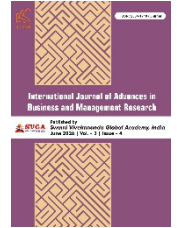




# DIGITAL LITERACY AS A PREDICTOR OF EDUCATION 4.0 SKILLS AMONG PROSPECTIVE TEACHERS



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Original Article

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## Abstract

Education 4.0 has changed the expectations for teacher preparation, as digital competence is now acknowledged as a prerequisite for creating future-oriented and technology-integrated pedagogical environments. A particularly important group in this context is prospective teachers undergoing pre-service training, whose current levels of digital literacy may substantially determine their readiness to enact the principles of Education 4.0. The present study examined digital literacy as a predictor of Education 4.0 skills among B.Ed. students in Kerala, India. A quantitative descriptive-correlational predictive design was used. A stratified random sample of 320 prospective teachers was selected from four government and government-aided colleges of education. Data were collected using two self-developed and validated instruments: the Digital Literacy Scale (*DLS*; 30 items;  $\alpha = 0.89$ ) and the Education 4.0 Skills Questionnaire (*E4.OSQ*; 35 items;  $\alpha = 0.91$ ). Data were analysed using Pearson's product-moment correlation and simple linear regression. Prospective teachers reported moderate-to-high levels of digital literacy ( $M = 3.72$ ,  $SD = 0.58$ ) and Education 4.0 skills ( $M = 3.61$ ,  $SD = 0.54$ ). A significant positive correlation was found between digital literacy and Education 4.0 skills ( $r = 0.67$ ,  $p < 0.001$ ), and regression analysis revealed that digital literacy significantly predicted Education 4.0 skills ( $\beta = 0.671$ ,  $t = 16.10$ ,  $p < 0.001$ ), accounting for 44.9% of the variance ( $R^2 = 0.449$ ). The findings indicate that digital literacy predicts the Education 4.0 skill readiness of prospective teachers. Teacher education programmes should therefore embed structured, multidimensional digital literacy development to prepare teachers for the challenges of Education 4.0 classrooms.

**Keywords:** Digital Literacy; Education 4.0; Prospective Teachers; Teacher Competency; 21st Century Skills

## Introduction

The worldwide revolution of education systems inspired by the Fourth Industrial Revolution has created a need for a redefined vision of teaching and learning, broadly termed Education 4.0 [1]. Unlike its predecessors, Education 4.0 is not just about the integration of digital tools into classroom routines but is also a cluster of professional competencies that include critical thinking, digital fluency, creativity, collaborative problem-solving, and adaptive responsiveness to rapidly changing knowledge environments [2]. It is thus both a matter of pedagogical urgency and policy concern to prepare teachers to foster these competencies in learners. In this sense, digital literacy has become an increasingly foundational attribute of the contemporary educator [3]. The concept has evolved significantly beyond basic computer literacy to include the ability to critically assess digital information, communicate and create content on digital platforms, manage online safety issues, and use emerging technologies for effective educational design [4]. This investigation is especially relevant to the Indian teacher education scenario. India has more than 17,000 teacher education institutions and a massive reform agenda through the National Education Policy 2020 [5], and the expectations of emerging teachers have undergone significant revision. The policy clearly visualises teachers who are digitally competent, able to facilitate experiential and technology-mediated learning, and ready to prepare students for a knowledge-driven, fast-changing economy [6]. Nevertheless, little systematic empirical research exists on the



relationship between digital literacy and Education 4.0 skill readiness among prospective teachers in India [7]. The present study addresses this gap by investigating digital literacy as a predictor of Education 4.0 skills among B.Ed. students studying in colleges of education in Kerala, a state known for its relatively sophisticated educational infrastructure in India. This study provides empirical evidence and practical directions towards the reform of teacher education in tandem with the imperatives of Education 4.0 through a quantitative predictive research design [8].

