R value of 0.579 makes it a moderately strong effect of IDL on PDL. This further illustrates Beta = 0.058, recommending an increase in IDL affects to increase the process of PDL. The t-value is 9.989, and the p-value is less than 0.05, making it a statistically significant relationship between independent and dependent variables in the process of training prospective teachers with information on data literacy, emphasizing the digital pedagogical literacy for future teachers of Karachi, Sindh, from the university teacher education programs.

Table 3: IDL impact on PDL

Variable	R value	B value	Std. Error	Beta	T	P
IDL	.579	.058	.058	.579	9.989	0.000

CC → PDL

In the evaluation of the digital core competences, the CC has been analyzed with the effect on PDL among the prospective teachers in university classrooms, where the R value 0.727 indicated a strong positive relationship between the two variables, with a B value of 0.696, for every one-unit increase of CC over an increase in PDL. The Beta value 0.727 shows that CC is a powerful predictor of the PDL in the process of a relationship. The t-value 14.842 confirms the strong relationship, where a p-value less than 0.05 illustrates a high significance between the independent and dependent variables. It proves that communication and collaboration contribute to improving the pedagogical digital literacy among the prospective teachers in the training process at the university classrooms in Karachi, Sindh.

Table 4: CC impact on PDL

Variable	R value	B value	Std. Error	Beta	T	P
CC	.727	.696	.047	.727	14.842	0.000

DCC → PDL

The linear regression analysis indicates that the third core digital competence, DCC, has a weak but positive impact on the PDL among the prospective teachers, with an R value of 0.285 and a B value of 0.223. It suggests that DCC has less impact on the PDL compared to IDL and CC on the PDL among the prospective teachers, in the teacher education departments of four selected universities in Karachi, Sindh. Besides that, a p-value less than 0.05 shows a statistically significant relationship between DCC and PLD.

Table 5: DCC impact on PDL

Variable	R value	B value	Std. Error	Beta	T	P
DCC	.285	.223	.053	.285	4.176	0.000

SWB → PDL

The fourth core competence, SWB, has a moderate positive effect on the PDL with an R value of 0.562 and a B value of 0.486. This shows increase of one unit helps to increase 0.486 units of the PDL in the process of the relationship. The t value of 9.554 shows a significant position with a p-value of less than 0.05, making a positive effect on the PDL among the prospective teachers in teacher education programs, and university classrooms in Karachi, Sindh.

Table 6: SWB impact on PDL

Variable	R value	B value	Std. Error	Beta	T	P
SWB	.562	.486	.051	.562	9.554	0.000

In addition, the linear regression analysis of four core competences as independent variables' impact on the PDL among the prospective teachers shows a significant effect, highlighting CC as the strongest predictive power affecting PDL in the process, and DCC weakest relationship and impact on the PDL. Nonetheless, all the relationships show statistically significant results, where digital content creation posits a weaker, and communication & collaboration competence with a stronger position in the process of relationship to the dependent variable (PLD) among the prospective teachers.

Hypotheses Testing

In the process of evaluating the impact of independent variables (IDL, CC, DCC & SWB) on the Pedagogical Digital Literacy (PDL) among the prospective teachers in the university classrooms, observing digital transformation in the trainee teachers' training programs via B.ED (Hons.). The process was assessed using the correlation and regression analysis, where four research hypotheses were observed and tested, revealing key findings based on statistical significance and effects on independent variables on the dependent variable. The p-value in the testing of hypotheses was observed at 0.05 (or 0.01), and R values as demonstrated in Table 07:

Table 7: Analysis of Hypotheses Testing

Hypotheses	R-value	P-value	Status
H1: IDL-PDL	0.579	<0.05	Accepted
H2: CC-PDL	0.727	<0.05	Accepted
H3: DCC-PDL	0.285	<0.05	Accepted
H4: SWB-PDL	0.562	<0.05	Accepted

The four hypotheses (with four independent variables) evaluated the impact on the PDL as the dependent variable, as elaborated and interpreted in the following:

The analysis reported that H1 via the linear regression analysis, R value at 0.579, revealed a moderately strong relationship between the IDL and PDL promoting digital skills among the prospective teachers in university classrooms. Moreover, the p-value less than 0.05 shows that the relationship between the two variables is statistically significant, and the **H1 was accepted**. This shows that IDL contributes to developing the digital pedagogical competence and literacy of the educators as prospective teachers at the universities in Karachi, Sindh.

