Teachers' Readiness in Integrating ICT in Teaching and Learning in Rural Government Schools of India, Using Exploratory and Confirmatory Factor Analysis Approach

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Abstract

This study assesses teachers' readiness to integrate Information and Communication Technology (ICT) in rural government schools of India, with a focus on competency, attitude, and usage. Using a multistage stratified random sampling method, data were collected from 235 teachers across three Regional Institutes of Education (RIE)-adopted blocks, namely Ichhawar, Chillika, and Hurda. Exploratory Factor Analysis (EFA) identified key dimensions, including three competency factors (advanced pedagogical skills, basic ICT literacy, and peripheral handling), two factors each for positive and negative attitudes, and two types of ICT usage (instructional and administrative). Confirmatory Factor Analysis (CFA) validated the proposed model, demonstrating high reliability (Cronbach's $\alpha > 0.86$).

The findings indicate that teachers possess basic ICT skills and generally hold positive perceptions regarding the educational value of ICT. However, the use of advanced digital tools, such as MOOCs and Free and Open-Source Software (FOSS), remains limited. Negative perceptions, including concerns about increased workload and reduced confidence, continue to impede deeper integration. ICT usage is largely confined to basic instructional purposes, with minimal application in administrative tasks. The study highlights the need for targeted capacity-building initiatives, enhanced technical support, promotion of FOSS, and institutional incentives. While rural teachers exhibit partial readiness for ICT integration, sustainable digital transformation requires comprehensive training, infrastructure development, and policy support.

Keywords: Attitude, Teacher Competency, Exploratory and Confirmatory Factor Analysis, ICT Integration, Teacher Readiness

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Introduction

Information and Communication Technologies (ICT) have been widely recognised as catalysts for educational advancement and the creation of inclusive knowledge societies, a theme consistently emphasised in UNESCO's EdTech-related documents over the past decade (Barakabitze *et al.*, 2019; Kanvaria and Yadav, 2024; Ukpe, 2023). The Global Education Monitoring Report 2023 further identifies ICT and digital literacy as fundamental rights in the twenty-first century. ICT plays a pivotal role in enhancing educational quality (Das, 2019; Himanshoo and Sharma, 2015; Livingstone, 2012; Saravanakumar, 2018; Vitanova *et al.*, 2015) and improving the performance of both teachers and learners.

To harness the full potential of ICT, teachers must possess adequate digital competencies (Morris, 2010; Suárez-Rodríguez *et al.*, 2018; Williams *et al.*, 2000). Teachers' ICT proficiency and their perceptions of its relevance to teaching and learning are critical determinants of successful ICT integration (Gebremedhin and Fenta, 2015; Lawrence and Tar, 2018; Mirzajani *et al.*, 2016). Sampson and Fytros (2008) conceptualised competency as a set of personal attributes—including knowledge, skills, and attitudes—required to perform activities effectively in a given context. Similarly, Klein *et al.* (2004) define competency as an interrelated combination of knowledge, skills, and attitudes enabling individuals to meet occupational standards.

Previous studies have explored the impact of ICT on education across various contexts. Research on ICT competency has been conducted in Ethiopia (Demissie *et al.*, 2022), Spain (Díaz *et al.*, 2016), Norway (Elstad and Christophersen, 2017), Thailand (Raob *et al.*, 2012), Belgium (Aesaert *et al.*, 2017), North Macedonia (Vitanova *et al.*, 2015), and Germany (Rubach and Lazarides, 2021). Studies examining teachers' attitudes towards ICT integration span diverse geographical contexts, including Norway (Scherer *et al.*, 2015), Canada (Shapka and Ferrari, 2003), England (Robertson *et al.*, 1995), Syria (Albirini, 2006), Singapore and the UK (Teo and Noyes, 2010), Iran (Mirzajani *et al.*, 2016), and several European countries (Eickelmann and Vennemann, 2017).

Similarly, ICT usage in education has been investigated in Turkey (Tezci, 2011), Spain (Gil-Flores *et al.*, 2017), the Netherlands (Drent and Meelissen, 2008; Voogt and Knezek, 2011), and Belgium (Tondeur *et al.*, 2008; Vanderlinde *et al.*, 2014; Van Braak *et al.*, 2004). Although these studies provide valuable insights, most address ICT competency, attitude, or usage in isolation. There remains a paucity of research that simultaneously examines all three dimensions, particularly within the Indian rural school context.

To address these gaps, the present study aims to: (i) analyse teachers' competencies in integrating ICT into teaching–learning processes in RIE-adopted blocks of India;

(ii) explore teachers' attitudes towards ICT integration; (iii) evaluate teachers' reported ICT usage; and (iv) propose evidence-based policy recommendations to enhance teachers' readiness for ICT integration.

Rationale of the Study

The integration of ICT in education has emerged as a global priority, particularly in developing countries such as India, where digital access and inclusion remain uneven. Teachers play a central role in translating technological potential into meaningful classroom practices. Their readiness—reflected in competencies, attitudes, and actual usage—largely determines the effectiveness of ICT integration.

Rural government schools face distinct challenges, including inadequate infrastructure, limited access to advanced training, and resistance stemming from low confidence or negative perceptions. While earlier studies have examined ICT competency, attitudes, or usage independently, few have adopted a holistic approach in the Indian rural context. By employing Exploratory and Confirmatory Factor Analysis, this study provides a comprehensive assessment of teachers' ICT readiness across three RIE-adopted blocks.

