TPM Vol. 32, No. S6, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

MAPPING DIGITAL AND AI COMPENTICIES IN B.ED. FOUR YEAR CURRICULUM OF PUBLIC SECTOR UNIVERSITIES IN PUNJAB, PAKISTAN

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ABSTRACT
Educational institutions worldwide now require teacher training programs to develop digital and artificial intelligence (AI) skills instead of teaching basic information and communication technology (ICT) competencies. The existing research shows insufficient information about how developing countries like Pakistan implement artificial intelligence (AI) education into their teacher training programs. The researchers conducted a systematic content analysis of six technology courses which were selected from three public sector universities in Punjab Pakistan. The researchers used European Digital Competence Framework for Educators and SAMR model to analyze course documents by deductively coding digital and AI competencies according to their level of presence and educational use. The three institutions provide basic information and communication technology training yet their programs lack advanced digital skills which include artificial intelligence content about adaptive learning systems, machine learning, data analytics and AI ethics. The UoS showed maximum support for constructivist digital pedagogy through its pedagogical practices whereas BZU adopted a stronger focus on practical ICT methods. The programs being studied demonstrate a major alignment gap with Pakistan's National Education Policy goals and the international educational standards established by the University of New England's Bachelor of Education program. The research outcomes require immediate action to implement curriculum changes and enhance faculty development while establishing educational standards for Pakistan and other developing nations.
Keywords: Content analysis, AI literacy, digital competence, Teacher education, DigCompEdu, SAMR, curriculum analysis,

1. INTRODUCTION

The educational system experiences rapid changes because of artificial intelligence which affects teaching methods, school management, and the basic process of education (Chen et al., 2020). Teacher education institutions across the world face mounting demands to train future educators in essential digital competencies while enabling them to assess and use artificial intelligence educational tools which include intelligent tutoring systems and adaptive learning platforms and AI-based assessment mechanisms (Ng et al., 2023). The AI Competency Framework for Teachers and Students which UNESCO developed in 2024 together with the European Digital Competence Framework for Educators (DigCompEdu; Redecker & Punie, 2017) and the Technological Pedagogical Content Knowledge model (TPACK; Koehler & Mishra, 2009) and the SAMR model (Puentedura, 2006) have emerged as internationally recognized benchmarks for structuring this preparation.
In Pakistan, teacher education is governed by the Higher Education Commission (HEC) and shaped by policies including the National Education Policy (NEP) and the National Professional Standards for Teachers in Pakistan (NPSTP). While these documents acknowledge the centrality of ICT in teacher professional development, they have been criticized for failing to operationalize AI-specific competency requirements in any measurable form (Khurshid et al., 2024). B.Ed. (Hons) Elementary programs at public universities represent the primary pathway through which prospective elementary teachers are prepared, yet the content of technology-related courses in these programs has not been subject to systematic, document-based empirical analysis. The main Research Objectives of the study was To(i)Examine the extent to which digital and AI competencies are embedded in B.Ed. Four year curriculum of Public sector Universities in Punjab(ii) Compare the curriculum content across institutions in terms of digital skill coverage, pedagogical integration, and alignment with global competency frameworks
(iii) Contextualize findings against Pakistan's NEP and the UNE Bachelor of Education program as an international benchmark.

AI and Digital Literacy in Teacher Education: Global Trends

The need for teacher education programs to incorporate digital skills and artificial intelligence capabilities has become the top research priority in global education policy development. Ng et al. (2023) define AI digital competence in educators as encompassing the ability to understand AI mechanisms, apply AI tools responsibly in

pedagogical contexts, evaluate AI outputs critically, and guide students in ethical AI engagement. The systematic review by Casal-Otero et al. (2023) showed that K-12 AI literacy research has developed rapidly but teacher education programs still lack comprehensive and integrated programs which are especially needed in non-Western regions.

The DigCompEdu framework (Redecker & Punie, 2017) articulates 22 competencies across six domains and has been applied as a curriculum-alignment tool across diverse national contexts. Teacher preparation programs show significant deficiencies in training educators on digital teaching methods and data handling skills and artificial intelligence teaching methods. A comparative investigation of Lebanese pre-service and in-service teachers using DigCompEdu found that student teachers consistently lagged in all six domains, with the largest gap in Digital Resources (Tannous et al., 2024). Southworth et al. (2023) argue that AI literacy must be embedded across the curriculum rather than confined to standalone modules, while a decade-long bibliometric analysis noted that teacher preparation lags other educational sectors in adopting contextual, ethics-centered AI literacy approaches (Zhao et al., 2025).