The H2 of the study, analyzed with the reports such as R value at 0.727, shows a strong positive relationship between CC and PDL among the prospective teachers. Communication and collaboration as the strongest impact on the digital pedagogical development among the trainee

teachers as prospective teachers in the university classrooms in Karachi. However, this resulted in accepting the H2 of the study, the association between CC and PDL.

In the relationship between DCC and PDL, the H3 analysis revealed that the R-value 0.285 has a weak but significant positive relationship, where digital content creation affects the digital pedagogical competence of the university's prospective teachers as future educators/teachers. The p-value less than 0.05 suggests to have a significant relationship between DCC and PDL, revealing that H3 of the study was accepted. This shows that digital content creation has a weaker but significant impact on the digital pedagogy competence among the prospective teachers studying in the B.Ed. Honors degree programs in the universities of Karachi, Sindh.

The relationship between SWB and PDL (H4) was evaluated, indicating a result of R-value of 0.562, making a moderately strong and positive relationship, where SWB affects the pedagogical digital literacy. The p-value less than 0.05 shows a significant association between SWB and PDL. This shows that an increase in the competency of becoming skilled future teachers serving in different sectors of schooling and higher education in Karachi, Sindh. Hence, the H4 of the study was accepted.

In the process of hypotheses testing, the findings indicate that H1-H4 were all accepted, where it directs that all the core competences i.e. information & data literacy, communication & collaboration, digital content creation and safety & well-being make strong or moderately strong impact on the digital pedagogical literacy among the prospective teachers, in becoming digitally skilled teachers in future, contributing in different sectors of education, from schools to universities in Karachi, Sindh, Pakistan.

Discussion and Results

The study examined the effect of four digital competencies, such as information and data literacy, communication & collaboration, digital content creation, and safety & well-being, on the pedagogical digital literacy, observing the digital competencies of prospective teachers under the training process during the teacher education degree programs, such as B.Ed. Hons, across the universities of Karachi, Sindh. The results from the linear regression and Pearson correlation highlight key empirical evidence, where all four digital competencies affect the pedagogical skills of the prospective teachers to become effective teachers in providing their services to various educational sectors in Sindh, Pakistan.

In the evaluation process, it was revealed that all four research hypotheses were accepted, indicating a strong point of communication and collaboration in providing digital pedagogical skills. This is closely linked with the socio-constructivist view of Vygotsky, in providing learning in a social process of collaborating and communicating, while enhancing the digital revolution of pedagogical skills among the prospective teachers. Understanding the social cognitive theory of Bandura can be linked to the concept of communication & collaboration over the pedagogical digital development and enhancement. In connection to information and data literacy, digital content creation, and safety of digital data and ethics can connect to DigCompEdu and TPACK frameworks of digital competencies.

These frameworks' connection helps the applications of the digital technologies to lead digital competences with the socio context of the pedagogical practices in the teacher education programs (Ghomi & Redecker, 2019). The results indicate and reveal that prospective teachers can enhance their pedagogical skills with the integration of information, data literacy, communications, collaboration, digital content, and safety and ethical protocols in the execution of the digital tools more effectively and proficiently. As the numerical evidences highlight the B values of 0.579

(IDL), 0.562 (SWB) with the p-values less than 0.05, they have a strong and significant impact on the digital pedagogical literacy and skills of the prospective teachers, to contribute to valuable pedagogical approaches in future contributions become in-service teachers for the educational institutions in Karachi, Sindh. Ala-Mukta (2011) critiques the information and data literacy context, providing a foundational base to managing curriculum design for the pedagogical approaches and students' learning.

The safety measures, following the ethical concerns to develop healthy pedagogical skills of digital literacy among the prospective teachers, can be effective with qualities of virtual contents, closely connecting to the digital citizenship model's principles (Falloon, 2020). This context of digital literacy provides prospective teachers with the knowledge of managing cyber threats and misinformation, providing awareness of digital ethical measures and responsibility in integrating technological tools in classroom practices.