The findings reveal that although teachers demonstrate basic digital skills and generally positive attitudes, advanced competencies and innovative pedagogical or administrative applications remain limited. Concerns regarding workload and self-efficacy further constrain ICT integration. Understanding these interrelated factors is essential for designing targeted professional development programmes and supportive policies. The study contributes empirical evidence from rural India to the global discourse on inclusive digital transformation in the education.

Aims of the Study

The aims of the study are as follows

- To analyses the competencies of teachers in integrating ICT in teaching-learning in adopted blocks of RIEs in India.
- To explore teachers' attitudes towards the integration of ICT in teaching-learning in the study area.
- To evaluate teachers' responses regarding their usage of ICT in teaching-learning in the study area.
- To suggest some effective policy recommendations based on empirical results to improve teachers' readiness in integrating ICT in Teaching and Learning.

Research Questions

The research questions of the study are as follows

- What are the competencies of teachers in integrating ICT into teaching–learning in the adopted blocks of RIEs in India?
- What are the attitudes of teachers towards the integration of ICT in teaching–learning in the study area?

- How do teachers respond regarding their actual usage of ICT in teaching–learning in the study area?
- What effective policy recommendations can be derived from empirical results to improve teachers' readiness in integrating ICT into teaching–learning?

Design of the Study

Sample Sites of the Study

The National Council of Educational Research and Training (NCERT), established in 1961, is an autonomous organisation under the Government of India responsible for advising on school education policies and programmes. NCERT undertakes research, develops educational materials, conducts teacher training, and disseminates educational innovations. As the nodal agency for implementing Sustainable Development Goal 4, NCERT also leads major ICT initiatives through the Central Institute of Educational Technology (CIET), including platforms such as DIKSHA and PM eVidya 200 DTH TV Channels (NCERT Annual Report, 2020).

NCERT operates through five Regional Institutes of Education (RIEs)—Ajmer (North), Bhopal (Central), Bhubaneswar (East), Shillong (North-East), and Mysuru (South). These institutes provide pre-service teacher education and support the implementation of national and state education policies. The present study was conducted as part of NCERT-funded interventions in three RIE-adopted blocks—Ichhawar (Sehore district, RIE Bhopal), Chillika (Khordha district, RIE Bhubaneswar), and Hurda (Bhilwara district, RIE Ajmer).

According to Census 2011 data, literacy rates in Sehore, Khordha, and Bhilwara districts are 59.50 per cent, 77.71 per cent, and 52.15 per cent, respectively. National Gross Enrolment Ratios stand at 93 per cent at the Primary level and 77.40 per cent at the Secondary level (UDISE+ 2023–24). Pupil–teacher ratios range from 10 at the Foundational level to 21 at the Secondary level, while 38.87 per cent of female teachers and 29.67 per cent of male teachers have received training in computer-assisted teaching (UDISE+ 2023–24).

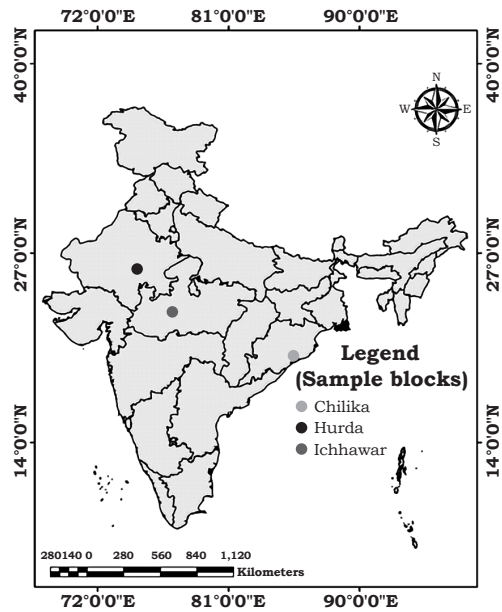

Fig. 1: Sample sites in different parts of India

Sample Design Procedure

The present study draws on data collected from teachers under the project titled "Implementation of ICT Interventions: A Block-level Research Study", conducted and funded by CIET, NCERT, between 2019 and 2023. A multi-stage stratified random sampling procedure was adopted for the study. Government school teachers from three blocks—Ichhawar, Khordha, and Hurda—constituted the sample.

Stage 1

In the first stage of sampling, states were selected based on the locations of the Regional Institutes of Education (RIEs). Initially, five states were identified; however, due to the unforeseen nationwide lockdown caused by the COVID-19 pandemic in March 2020, the data collection process was prematurely halted. Consequently, only three states—Madhya Pradesh, Rajasthan, and Odisha—were included in the study using purposive sampling.

Fig. 2: Sample design

Stage 2

In the second stage, the districts and community development blocks within the selected states were chosen based on the established field contacts of the respective RIEs to facilitate access. Accordingly, purposive sampling was employed to select the community development blocks of Ichhawar, Hurda, and Chilika in the respective states.

Stage 3

At the third stage, schools were identified using stratified random sampling. 10 per cent of the total government schools from each selected community development block were included in the sample.

Stage 4

In the final stage, of the sampling procedure, 5 teachers from each school were selected using a random

Table 1
Socio-demographic Characteristics of the Respondents

Demographic Variables	Frequency (f)	Percentage (%)
Gender		
Male	139	59.15
Female	96	40.85
Age (in years)		
Less than 30	38	16.17
30–40	68	28.94
40–50	78	33.19
50 and above	51	21.70
Teaching Experience (in years)		
0–5	54	22.98
5–10	50	21.28
10–20	62	26.38
20 and above	69	29.36
Level of Professional Education		
No Degree	11	4.68
Diploma/Certificate	104	44.26
Degree	120	51.06
Experience of Using Computer (in years)		
Never used	114	48.51
Less than 1 year	55	23.40
1–5 years	41	17.45
5–10 years	14	5.96
More than 10 years	11	4.68
N = 235		

sampling approach. In this way, the total representative sample of teachers for this study was 235 (Fig. 2).