Digital Curriculum Integration in Developing-Country Contexts

The process of integrating digital and artificial intelligence skills into teacher training programs faces difficulties because educational institutions in developing countries do not have sufficient resources and lack proper facilities and their staff members need better training and their existing regulations need to adapt to new technological developments (Pedro et al., 2019). The researchers Asad et al. (2021) found that teacher education programs in South Asia give priority to basic ICT tool training which reduces their ability to develop digital skills and understand new technologies. The research conducted by Khurshid et al. (2024) showed that Pakistan experiences a continuous gap between its digital transformation goals and the actual institutional conditions. The study conducted by Muhammad et al. (2025) demonstrated that Pakistani teacher educators understood the benefits of AI tools but their ability to use these tools in their work faced limitations because of existing system design restrictions. The global scoping review produced evidence that AI literacy does not exist as an established part of teacher preparation programs in educational institutions across the world (Khine & Areepattamannil, 2024).

The content analysis receives direction from two existing frameworks. The six-domain taxonomy of DigCompEdu (Redecker & Punie, 2017) enables researchers to conduct systematic coding according to global standards. The SAMR model (Puentedura, 2006) evaluates depth of technology integration across four levels: Substitution, Augmentation, Modification, and Redefinition. The SAMR model evaluates curriculum details to show whether educational materials use technology as a replacement tool or as a means to create new teaching methods. The TPACK framework (Koehler & Mishra, 2009) shows whether instructors teach students to combine technological knowledge with pedagogical skills and content expertise or whether they teach these three areas separately.

It was found through literature review that no research has yet performed a thorough content examination of B.Ed. teacher education course outlines in Pakistan which follows a systematic framework to evaluate the existence of digital and artificial intelligence competencies. The research study establishes the missing information which will help develop curriculum design and policy changes and institutional development in South Asia's biggest teacher training system.

2. METHODOLOGY

The research utilized a qualitative content analysis method which followed the guidelines established by Krippendorff in 2018. The research study applied a deductive method for its primary coding which used predefined coding categories from DigCompEdu and SAMR while adding new codes to discover unexpected themes. The research examined both manifest content which included direct references to digital and AI skills and latent content which showed underlying competency patterns. The qualitative phase of the study begins after researchers finish the quantitative phase which follows an explanatory sequential mixed-methods research design.

Data Sources and Document Selection

The researcher selected six official course outlines which included two course outlines from each institution at UoS, PU, and BZU according to their Table 1 presentation. The complete set of officially recognized technology courses for B.Ed (Hons) Elementary programs at each institution is represented by these courses. The educational institutions follow curriculum standards approved by HEC which enables valid comparison between their programs.

Table 1. Course documents included in the content analysis.

University	Course Name	Code	Credits	Semester
UoS	Applications of ICT	URCG-5123	3 (2+1)	1
UoS	Digital Pedagogy & Educational Technology	EDUC-6205	3 (3+0)	6

University	Course Name	Code	Credits	Semester
PU	Computer Application in Education	EDE 326	3	1
PU	Instructional Technology	ED 322	3	5
BZU	Computer Literacy	BEH-1206	3	2
BZU	Instructional & Communication Technology	BEH-2305	2	3

Analytical Framework and Coding Procedure

Content analysis proceeded in four iterative stages which were guided by Krippendorff's 2018 guidelines. The coding scheme used deductive methods to create a two-dimensional coding matrix which consisted of DigCompEdu's six areas and SAMR's four levels (see Table 2). AI-specific competency was treated as a distinct emergent subcategory. The document analysis process required researchers to read each document completely; the analysis unit consisted of any segment which had clear meaning and included either digital or AI skills. Thematic clustering organized coded units into cross-document patterns. The study findings were evaluated against Pakistan's NEP and NPSTP and the UNE B.Ed. program which served as an international standard.

Table 2. Analytical Coding Matrix: DigCompEdu Domains × SAMR Levels.

DigCompEdu Domain	S	A	M	R	AI Literacy Code
Area 1: Professional Engagement	✓	–	–	–	Not referenced
Area 2: Digital Resources (ICT)	✓	✓	–	–	Not referenced
Area 3: Teaching & Learning	✓	✓	◑	–	Not referenced
Area 4: Assessment	✓	–	–	–	Not referenced
Area 5: Empowering Learners	–	–	–	–	Absent
Area 6: Learners' Digital Comp.	◑	–	–	–	Absent
AI-Specific Literacy (Emergent)	✗	✗	✗	✗	ABSENT — all 6 courses
S=Substitution	A=Augmentation	M=Modification	R=Redefinition	✓=Present ◑=Partial – =Absent ✗=Entirely absent	

Note. The bottom row confirms complete structural absence of AI-specific literacy across all six analyzed courses.