## Literature Review

### Digital Literacy: Conceptual Foundations and Evolving Dimensions

Digital literacy was initially conceived as the ability to comprehend and manipulate information from diverse digital sources; a competency strongly linked to the emergence of the internet in the 1990s [9]. Since then, contemporary frameworks have considerably expanded this definition [10]. Digital literacy has been broken down into three interlocking strands: technical, cognitive, and social-emotional, claiming that true digital competence requires all three to operate in concert rather than any one strand alone [11]. The European Commission's Dig Comp 2.1 framework [12] further operationalised digital competence into five domains: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. The idea of digital literacy is very important, and it has been used to make policies and evaluate programmes in many different countries and schools. Digital literacy is not only about knowing how to use computers; it is also about being an effective teacher and making sound decisions about how to teach [13]. This is also reflected in the Teacher Digital Competency framework introduced by Chiu et al. [14]. This framework is like the Technological Pedagogical Content Knowledge model, which was developed by Mishra and Koehler in 2006 [15]. This model suggests that teachers need to know about the subject they are teaching, how to teach it, and how to use technology to enhance the teaching and learning process [16]. Some scholars, such as Ertmer and Ottenbreit-Leftwich, found in 2010 that teachers are more likely to use technology when they are confident and receive support from their institutions [17]. This means that digital literacy is not only about knowing how to use technology, but also about how teachers feel about it and the level of support they receive [18]. Increasing attention is also being paid to how researchers measure digital literacy. For example, Porat and his team found in 2018 that high school students often believe they are better at using technology than they are [19]. This is a problem because it means that researchers may not always obtain an accurate picture of students' actual digital competence. Other scholars, such as Ilomäki and her team, argue that digital literacy is still a developing concept and that it is difficult to define it in a way that works universally across all contexts [20]. Therefore, digital literacy remains highly important because it helps teachers and students develop the skills, they need to use technology effectively in educational settings [21].

### Education 4.0: Characteristics and Skill Demands

Education 4.0 is widely understood as an educational response to the disruptions of the Fourth Industrial Revolution, characterised by the convergence of artificial intelligence, machine learning, robotics, the Internet of Things, and big data across all sectors of social and economic life [22]. Aziz Hussin [23] identified eight distinctive features of Education 4.0 relevant to classroom practice: learning at different times and places, customised and personalised learning, project-based learning, field experiences and simulations, data-informed assessment, assessment for learning rather than assessment of learning, student agency in learning design, and mentoring relationships that replace conventional instructional hierarchies. Together, these features demand that teachers possess not only disciplinary knowledge but also a sophisticated repertoire of digital competencies and human-centred interpersonal skills. The World Economic Forum [24] identified critical thinking, creativity, emotional intelligence, complex problem-solving, and technology literacy as the most valued professional competencies for the near-future labour force, a profile that substantially overlaps with the skill demands of Education 4.0 classrooms. Voogt and Roblin [25] conducted a comparative analysis of international 21st-century skill frameworks and identified collaboration, communication, ICT literacy, cultural competency, and problem-solving as recurring constructs [26]. For pre-service teachers specifically, Kimonen and Nevalainen [27] argue that these competencies must be cultivated during initial teacher preparation and embedded as professional dispositions rather than discrete, add-on skill modules. Shi et al. [28] studied digital transformation in higher education and noted that although educators generally valued digital tools, there was significant variation in competency and in the

pedagogically meaningful use of digital tools. They also observed that structural and motivational barriers persisted and were not overcome by access alone [29].

### Digital Literacy and Education 4.0: Connecting the Variables

There is strong empirical support for the theoretical connection between digital literacy and Education 4.0 skills. Lohr et al. [6] reviewed the literature on the connection between 21st-century skills and digital skills and found a large conceptual and empirical overlap, especially in the areas of critical evaluation of information, collaborative content creation, and creative problem-solving. The seminal argument by Gunn [30], that today's learners expect educators to be fluent in digital environments, was an early prompt for the expectation that teachers themselves need strong digital capabilities as a prerequisite for a credible pedagogical presence. Nagel and Amdam [31] extended this argument by demonstrating that professional digital competence is a prerequisite for the pedagogical change envisaged by Education 4.0, rather than merely a technical add-on to current practice. Research in pre-service teacher education contexts consistently shows that higher levels of digital literacy are related to higher levels of preparedness for technology-integrated, learner-centred teaching [32]. However, few studies have operationalised this association as an empirical predictive relationship using validated measurement instruments, especially in the Indian teacher education context [33]. The present study aims to fill this gap.