Method of the Study

Sources of Data

Both secondary and primary data were used in the present study. Secondary data sources included the Census of India (2011), NCERT Annual Report 2019–2020, UDISE+ 2019–20 Report, and UDISE+ 2023–24 Report. For the primary data, a survey was conducted using a pre-structured survey schedule administered to the selected teachers.

Methodology

Exploratory Factor Analysis (EFA)

Exploratory factor analysis (EFA) is a multivariate statistical technique that plays a critical role in the development and validation of psychological theories and measurement instruments (Gorsuch, 1997; Ishiwatari *et al.*, 1991; Ponnam *et al.*, 2014; Reio and Shuck, 2015; Watkins, 2018). In the present study, EFA was employed to identify latent variables underlying teachers' ICT competencies, attitudes, and usage patterns (Gebremedhin *et al.*, 2022; Reio and Shuck, 2015; Rönkkö and Cho, 2022; Ul Hadia *et al.*, 2016).

The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was calculated for both individual items and composite factors, with values greater than 0.60 considered acceptable (Gebremedhin *et al.*, 2022; Rönkkö and Cho, 2022; Ul Hadia *et al.*, 2016). Item loadings above 0.30 are generally regarded as acceptable; however, in this study, a stricter loading criterion of ≥ 0.50 was adopted. This threshold was chosen to ensure stronger factor interpretability, particularly in cases where cross-loadings may occur, as items with higher loadings are considered more meaningful (Gebremedhin *et al.*, 2022; Rönkkö and Cho, 2022; Ul Hadia *et al.*, 2016).

Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis (CFA) is a hypothesis-testing technique that allows researchers to specify, estimate, and evaluate factor-analytic models (Marsh, 1994; Watkins, 1989). It enables the assessment of model fit and comparison of competing models using established goodness-of-fit indices (Goretzko *et al.*, 2024; Levine, 2005; Marsh, 1994; Watkins, 1989).

Although the chi-square statistic was computed, it was not used as the sole indicator of model fit due to its sensitivity to large sample sizes (Alavi *et al.*, 2020; Gebremedhin *et al.*, 2022; Hidayat *et al.*, 2018; Yokokura *et al.*, 2017). The Standardised Root Mean Square Residual (SRMR) was used as a primary fit index, with values between 0.00 and 0.05 indicating good fit and values up to 0.08 considered acceptable (Gebremedhin *et al.*, 2022; Goretzko *et al.*, 2024; Hidayat *et al.*, 2018; Lanasa *et al.*, 2009; Yokokura *et al.*, 2017).

Additionally, the Root Mean Square Error of Approximation (RMSEA) was employed, where values between 0.05 and 0.08 were interpreted as indicating an adequate model fit. Comparative Fit Index (CFI) values of 0.95 or above were considered indicative of good fit, while values between 0.90 and 0.95 represented acceptable fit (Gebremedhin *et al.*, 2022; Goretzko *et al.*, 2024; Hidayat *et al.*, 2018; Lanasa *et al.*, 2009; Yokokura *et al.*, 2017).

Reliability Test

Following EFA, the reliability and internal consistency of the scales were assessed. Cronbach's alpha coefficient was calculated for the overall attitude scale as well as for the individual factors derived from factor analysis (Gebremedhin *et al.*, 2022). A Cronbach's alpha value greater than 0.70 was considered satisfactory, while values exceeding 0.90 were regarded as excellent (Gebremedhin *et al.*, 2022; Guillén-Gámez and Mayorga-Fernández, 2021).

In addition, McDonald's Omega coefficient was computed, as it provides a more accurate estimate of reliability when item loadings are uneven. Omega values above 0.70 were considered indicative of acceptable reliability (Guillén-Gámez and Mayorga-Fernández, 2021). Finally, Pearson's correlation coefficient was used to examine the relationships among the dimensions of the instrument (Guillén-Gámez and Mayorga-Fernández, 2021).

Results

Results of Exploratory Factor Analysis

Analysis of Teachers' Competency in ICT Integration

To assess the suitability of the data for exploratory factor analysis, the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity were performed. The KMO value was found to be 0.949, which exceeds the recommended threshold of 0.60, indicating excellent sampling adequacy. Bartlett's Test of Sphericity yielded a chi-square value of 5894.20 with a significance level of $p < 0.001$, leading to the rejection of the null hypothesis and confirming the appropriateness of factor analysis.

The communality values for all competency items were above 0.30, indicating that the items shared sufficient common variance. Exploratory factor analysis was conducted on 26 items related to teachers' ICT competency, as illustrated in Fig. 3. The analysis revealed three distinct factors:

F1: Advanced digital pedagogical competency

F2: Basic digital and ICT operational skills

F3: Computer and peripheral handling skills

Together, these three factors accounted for 69.78 per cent of the total variance. Factors F1 and F2 jointly explained 47.29 per cent of the total variance. As presented in Table 2, 24 items with factor loadings of ≥0.40 were retained in the final

model. Of these, nine items loaded onto F1 (advanced digital pedagogical competency), seven items onto F2 (foundational ICT literacy), and eight items onto F3 (computer and peripheral handling skills).

Varimax rotation was applied to facilitate interpretation of the factor structure. Items with weak loadings (< 0.50) were excluded, resulting in the retention of 24 out of the original 26 items. No cross loading of items was observed, indicating a clear and stable factor structure for teachers' ICT competency in teaching and learning.