The findings show that teachers trained in teacher education programs are predicted to be weaker but significantly via digital content creation skills, and the statistical analysis shows the B value of 0.285, relatively less than other key competencies of digital potentials and skills towards the pedagogical digital literacy framework. The p-value less than 0.05 highlights a significant association with the digital competencies, with a weaker statistical impact on these pedagogical skills in the digital horizon, across the universities of Karachi, Sindh. In the landscape of Pakistan's higher education, where teacher education programs are contributing digital pedagogical skills, they equip the future teachers with valuable digital literacy skills in the higher education institutions (Shahzad, Ahmed & Khan, 2024).

Theoretical and Practical Recommendations

Theoretical Implications

The study contributes theoretical implications, providing theoretical links of global frameworks such as DigCompEdu and TPACK, connecting to the local models of teachers' education programs in the universities of Karachi, Pakistan. These frameworks have measurable variables that can affect the teacher education programs in Pakistan. Contributions can be integrated with these models to hierarchies of digital competencies to pedagogical skills of the prospective teachers. These pre-service teachers face resource constraints, even though progress can be made by executing this global digital competency framework in education and technological advances towards pedagogical development. The digital models can observe the Vygotsky and Bandura views on the social structuring of the digital competencies via collaboration and communication skills. This can help go behind digital-based learning and pedagogical training with the execution of theoretical frameworks in the context of pedagogical digital literacy.

Practical Recommendations

After revealing key findings of the study on the digital competencies of the prospective teachers, the study recommends practical measures for the educators, curriculum planners, and key stakeholders, as in the following:

The B. ED Hons degree program curricula shall be revised, integrating communication & collaboration contents with a mandatory module of using platforms such as Google Workspace, MS Teams, and other useful digital-based projects, enhancing prospective teachers' skills in online learning, making pedagogical courses easier to master.

The university's higher authorities shall convince the Higher Education Commission (HEC) of the investment in reliable internet connections for the public sector universities, providing access to

research tools and sources, pedagogical platforms for learning effective skills online, as such DELSI is one of the effective platforms arranged in collaboration with the Coursera platform. These platforms shall be effective if prospective teachers are provided proper guidance and training to access and use them to access relevant content and courses related to digital skills and pedagogical training.

The programs shall be arranged to train prospective teachers with the skills of digital content development, where this skill can help to attain specific pedagogical goals, valuable assessment strategies, and digital innovation. Besides all these, counselling is required in the following ethical concerns to ensure safe use of digital tools for the purpose of skills development in pedagogy, instead of accessing these tools for leisure time and useful content creation and skills learning.

Conclusion

The research study addressed the aim of the study to examine PDL into core competencies, developing the teaching skills of prospective teachers in higher education classrooms, practices in Karachi, Pakistan. The results reveal a significant impact of using core digital competencies in building pedagogical digital literacy among the prospective teachers. The findings argue that fostering collaborative digital competence can promote a digital social protocol in training the prospective teachers with effective communication, following the ethical concerns and safety models for digital platforms. This is important for future researchers to examine the ethical measures in the process of training the pre-service teachers with digital competency. These ethical measures are important to be critically explored and examined in the context of teacher education programs.

References

1. Ala-Mutka, K. (2011). *Mapping digital competence: Towards a conceptual understanding*. Institute for Prospective Technological Studies.
2. Ameer, S., & Hukamdad, M. (2025). Digital Citizenship and Online Learning in Pakistan: Highlighting the Need for Promoting Responsible Online Behavior in a Growing Digital Education Landscape. *ProScholar Insights*, 4(2), 81-95.
3. Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall.
4. Basal, D. V. (2022). Instructional competencies of technology and livelihood education (TLE) teachers: Basis for a competency-based module. *International Journal of Research Publications*, 96(1), 145-157.
5. Cabero-Almenara, J., Gutiérrez-Castillo, J. J., Barroso-Osuna, J., & Rodríguez-Palacios, A. (2023). Digital teaching competence according to the DigCompEdu framework. Comparative study in different Latin American universities. *Journal of New Approaches in Educational Research*, 12(2), 276-291.
6. Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (Digcompedu). *European journal of education*, 54(3), 356-369.
7. Çeken, B., & Taşkın, N. (2022). Multimedia learning principles in different learning environments: A systematic review. *Smart Learning Environments*, 9(1), 19.
8. Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational technology research and development*, 68(5), 2449-2472.
9. García-Vandewalle García, J. M., García-Carmona, M., Trujillo Torres, J. M., & Moya Fernández, P. (2023). Analysis of digital competence of educators (DigCompEdu) in