### Research Gap

Although there is a large body of literature on digital literacy and 21st-century skills in general, specific empirical gaps remain [34]. Most current studies treat these constructs as parallel dimensions without formally testing the predictive relationship between them [35]. Research set in Indian teacher education contexts is particularly scarce, and when it does exist, it is primarily qualitative or restricted to geographically limited small samples [36]. In addition, few studies have operationalised Education 4.0 skills as a measurable outcome variable using a validated multidimensional instrument [37]. The present study attempts to fill these gaps by using a predictive quantitative design with a representative sample of prospective teachers from Kerala [38]. The study uses two self-developed instruments based on established theoretical frameworks and validated through rigorous procedures [39].

### Objectives of the Study

The study was guided by the following objectives:

- To assess the level of digital literacy among prospective teachers.
- To assess the level of Education 4.0 skills among prospective teachers.
- To determine the relationship between digital literacy and Education 4.0 skills among prospective teachers.
- To determine whether digital literacy significantly predicts Education 4.0 skills among prospective teachers.

### Hypotheses

- H<sub>01</sub>: There is no significant relationship between digital literacy and Education 4.0 skills among prospective teachers.
- H<sub>02</sub>: Digital literacy does not significantly predict Education 4.0 skills among prospective teachers.

## Methodology

### Research Design

This study used a quantitative descriptive-correlational predictive research design. The descriptive section described the levels of digital literacy and Education 4.0 skills in the sample [40]. The correlational component determined the strength and direction of the bivariate association between the two constructs [41]. The predictive component determined the extent to which digital literacy explained the variance in Education 4.0 skill readiness. Methodologically, this design is appropriate for identifying predictive relationships between measured variables without experimental intervention [42].

## Population

The target population comprised prospective teachers enrolled as students in regular two-year B.Ed. programmes affiliated with universities in Kerala. The teacher education infrastructure in Kerala consists of government, government-aided, and self-financing colleges, which offer meaningful variation in institutional context and student background.

## Sample and Sampling Technique

The total sample of 320 prospective teachers was selected through stratified random sampling, with institution type, government versus government-aided, as the stratification variable. Four colleges of education, two government and two government-aided, were randomly selected. Respondents were proportionally sampled from each institution. The final sample consisted of 198 female participants (61.9%) and 122 male participants (38.1%), aged between 21 and 30 years ( $M = 23.4$  years). This sample size is greater than the recommended minimum ratio of 20 participants per predictor variable for regression-based research [43], indicating that the sample is adequate for the planned analyses.

## Research Tools

Two instruments were employed for data collection.

**Digital Literacy Scale (DLS).** The investigator created a 30-item self-report scale, anchored on the Dig Comp 2.1 framework [44] and the multidimensional conceptualisation of digital literacy by Ng [45]. The scale consists of five dimensions: Technical Skills (6 items), Information and Data Literacy (6 items), Communication and Collaboration (6 items), Digital Content Creation (6 items), and Safety and Problem-Solving (6 items). Items were rated on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), with higher aggregate scores indicating greater digital literacy skills.

**Education 4.0 Skills Questionnaire (E4.0SQ).** The developers of this questionnaire used the Education 4.0 framework and the Future Skills Taxonomy by the World Economic Forum [24] to create it. The questionnaire contains 35 self-report items and is divided into five domains: Critical Thinking and Problem-Solving (7 items), Creativity and Innovation (7 items), Collaboration and Communication (7 items), Digital Fluency (7 items), and Adaptability and Self-Directed Learning (7 items). Respondents rate each item using a 5-point Likert scale, with higher scores indicating greater readiness for the skills required in Education 4.0.