Table 2
Rotated Component Matrix of Factors for Competency in Integrating ICT in Teaching–Learning

Components		Factors		
		1	2	3
Comp. 1	Operating a computer (log in and log out)	–	0.608	0.458
Comp. 2	Navigating in the operating system	–	0.439	0.594
Comp. 3	Using Word processing like creating document, editing, inserting tables etc.	–	0.408	0.679
Comp. 4	Using spreadsheets like processing data, creating tables, graphs etc.	–	–	0.720
Comp. 5	Creating presentations like inserting images, videos, hyperlinks, animations, etc.	0.501	–	0.639
Comp. 6	Connecting to Internet in computers and smart phones	–	0.606	0.518
Comp. 7	Using e-mail, web surfing, and search engines like Google, Yahoo, Bing	–	0.644	0.532
Comp. 8	Using social media such as Facebook, Twitter, LinkedIn, WhatsApp etc.	–	0.733	–
Comp. 9	Using virtual drives like Google Drive, SkyDrive, Dropbox	0.415	–	0.596
Comp. 10	Creating own Blog	0.685	–	0.474
Comp. 11	Creating multimedia presentations	0.614	–	0.532
Comp. 12	Installing and uninstalling software applications	0.527	–	0.604
Comp. 13	Keeping the computer updated and secure from virus and malwares	0.533	–	0.612
Comp. 14	Connecting and using computer peripherals (pen drive, hard disk, CDs, and DVDs)	–	0.505	0.656
Comp. 15	Connecting and using devices (speakers, digital cameras, printers, scanners, projectors and Mobile phones)	–	0.478	0.637
Comp. 16	Using smart phone	–	0.822	–
Comp. 17	Downloading the mobile apps	–	0.864	–
Comp. 18	Creating resources (images, video, audio) using smart phones	–	0.761	–
Comp. 19	Using audio-visual communication like Messengers, SKYPE, tele-conferencing, etc.	0.540	0.507	–
Comp. 20	Using collaborative learning activities online like discussion forums, Google docs, etc.	0.632	0.488	–
Comp. 21	Abilities to navigate in a MOOC course	0.756	–	–
Comp. 22	Using Free and Open System Software (FOSS) like Geogebra, Audacity, Freeplane etc.	0.817	–	–
Comp. 23	Preparing online quizzes and activities	0.730	–	–
Comp. 24	Using assistive technologies like Text to Speech, special softwares, tactile materials	0.707	–	–
Comp. 25	Using Virtual and Augmented Reality (VR/AR) based resources	0.799	–	–

Source: Researcher — Primary Survey (N = 235)

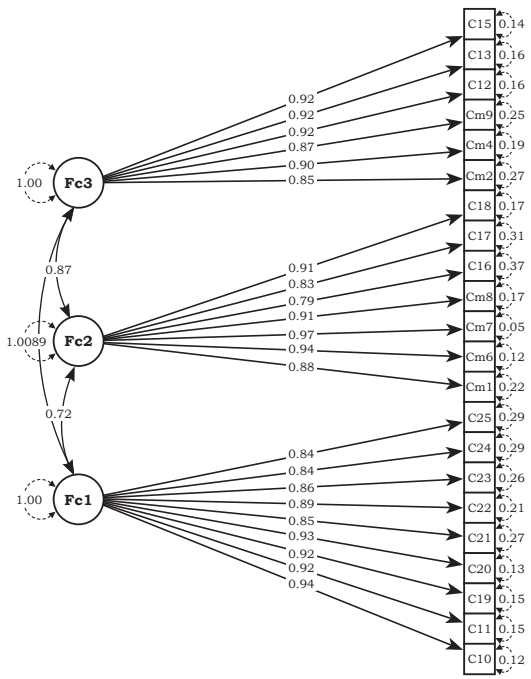

Fig. 3: Diagram for confirmatory factor analysis of competency

ICT Integration: Attitude of Teachers

Attitude based on Positive Statements towards the Integration of ICT in Teaching–learning

The KMO value was reported as 0.897, which is greater than the acceptable threshold of 0.60, indicating the suitability of the data for factor analysis Bartlett's Test of Sphericity yielded a chi-square value of 1229.72 with a significance level of $p < 0.001$, leading to the rejection of the null hypothesis and acceptance of the alternative hypothesis. This confirms that the correlation matrix was appropriate for exploratory factor analysis.

The communality values for all items were within the acceptable range of > 0.30. Exploratory factor analysis was conducted on 12 items, as illustrated in Figure 4 and Table 3. The analysis revealed two factors, labelled as:

F1: Positive perception of ICT in teaching and professional growth, and

F2: ICT for engaging and empowering student learning.

These two factors together explained 44.65 per cent of the total variance. As shown in Table 3, all 12 items with factor loadings of ≥ 0.40 were retained in the final model. Of these, seven items loaded onto F1 (positive perceptions of ICT in teaching and professional growth), while five items loaded onto F2 (ICT for engaging and empowering student learning).

Varimax rotation was applied to facilitate interpretation of the factor structure and to obtain a clearer pattern of item loadings.