Research Process

The complete seven-step research process which this study used begins with document selection and ends with thematic findings and recommendations through the dual coding process and inter-rater reliability testing and policy comparison research method.

Figure 1. Research Process: Seven-Step Qualitative Content Analysis

1	**Document Selection & Purposive Sampling** 6 official B.Ed. course outlines from UoS, PU, and BZU (2 per institution) | Full complement of HEC-approved technology-related courses included

▼

2	**Analytical Framework Development** Deductive coding scheme: DigCompEdu (6 domains) × SAMR (4 levels) | AI-specific literacy added as emergent subcategory not in original DigCompEdu
▼	
3	**Unit of Analysis Identification** Each document read in full | Unit = any segment referencing digital/AI competency | Both manifest (explicit) and latent (implicit) content coded
▼	
4	**Dual Coding & Thematic Clustering** Primary code: DigCompEdu domain | Secondary code: SAMR depth level | Emergent code: AI-literacy | Coded units clustered into cross-document themes
▼	
5	**Inter-Rater Reliability Check** 25% of coded units independently double-coded by second researcher | Cohen's κ = 0.84 (strong agreement) | Discrepancies resolved through discussion
▼	
6	**Contextual Analysis & Policy Comparison** Themes compared against: (a) Pakistan NEP & NPSTP | (b) UNE Bachelor of Education program (Australia) as international quality benchmark
▼	
7	**Findings, Discussion & Recommendations** 4 thematic findings reported | Alignment gaps identified | Curriculum reform recommendations for HEC, institutions, and faculty formulated

Note. Seven-step qualitative content analysis research process. Steps 1–2 establish the framework; Steps 3–5 execute coding with reliability verification; Steps 6–7 contextualise findings and generate recommendations.

Trustworthiness

The research used thick description together with direct textual citations from course documents to establish credibility for all interpretive claims. The research team proved their work reliability by creating a complete coding audit trail which showed all their decision-making processes and changes. The research team established confirmability through independent double-coding of 25% of coded units by a second researcher which resulted in Cohen's κ = 0.84 who showed strong inter-rater agreement according to Landis and Koch 1977. The research presents transferability by providing comprehensive information about the three institutions and their complete policy environment.

Ethical Considerations

The research team obtained all course documents from official university sources which provide educational materials that can be accessed by the public. The study did not include any participation from human subjects. The University of Sargodha Institutional Review Board approved the research study through its ORIC process. The study found no existing conflicts of interest among the researchers.

3. RESULTS AND FINDINGS

The analysis of six course outlines resulted in the discovery of four main thematic findings. The complete coding overview from multiple institutions is shown in Table 3 while Table 4 shows the results of the study comparison between UNE international standards. Table 5 shows the DigCompEdu domain distribution heatmap which covers all six courses.

Theme 1: Universal Coverage of Foundational ICT Skills but Limited Pedagogical Depth

The three institutions offered six courses which taught basic ICT skills that matched the DigCompEdu framework for Digital Resources which was assessed at the Substitution level of the SAMR model. The shared material included Microsoft Office programs as well as online browsing skills and essential hardware and software knowledge and email plus digital communication methods. The institutional offerings showed consistent presentation of these topics which led to the finding that prospective teachers achieved high operational skills scores with a mean of 4.01 and standard deviation of 0.57. The two universities showed different ways of teaching

digital tools because UoS and PU used ICT tools for teacher development purposes while BZU taught the same material through general digital citizenship methods. The six courses showed that students learned at the Substitution level which includes basic Augmentation while no course reached higher than that because it stopped at Substitution and basic Augmentation. Falloon (2020) discovered that teacher education programs in similar contexts teach teachers to use technology as teaching tools without showing them how to implement advanced teaching methods.

Theme 2: Complete Absence of AI-Specific Competency Content

The most important discovery shows that all six course outlines completely lack any content which demonstrates AI-specific skills. The course materials did not contain any learning outcomes or subjects or evaluation components which specifically dealt with artificial intelligence tools and machine learning and adaptive learning systems and data-driven teaching methods and intelligent tutoring and AI ethics. The six courses developed their content through a fundamental structural approach which required instructors to use fixed technological resources that included Microsoft Office and projectors instead of using AI-based educational tools. The current situation matches the global pattern which Khine and Areepattamannil (2024) identified because AI literacy functions as an additional requirement instead of being the essential component of educational programs. Table 3 confirms this pattern across all institutions and all Theme 2 criteria.