- teacher trainees: the context of Melilla, Spain. *Technology, Knowledge and Learning*, 28(2), 585-612.
10. Ghomi, M., & Redecker, C. (2019). Digital Competence of Educators (DigCompEdu): Development and Evaluation of a Self-assessment Instrument for Teachers' Digital Competence. In *CSEDU (1)* (pp. 541-548).
 11. Guitert, M., Romeu, T., & Baztán, P. (2021). The digital competence framework for primary and secondary schools in Europe. *European Journal of Education*, 56(1), 133-149.
 12. Habib, M., & Soomro, T. R. (2021). Digital divide and educational inequity during COVID-19: A case study of Pakistan. *Journal of Applied Research in Higher Education*, 13(4), 1120- 1135.
 13. Lachheb, A., Abramenska-Lachheb, V., Moore, S., & Gray, C. (2023). The role of design ethics in maintaining students' privacy: A call to action to learning designers in higher education. *British Journal of Educational Technology*, 54(6), 1653-1670.
 14. Li, K., Wijaya, T. T., Chen, X., & Harahap, M. S. (2024). Exploring the factors affecting elementary mathematics teachers' innovative behavior: An integration of social cognitive theory. *Scientific Reports*, 14(1), 2108.
 15. Mattson, K. (2024). *Digital citizenship in action: empowering students to engage in online communities*. ASCD.
 16. Mishra, M., Gorakhnath, I., Lata, P., Rani, R., & Chopra, P. (2022). Integration of technological pedagogical content knowledge (TPACK) in classrooms through a teacher's lens. *International journal of health sciences*, 6(S3), 12505-12512.
 17. Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers college record*, 108(6), 1017-1054.
 18. Nanjundeswaraswamy, T. S., & Divakar, S. (2021). Determination of sample size and sampling methods in applied research. *Proceedings on engineering sciences*, 3(1), 25-32.
 19. Nilsson, P. (2022). Technological Pedagogical Content Knowledge (TPACK) in Teacher Education: Supporting Preservice Teachers' Reflections and Use of Digital Technologies in Science Teaching. In *2022 American Education Research Association Annual Meeting (AERA 2022), San Diego, California, USA and Virtual, April 21-26, 2022*. AERA.
 20. Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS*. Routledge.
 21. Pongsakdi, N., Kortelainen, A., & Veermans, M. (2021). The impact of digital pedagogy training on in-service teachers' attitudes towards digital technologies. *Education and Information technologies*, 26(5), 5041-5054.
 22. Rasskazova, O., Alexandrov, I., Burmistrov, A., Siniavina, M., & Cornelis, E. (2020). Key Competencies in the Digital Age and Transformation of Education. In *IOP Conference Series: Materials Science and Engineering* (Vol. 940, No. 1, p. 012093). IOP Publishing.
 23. Redecker, C., & Punie, Y. (2017). Digital competence of educators. *Edited by Yves Punie*.
 24. Santos, C., & Pedro, N. (2024). What is the applicability of the DigCompEdu Framework for online higher education? A study with Portuguese teachers. *Revista Digital de Investigación En Docencia Universitaria*, 18(1), 1-18.
 25. Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. Pearson education.
 26. Shahzad, K., Ahmed, S., & Khan, N. M. (2024). Digital Literacy in Academic Libraries: Assessing Skills and Challenges among Library Professionals in Pakistani Universities. *Journal of Information Management and Library Studies*, 7(1), 184-217.
 27. Soomro, K. A., Kale, U., Curtis, R., Akcaoglu, M., & Bernstein, M. (2020). Digital divide among higher education faculty. *International Journal of Educational Technology in Higher Education*, 17(1), 21.

28. Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens-With new examples of knowledge, skills and attitudes*.
29. Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
30. Zhou, P., Yu, Y., Zhang, Y., Li, Y., & Tang, Y. (2023). Exploring Factors Influencing Teachers' Digital Competence Based on the Social Cognitive Theory. In *2023 Twelfth International Conference of Educational Innovation through Technology (EITT)* (pp. 56-60). IEEE.