Table 3
Rotated Component Matrix of Factors for Attitude based on Positive Statements towards the Integration of ICT in Teaching–Learning

Components		Factors	
		1	2
Att P1.	Use of ICT in classroom helps in improving students' learning	–	0.643
Att P3.	Use of ICT has an advantage over traditional methods of teaching	–	0.648

Att P4.	Use of ICT makes the subject more interesting	–	0.788
Att P5.	Use of ICT enhances independent learning among students	–	0.552
Att P6.	Use of ICT helps in dealing with heterogeneous group of students	0.472	–
Att P7.	Use of ICT improves my job performance	0.717	–
Att P8.	Using ICT is respected in professional circle	0.749	–
Att P9.	Use of ICT increases my efficiency as a teacher	0.479	0.433
Att P10.	Use of FOSS softwares are beneficial	0.539	–
Att P11.	Use of ICT saves the time due to availability of open educational resources	–	0.443
Att P12.	Use of ICT makes sharing of ideas easier	0.658	0.419
Att P13.	AUse of ICT makes the learner more divergent thinker	0.511	–

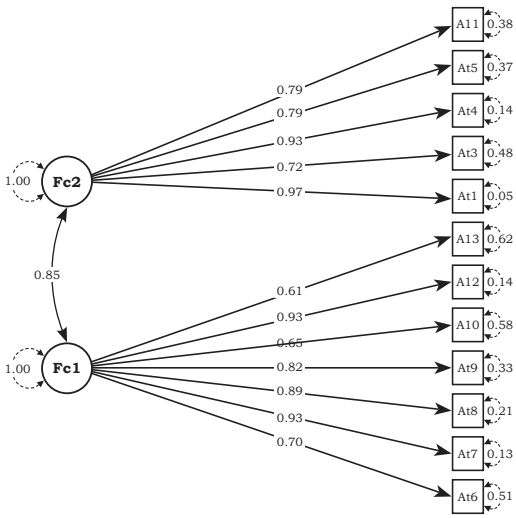

Fig. 4: Diagram for confirmatory factor analysis of positive attitude

Attitude based on Negative Statements towards the Integration of ICT in Teaching–learning

The KMO value was reported as 0.858, which is greater than 0.6, indicating the suitability of the model for factor analysis. Bartlett's Test of Sphericity yielded a chi-square value of 1074.57 with a p-value <0.001, leading to the rejection of the null hypothesis and acceptance of the alternative hypothesis. The communality values were within an acceptable range (> 0.3) for all items in the construct.

Exploratory factor analysis (EFA) was conducted on the 12 items and is illustrated in Fig. 5 and Table 4. The analysis revealed two factors, labelled as

F1: Perceived drawbacks and personal barriers to ICT use and

F2: Perceived professional and pedagogical threats of ICT. Together, these two factors explained 45.47 per cent of the total variance in the data.

As shown in Table 3, 10 items with factor loadings ≥ 0.4 were retained in the final model. Of these, six items loaded onto F1 (Perceived drawbacks and personal barriers to ICT use), while four items loaded onto F2 (Perceived professional and pedagogical threats of ICT). For factor extraction, varimax rotation was applied to identify the underlying item structure and facilitate interpretation.

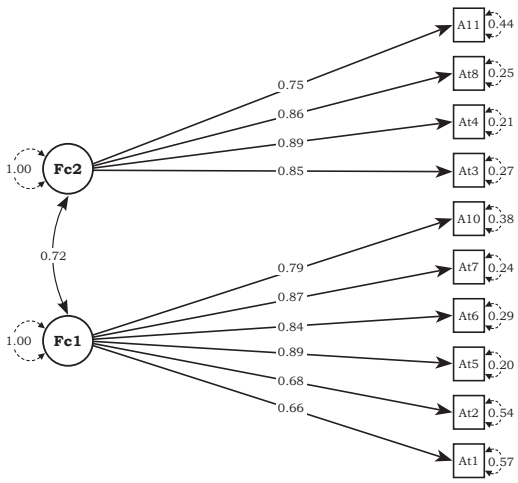

Fig. 5: Diagram for confirmatory factor analysis of negative attitude

Table 4
Rotated Component Matrix of Factors for Attitude based on Negative Statements towards the Integration of ICT in Teaching-Learning

Components		Factors	
		1	2
Att N1.	Use of ICT is a waste of time	0.512	–
Att N2.	Use of ICT encourages unethical practices	0.411	–
Att N3.	Use of ICT makes me overburdened	–	0.750
Att N4.	Use of ICT creates anxiety	–	0.785
Att N5.	Use of ICT in classes makes me less confident	0.749	–
Att N6.	Use of ICT complicates the task in the classroom	0.742	–
Att N7.	Use of ICT leads to frustration	0.739	–
Att N8.	Use of ICT makes students as passive listener	0.465	0.515
Att N10.	Use of ICT affects the health of a person	0.578	–
Att N11.	Use of ICT reduces the importance of teachers	–	0.688

Analysis of teachers' responses on the usage of ICT in teaching–learning

To assess the suitability of the data for exploratory factor analysis (EFA), the KMO measure of sampling adequacy and Bartlett's Test of Sphericity were conducted. The KMO value was reported as 0.949, which exceeds the recommended threshold of 0.6, indicating that the data were suitable for factor analysis. Bartlett's Test of Sphericity yielded a chi-square value of 4379.89 with a p-value < 0.001, leading to the rejection of the null hypothesis and acceptance of the alternative hypothesis. The communality values for all items were within the acceptable range (> 0.3).

Exploratory factor analysis was conducted on 23 items, as illustrated in Fig. 6 and Table 5.