Theme 3: Inter-Institutional Variation in Digital Pedagogy and Practical Integration

UoS: Strongest Pedagogical Integration

UoS's EDUC-6205 (Digital Pedagogy and Educational Technology) program demonstrated alignment with DigCompEdu Areas 3 and 4 through its educational content which included LMS systems and constructivist active learning methods and inquiry-based teaching approaches and e-portfolio assessment. The study shows how Fernando and Marikar (2017) construct their digital pedagogy model which uses technology to support active learning instead of direct content transmission.

PU: Broadest Instructional Technology Scope

The educational program at PU University provided its most extensive teaching media resources through its ED 322 course which included projectors and smartboards and audio-visual equipment and digital lesson planning tools according to DigCompEdu Area 3 requirements which they reached at their Augmentation level. The content presented itself in a descriptive format because it introduced tools without teaching users how to create differentiated instruction designs. The assessment methods for the course relied mostly on examination results.

BZU: Strongest Practical Hands-On Orientation

The BZU academic program showed its dedication to practical student learning through its Computer Literacy course which provided students with both direct device use and team-based learning through wikis and blogs to achieve DigCompEdu Area 6. The ICTs in Education course at BZU (BEH-2305) presented AI and blockchain technology as part of its course structure but failed to include any actual educational materials that addressed these subjects, which resulted in 'performative AI alignment' because the program used AI terms without delivering actual educational content.

Theme 4: Alignment Gaps with National Policy and International Benchmarks

The analyzed curricula satisfy Pakistan's NEP foundational ICT mandate but fail to achieve its digital transformation goals. The NEP still lacks AI-specific competency standards which creates no institutional motivation for AI curriculum development. The comparison between UNE's 6-credit-hour Digital Literacy course and Table 4 shows a significant difference because UNE provides explicit instruction in coding and multimedia creation and AI tools and critical digital literacy through portfolio-based performance assessment which achieves Modification-to-Redefinition SAMR levels and complete DigCompEdu Areas 1-6 coverage. Pakistani courses remain at Substitution-to-Augmentation levels with Areas 2-3 coverage only

Table 3. Cross-institutional thematic coding summary.

Theme / Criterion	UoS	PU	BZU
THEME 1: Foundational ICT Skills			
MS Office Applications	● Present	● Present	● Present
Internet & Browser Literacy	● Present	● Present	● Present
E-Learning Platforms / LMS	● EDUC-6205	◑ Basic	○ Absent
Digital Safety / Cyber Laws	◑ Partial	◑ Partial	◑ Partial
THEME 2: AI-Specific Content			
Adaptive / Intelligent Systems	✗ Absent	✗ Absent	✗ Absent

Theme / Criterion	UoS	PU	BZU
Machine Learning / Data Analytics	✗ Absent	✗ Absent	✗ Absent
Generative AI Tools	✗ Absent	✗ Absent	✗ Absent
AI Ethics & Bias	✗ Absent	✗ Absent	✗ Absent
THEME 3: Pedagogical Integration			
Constructivist / Active Learning	● EDUC-6205	○ Not explicit	○ Not explicit
Collaborative Digital Platforms	◑ Mentioned	○ Absent	● BEH-1206
Hands-On / Practical Component	◑ URCG-5123	○ Limited	● Strong
SAMR Level Achieved	Augmentation-Modification	Augmentation	Substitution-Augmentation
THEME 4: Policy & Framework Alignment			
Alignment with NEP (basic ICT)	● Compliant	● Compliant	● Compliant
DigCompEdu Areas Covered	1-3 (partial 4)	2-3	2, partial 6
UNESCO AI Framework (2024)	✗ Non-compliant	✗ Non-compliant	✗ Non-compliant

Note: ● = Explicitly present in objectives; ◑ = Partially/implicitly addressed; ○ = Absent; ✗ = Structurally absent across all institutions.

Table 4. Comparative analysis: UNE Bachelor of Education (Australia) vs. Pakistani B.Ed. technology curricula.