## Validity and Reliability

The experts ensured that the items in the two instruments were valid and relevant by consulting ten specialists knowledgeable in educational technology and teaching. These specialists reviewed each item and evaluated its quality, with the results indicating strong content validity, as item-level scores ranged from 0.80 to 1.00. This confirmed that the instruments were valid. Additionally, the experts assessed the overall instruments, yielding instrument-level content validity scores of 0.92 and 0.91, which are considered acceptable according to Mohd Yusoff. Prior to the main study, a pilot test was conducted with 35 pre-service teacher students, which demonstrated that the instruments were reliable, with reliability coefficients of 0.86 and 0.88. Minor modifications were then made to the instruments based on the participants' feedback. In the main study, the instruments demonstrated high reliability, with coefficients of 0.89 and 0.91, indicating that they are consistent and capable of producing stable results [46].

## Data Collection Procedure

The authors collected data during the year 2026, after obtaining permission from each college that participated in the study. They informed all students about the purpose of the study, emphasizing that participation was voluntary and that their responses would be kept confidential. Students provided their consent to participate before receiving the questionnaires. The questionnaires were administered during class sessions and completed by hand. Upon initial review of the data, the authors found 325 completed sets of responses; however, five sets were discarded due to excessive missing information. Consequently, the final dataset comprised 320 usable responses for the study.

## Statistical Techniques

Descriptive statistics, including means and standard deviations, were calculated to understand the levels of both study variables [47]. The relationship between digital literacy and Education 4.0 skills was examined through correlation analysis to determine the strength and direction of the association [48]. Subsequently, a simple linear regression analysis was conducted to investigate the extent to which digital literacy could predict Education 4.0 skills [49]. All analyses were performed using IBM SPSS Statistics Version 25 software [50], and results were considered statistically significant if the  $p$ -value was less than 0.05. The analyses provided insights into the levels and interrelation of digital literacy and Education 4.0 skills, with digital literacy serving as the predictor variable for Education 4.0 skills in this study.

## Results and Interpretation

### Descriptive Statistics

Table 1 presents the background characteristics of the 320 participants. Most of the participants were female (61.9%), reflecting the overall proportion of women in B.Ed. programmes in Kerala. Table 2 provides descriptive statistics for the two primary study variables. Participants reported moderate-to-high proficiency in using digital tools ( $M = 3.72$ ,  $SD = 0.58$ ) and moderate-to-high Education 4.0 skills ( $M = 3.61$ ,  $SD = 0.54$ ). The authors assessed the normality of the distributions for both variables, which fell within acceptable limits ( $\pm 2.0$ ), indicating that parametric statistical analyses were appropriate.

### Correlation Analysis

Table 3 presents the results of the Pearson correlation analysis. A positive relationship was found between digital literacy and Education 4.0 skills, with a correlation coefficient of  $r = 0.67$  for 318 participants, which is highly significant ( $p < 0.001$ ). This indicates that prospective teachers with higher levels of digital literacy tend to demonstrate stronger Education 4.0 skills. According to Cohen's [51] guidelines, a correlation of 0.67 is considered large. Based on this correlation, the null hypothesis ( $H_{01}$ ) stating that there is no relationship between digital literacy and Education 4.0 skills is rejected.

### Regression Analysis

A simple linear regression analysis was conducted with digital literacy as the predictor and Education 4.0 skills as the outcome variable. Table 4 presents the model summary, and Table 5 presents the regression coefficients. The overall model was statistically significant,  $F(1, 318) = 259.12$ ,  $p < 0.001$ . Digital literacy accounted for 44.9% of the variance in Education 4.0 skills ( $R^2 = 0.449$ , Adjusted  $R^2 = 0.448$ ), indicating a substantively meaningful predictive relationship. The standardised regression coefficient was  $\beta = 0.671$ ,  $t(318) = 16.10$ ,  $p < 0.001$ , confirming that digital literacy is a significant positive predictor of Education 4.0 skills. Accordingly,  $H_{02}$  was rejected. The unstandardised regression equation for predicting Education 4.0 skills from digital literacy is:  $\hat{Y}$  (Education 4.0 Skills) =  $1.30 + 0.62 \times$  (Digital Literacy). This equation indicates that for every one-unit increase in digital literacy score, the Education 4.0 skills score increases by 0.62 units, holding all other factors constant.