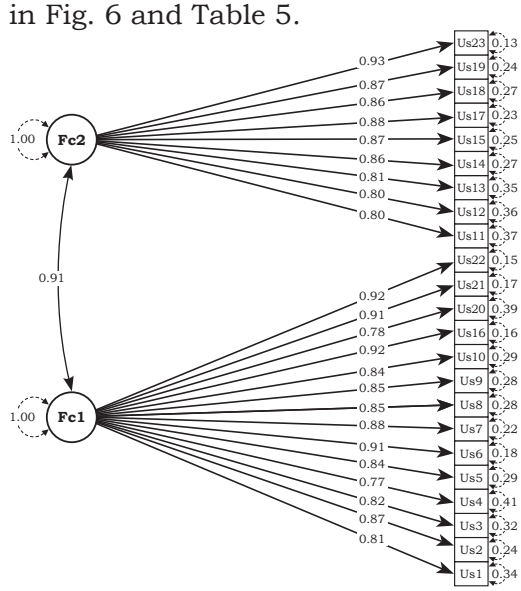

Fig. 6: Diagram for confirmatory factor analysis of usage

The analysis revealed two factors, labelled as

F1: Pedagogical use of ICT in classroom practice and

F2: Administrative and professional use of ICT. Together, these two factors explained 59.81 per cent of the total variance.

As shown in Table 5, all 23 items with factor loadings ≥ 0.4 were retained in the final model. Of these, 14 items loaded onto F1 (Pedagogical use of ICT in classroom practice), while nine items loaded onto F2 (Administrative and professional use of ICT). Varimax rotation was applied during factor extraction to identify the underlying item structure and facilitate interpretation. Weakly loaded items (< 0.5) were excluded, resulting in a final set of 23 items related to teachers' integration of ICT in teaching–learning, with no cross-loadings observed.

Table 5

Rotated Component Matrix of Factors for the Usage of ICT in Teaching–Learning

Components		Factors	
		1	2
Usage 1	I design my lesson on the basis of digital resources available.	0.714	—
Usage 2	I plan online collaborative activities for my students	0.690	—
Usage 3	I search the relevant digital resources for my topic.	0.630	—
Usage 4	I develop my own digital resources for my classes.	0.680	—
Usage 5	I use Free and Open Source Software (FOSS) for making different digital resources.	0.687	—
Usage 6	I use ICT tools to make presentations in classroom.	0.746	—
Usage 7	I integrate ICT (audio/video/multimedia/websites) in my lesson while teaching	0.753	—
Usage 8	I communicate with my students using ICT tools, such as, e-mail, Google groups besides face-to-face mode.	0.653	—
Usage 9	I allow my students to employ ICT in various activities (Assignments, Projects, Teaching Aids)	0.729	—
Usage 10	I prepare online quizzes and assessments for my students	0.626	—
Usage 11	I use email to communicate with the officials and colleagues	0.457	0.500
Usage 12	I create groups on social networking sites to communicate exam dates and assignments.	—	0.577
Usage 13	I use online spreadsheets to maintain attendance record of students and share it with my colleagues.	—	0.724
Usage 14	I maintain result records of students through online spreadsheets.	—	0.755
Usage 15	I schedule important events through online calendars.]	—	0.729
Usage 16	I use ICT to communicate with parents and community.	0.588	0.577

Usage 17	I use ICT for admission and fees purposes		0.768
Usage 18	I use ICT to help school administration in day to day work	—	0.692
Usage 19	I use NROER/e-PATHSHALA/SWAYAM (MOOCs)/ SWAYAM PRABHA/online textbooks	0.525	0.534
Usage 20	I use Blended and Flipped learning methods to teach my topics	0.515	0.426
Usage 21	I share my teaching resources through online Groups/Blogs	0.610	0.536
Usage 22	I use ICT tools for doing research in education	0.609	0.568
Usage 23	I use online platforms for giving online presentations in seminars and conferences	0.525	0.584

Findings of Confirmatory Factor Analysis

The findings of the exploratory factor analysis (EFA) indicated the presence of three latent factors within the competency dimension (Table 2). Confirmatory factor analysis (CFA) was therefore conducted to validate the factorial structure of competency in integrating ICT in teaching–learning and to examine the suitability of the proposed model based on the structure identified through EFA. The CFA results are presented in Fig. 3, where all factor loadings exceeded 0.5, ranging from 0.79 to 0.97. All factor loadings were statistically significant ($p < 0.001$). The model fit indices indicated an acceptable overall fit ($x^2 = 971$, $df = 205$, $p < 0.01$; *RMSEA* = 0.126; *CFI* = 0.84; *TLI* = 0.82; *SRMR* = 0.0758), suggesting sufficient goodness of fit.

The EFA results further revealed two latent factors within the positive attitude dimension (Table 3). To confirm the factorial validity of teachers' positive attitudes towards the integration of ICT in teaching–learning, CFA was performed. As shown in Fig. 4, all factor loadings were greater than 0.5, ranging from 0.61 to 0.97, and were statistically significant ($p < 0.001$). The model fit indices ($x^2 = 137$, df = 53, $p < 0.01$; *RMSEA* = 0.082; *CFI* = 0.927; *TLI* = 0.909; *SRMR* = 0.0512) indicated an adequate model fit, demonstrating sufficient goodness of fit.

Similarly, the EFA results indicated the presence of three latent factors within the negative attitude dimension (Table 4). CFA was conducted to validate the factorial structure of negative attitudes towards ICT integration in teaching–learning. As illustrated in Fig. 5, factor loadings exceeded 0.5, ranging from 0.66 to 0.89, and all were statistically significant ($p < 0.001$). The fit indices ($x^2 = 132$, $df = 34$, $p < 0.01$; *RMSEA* = 0.111; *CFI* = 0.894; *TLI* = 0.86; *SRMR* = 0.0728) indicated an acceptable level of model fit.