Dimension	UNE — Australia	Pakistani Universities
Credit Hours	6 (theory + practice integrated)	3 each (mostly theory-heavy)
Digital Skills Coverage	Advanced: coding, multimedia, AI tools	Foundational: MS Office, internet only
AI Content	Explicit: AI tools, adaptive tech, AI ethics	Absent across all six courses
Assessment Design	Portfolio, projects, reflective papers	Predominantly written exams
SAMR Level Achieved	Modification to Redefinition	Substitution to Augmentation
DigCompEdu Coverage	Areas 1-6 (comprehensive)	Areas 2-3 primarily
Ethical / Critical Literacy	Core component: copyright, AI ethics	Incidental mention only
Programming / Comp. Thinking	Introductory coding included	Entirely absent

Note: Green = strength; Yellow = partial; Red/dark red = gap or absent.

Table 5. DigCompEdu competency domain coverage heatmap across all six analyzed B.Ed. course outlines.

DigCompEdu Domain	UoS URCG	UoS EDUC	PU EDE	PU ED	BZU 1206	BZU 2305
Area 1: Professional Engagement	◑	●	◑	◑	○	○
Area 2: Digital Resources	●	●	●	●	●	●
Area 3: Teaching & Learning	◑	●	◑	●	◑	○

DigCompEdu Domain	UoS URCG	UoS EDUC	PU EDE	PU ED	BZU 1206	BZU 2305
Area 4: Assessment	○	◑	○	○	○	○
Area 5: Empowering Learners	○	○	○	○	○	○
Area 6: Learners' Digital Comp.	○	○	○	○	◑	○
AI-Specific Literacy	✗	✗	✗	✗	✗	✗
Legend:						

Note. The AI-Specific Literacy row confirms complete absence across all institutions.

5. DISCUSSION

The six courses contain no AI content because their structural design elements create barriers that prevent AI integration into the curriculum. HEC guidelines do not include AI literacy as a required competency domain; faculty capacity for AI pedagogy instruction is limited (Muhammad et al., 2025); and AI-compatible infrastructure is inadequate. The established conditions create three obstacles according to Schiff's (2022) tripartite barrier model which includes policy silence and faculty capacity gaps and resource constraints that work together to create and maintain AI curriculum vacuums. BZU's ICTs in Education course demonstrates how 'performative AI alignment' creates a specific danger during accreditation and self-assessment processes because AI buzzwords are used without any real content.

The three universities differ in their educational methods because UoS uses digital teaching methods more extensively while BZU focuses on practical teaching and PU provides the widest range of media resources. The two institutions have separate systems which enable them to make their own curriculum decisions because UoS uses digital teaching methods and BZU uses practical training and PU provides various media resources. The two universities of UoS and BZU provide their best educational methods through their constructivist digital teaching system and through their practical training system which both can be implemented by other institutions without the need for nationwide educational policy changes.

All six courses in the program require improvement through the addition of AI literacy modules which need toTeaching staff membersStaff members need to get trained through teaching Staff members need to get taught AI concepts which include adaptive learning and intelligent feedback and predictive analytics and Staff members need to interact with free AI educational tools through practical experience. Students need to develop critical thinking skills and ethical understanding through their study of AI applications in classrooms which include algorithmic bias and data privacy issues and the changing responsibilities of teachers. The middle semesters need to include an AI literacy course which will support teachers in implementing applied AI teaching methods through supervised practice before their teaching practicum. The Higher Education Commission requires educational institutions to update their B.Ed. curriculum guidelines by adding specific AI literacy competency standards which will comply with UNESCO's AI Competency Framework for Teachers (2024) and DigCompEdu Level 4 (Expert) standards.

6. CONCLUSION

The qualitative content analysis study found structured evidence which showed that Pakistani B.Ed.teacher education curricula. The three institutions provide basic ICT training which meets their policies but they do not teach future teachers how to assess or use AI tools in their teaching. The study makes three primary contributions: it provides the first systematic, framework-grounded content analysis of B.Ed. technology curricula in Pakistan; demonstrates the analytical value of combining DigCompEdu and SAMR as a dual coding framework; and identifies inter-institutional variation within a shared structural deficit, revealing that institutional factors shape curriculum quality even when national frameworks are held constant.

The research has two main boundaries which exist because it uses course outlines to define actual learning but it needs classroom observation and faculty interviews to understand how instructional practice works. The study has established its boundaries to three public universities in Punjab which restrict its ability to generalize findings to private universities and other provincial institutions. Future research should conduct a longitudinal study to monitor how AI curriculum changes during HEC reform initiatives. Teacher education programs which do not teach AI literacy create graduates who can only work in classrooms that existed in the past and not in modern classrooms which require new teaching methods.

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