**Table 1: Demographic Profile of Respondents (N = 320)**

Variable	Category	Frequency	Percentage (%)
Gender	Female	198	61.9
	Male	122	38.1
Age (Years)	21-23	147	45.9
	24-26	128	40.0
	27-30	45	14.1
Institution Type	Government	162	50.6
	Government-Aided	158	49.4

Source: Collected by Author

**Table 2: Descriptive Statistics for Digital Literacy and Education 4.0 Skills (N = 320)**

Variable	N	M	SD	Skewness	Kurtosis
Digital Literacy	320	3.72	0.58	-0.31	0.18
Education 4.0 Skills	320	3.61	0.54	-0.27	0.12

Note. Scores based on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

Source: Collected by Author

**Table 3: Pearson Correlation between Digital Literacy and Education 4.0 Skills**

Variable	1	2
1. Digital Literacy	-	
2. Education 4.0 Skills	0.671**	-

Note. \*\* $p < 0.001$  (two-tailed).

Source: Collected by Author

**Table 4: Model Summary: Digital Literacy Predicting Education 4.0 Skills**

R	R <sup>2</sup>	Adjusted R <sup>2</sup>	SEE	F	df <sub>1</sub>	df <sub>2</sub>	p
0.671	0.449	0.448	0.401	259.12	1	318	< 0.001

Note. SEE = Standard Error of the Estimate.

Source: Collected by Author

**Table 5: Regression Coefficients: Digital Literacy Predicting Education 4.0 Skills**

	B	SE	$\beta$	t	p
(Constant)	1.30	0.15		8.67	< 0.001
Digital Literacy	0.62	0.04	0.671	16.10	< 0.001

Note. Dependent variable: Education 4.0 Skills.

Source: Collected by Author

## Discussion

The results of this study align with and extend existing knowledge about digital skills and teaching readiness for the future. A positive relationship was observed between proficiency in digital tools and the possession of skills required for Education 4.0 [52]. Specifically, the study found a strong correlation ( $r = 0.67$ ) between digital literacy and Education 4.0 skills, indicating that prospective teachers' competence in digital environments is closely connected to their ability to meet the pedagogical demands of Education 4.0 [4]. This finding is consistent with previous reviews demonstrating links between digital literacy and other critical 21st-century skills, such as creativity, critical thinking, and collaborative problem-solving, all of which are central to Education 4.0 [53, 54]. The strength of the relationship, explaining approximately 45% of the variance, is comparable to, though slightly stronger than, findings from studies in other countries, potentially reflecting the specific relevance of digital competencies for pre-service teachers. Descriptive results showed moderately high average scores for digital literacy (M = 3.72) and Education 4.0 skills (M = 3.61), indicating a foundation for readiness but also highlighting areas for improvement, as not all students demonstrated competency across all domains [55, 56]. This variability mirrors prior observations that students' proficiency in digital learning is influenced by factors such as access, institutional support, and personal motivation. One important consideration is that self-reported measures may overestimate actual digital literacy, and research suggests there can be a considerable gap between perceived and actual skills. Future studies should therefore incorporate direct assessments of digital competencies in addition to self-reports. The findings are further illuminated by the Technological Pedagogical

Content Knowledge (TPACK) framework, which posits that technological knowledge is effective only when integrated with pedagogical and content knowledge [57]. From this perspective, digital literacy functions as a foundational substrate: prospective teachers who command the full spectrum of digital competencies—technical, informational, communicative, creative, and safety-oriented—are better positioned to design and implement project-based, learner-centred, and data-informed learning experiences demanded by Education 4.0 [58, 59]. The regression coefficient ( $\beta = 0.671$ ) provides direct empirical support for this conceptual logic within an Indian teacher education context, validating the argument that professional digital competence constitutes a prerequisite for Education 4.0 pedagogical transformation, particularly for pre-service teachers at the initial stage of professional formation.