Finally, the EFA results showed two latent factors within the usage dimension (Table 5). CFA was carried out to confirm the factorial validity of ICT usage and to evaluate the appropriateness of the proposed model. As shown in Figure 6, all factor loadings were greater than 0.5,

ranging from 0.77 to 0.93, and were statistically significant ($p < 0.001$). The overall model fit was found to be adequate (x^2 = 827, df = 229, $p < 0.01$; *RMSEA* = 0.105; *CFI* = 0.861; *TLI* = 0.847; *SRMR* = 0.0549), indicating sufficient goodness of fit.

Reliability Analysis

The overall reliability of Model 1 for the competency dimension was assessed using Cronbach's alpha (a), which yielded a very high value (a = 0.968). Additionally, McDonald's Omega coefficient was computed and indicated excellent reliability (ω = 0.969). According to previous studies, a Cronbach's alpha value of ≥ 0.70 indicates acceptable reliability (Gebremedhin *et al.*, 2022; Guillén-Gámez and Mayorga-Fernández, 2021). Similarly, an Omega coefficient of ≥ 0.70 reflects acceptable and more precise reliability, particularly when item loadings are unequal (Guillén-Gámez and Mayorga-Fernández, 2021).

For Model 2, representing the positive attitude dimension, Cronbach's alpha was recorded as 0.868, and McDonald's Omega coefficient as 0.887, indicating satisfactory reliability (Tables 6 and 7). In Model 3, corresponding to the negative attitude dimension, Cronbach's alpha was 0.864 and the Omega coefficient was 0.868, demonstrating favourable reliability for model acceptance. In Model 4, representing the usage dimension, both Cronbach's alpha and McDonald's Omega coefficients were recorded as 0.965, indicating excellent reliability (Table 7).

Pearson's correlation coefficient was employed to examine inter-item relationships within each dimension. Fig. 7 presents the correlation heat map, while the detailed correlation matrices are provided in Table 1 of the supplementary file. The results indicate that correlations among items within each dimension were positive and statistically significant.

In the first model (competency dimension), the highest correlation was observed between comp 15 and comp 14 (r = 0.85), followed by comp 4 and comp 3 (r = 0.83), comp 5 and comp 4 (r = 0.82), and comp 17 and comp 16 (r = 0.82). The lowest correlations were found between comp 21 and comp 16 (r = 0.19), comp 22 and comp 17 (r = 0.19), comp 22 and comp 16 (r = 0.21), and comp 17 and comp 10 (r = 0.28).

In the second model (positive attitude dimension), the highest correlation was observed between attp 8 and attp 7 (r = 0.71), followed by attp 4 and attp 1 (r = 0.64), and attp 12 and attp 7 (r = 0.61). The lowest correlations were found between attp 13 and attp 2 (r = 0.01), attp 13 and attp 3 (r = 0.14), and attp 11 and attp 2 (r = 0.15).

In the third model (negative attitude dimension), the highest correlation occurred between attn 4 and attn 3 (r = 0.68), followed by attn 7 and attn 5 (r = 0.63), and attn 7 and attn 6 (r = 0.62).

The lowest correlations were observed between attn 12 and attn 1 (r = 0.13), and attn 3 and attn 1 (r = 0.15).

In the fourth model (usage dimension), the highest correlation was found between usage 22 and usage 21 (r = 0.78), followed by usage 14 and usage 13 (r = 0.77), usage 7 and usage 6 (r = 0.75), and usage 8 and usage 7 (r = 0.72).

Table 6
Fit Statistics of Tested CFA Models

Model	Specification	Chi Square (x^2)			RMSEA	RMSEA 90% CI		CFI	TLI	SRMR	AIC	BIC
		value	df	P value		Lower	Upper					
First	Competency	971	205	< .001	0.126	0.118	0.134	0.84	0.82	0.0758	7297	7539
Second	Positive attitude	137	53	< .001	0.0821	0.0653	0.0991	0.927	0.909	0.0512	3783	3911
Third	Negative attitude	132	34	< .001	0.111	0.091	0.131	0.894	0.86	0.0728	4634	4742
Fourth	Usage	827	229	< .001	0.105	0.0977	0.113	0.861	0.847	0.0549	7553	7795