### **Educational Implications**

These findings have several concrete implications for teacher education policy and practice. Teacher education institutions should reconsider the structure of digital literacy instruction within B.Ed. curricula. Many current programmes address digital literacy narrowly, emphasising operational tool proficiency while neglecting the critical, creative, and socio-communicative dimensions identified as essential by the Dig Comp framework and the present study. A shift toward multidimensional digital competency development, aligned with frameworks such as Dig Comp 2.1, would better prepare prospective teachers to meet the full range of Education 4.0 demands. Teacher educators themselves must be supported in developing and modelling the professional digital competencies they are expected to facilitate. Additionally, B.Ed. students should be encouraged to engage in self-directed digital skill development through curated digital platforms, reflective practice portfolios, and peer-collaborative learning communities. Fostering metacognitive awareness of one's own digital competency gaps—understanding what one does not yet know—is itself an Education 4.0-relevant disposition that pre-service programmes are particularly well-positioned to cultivate.

### **Limitations of the Study**

Several limitations of this study merit acknowledgment. First, the sample was drawn exclusively from colleges of education in Kerala, which limits the generalisability of the findings to other states with different digital infrastructures, policy environments, and institutional contexts. Second, both instruments relied on self-report, introducing the potential for social desirability bias and the well-documented tendency for individuals to overestimate their own competencies. Third, the cross-sectional design precludes any causal interpretation; the regression findings describe a predictive associational relationship rather than a definitive directional cause-and-effect. Fourth, the model explained approximately 45% of the variance in Education 4.0 skills, indicating that multiple other predictors—including metacognitive awareness, quality of institutional support, technology self-efficacy, and peer collaboration—account for the remaining variance and warrant systematic investigation in future research.

### **Future Research**

Future research should pursue several directions. Longitudinal designs that track the co-development of digital literacy and Education 4.0 skills across the full B.Ed. training period would yield richer insight into temporal dynamics and the relative contributions of programme-based versus self-directed development. Multi-state comparative studies could examine whether variations in digital infrastructure, policy support, and institutional culture moderate the relationship between digital literacy and Education 4.0 skills. Incorporating performance-based digital competency assessments alongside self-report instruments would address the known limitations of perception-only measurement. Future studies might also extend the predictive model to include additional variables, such as metacognitive awareness, technology self-efficacy, and mentoring quality, potentially yielding more comprehensive and explanatory models. Mixed-methods extensions would be particularly valuable for elucidating the mechanisms through which digital literacy translates into Education 4.0 pedagogical readiness, providing the contextual nuance that quantitative designs alone cannot fully capture.

## **Conclusion**

This study provides systematic empirical evidence that digital literacy is a significant and substantive predictor of Education 4.0 skill readiness among prospective teachers in Kerala, India. The observed positive correlation ( $r = 0.67$ ) and regression model ( $R^2 = 0.449$ ) indicate that nearly half of the variation in Education 4.0 skill profiles can be attributed to digital literacy levels, positioning digital competence as a foundational prerequisite for future-ready teacher preparation. These findings affirm the theoretical arguments advanced by frameworks including TPACK, Dig Comp 2.1, and Hussin's Education 4.0 model, while contributing an empirically grounded perspective from Indian teacher education to a literature predominantly shaped by Western educational contexts. As teacher education institutions navigate the transition toward Education 4.0, equipping prospective teachers with robust, multidimensional digital literacy, rather than narrow tool proficiency, is not a discretionary enhancement but a professional and pedagogical imperative.

## Conflict of Interests

The authors declare that they have no conflict of interests.

## Authors' Contributions

All authors contributed to the design, data collection, analysis, and writing of the manuscript.

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