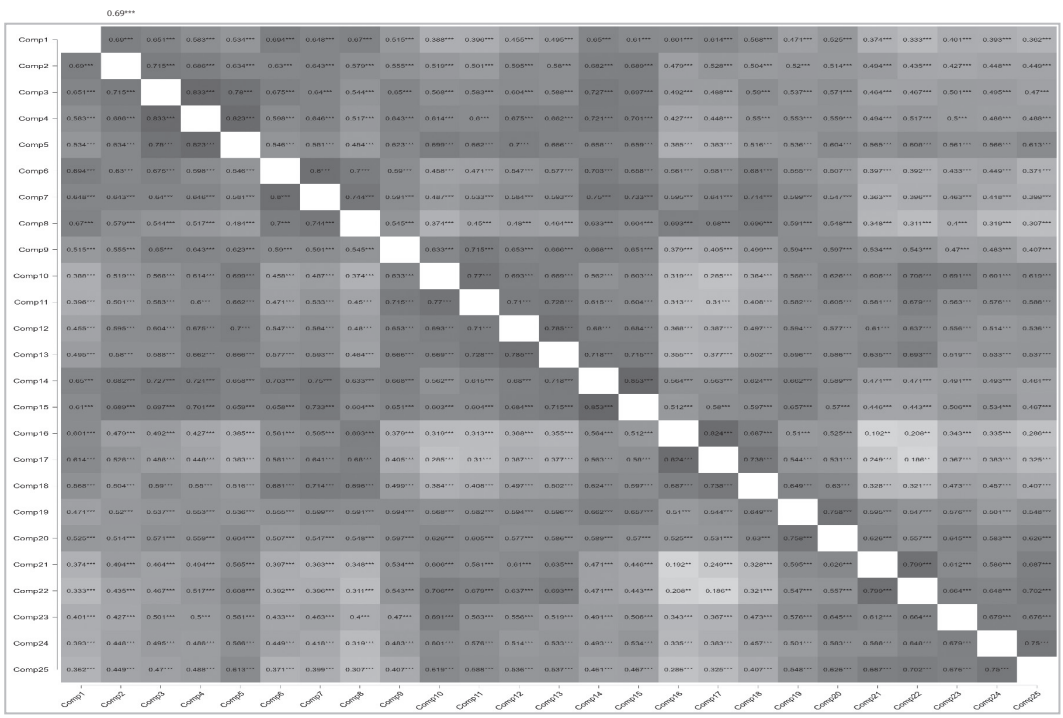

Fig. 7: Correlation heatmap among the items under four dimensions for Competency

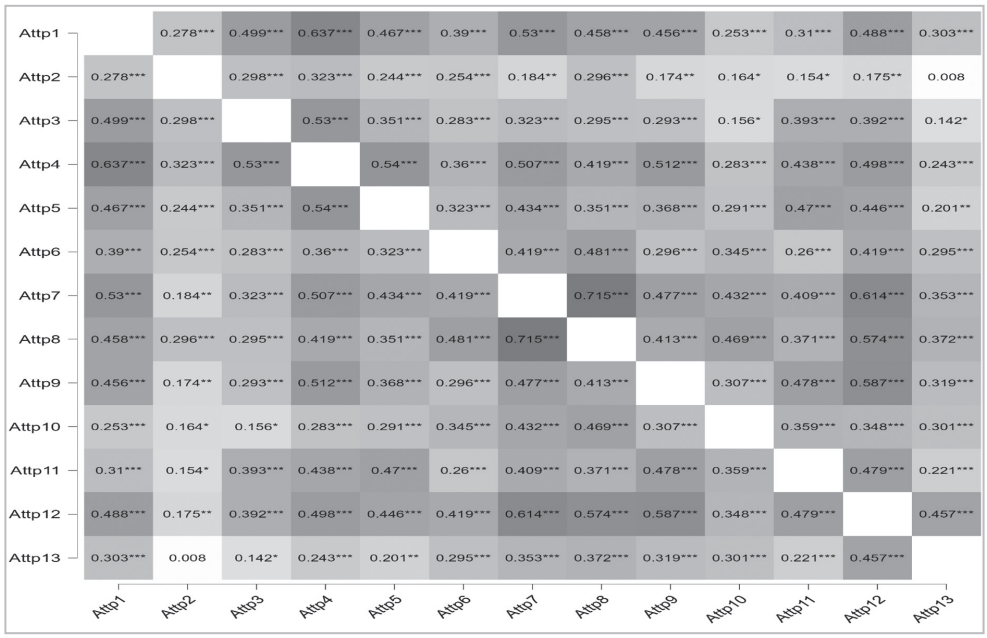

Fig. 8: Correlation heatmap among the items under four dimensions for Positive attitude

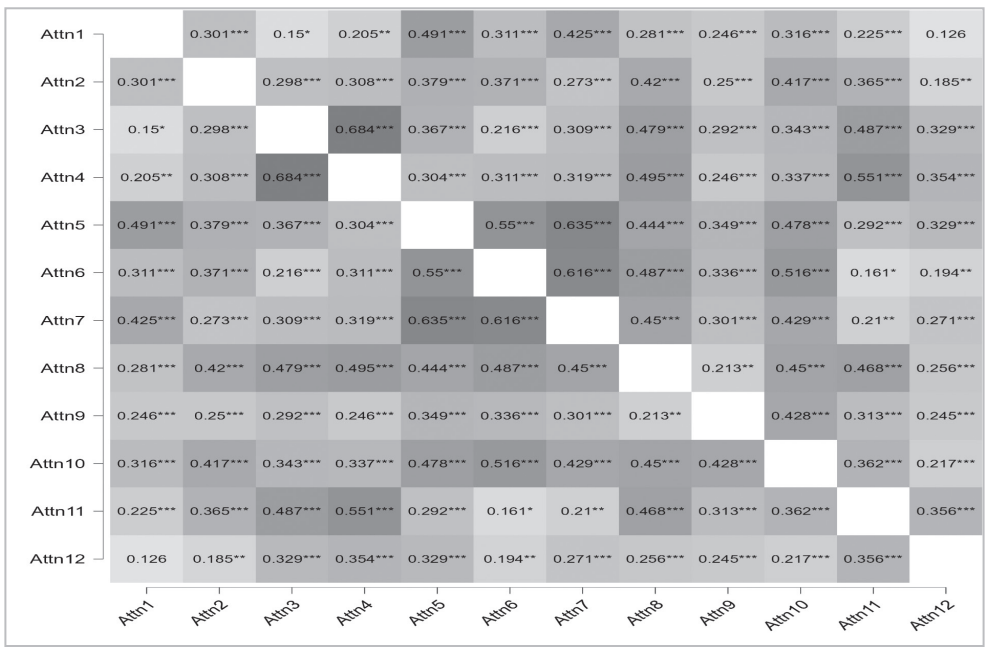

Fig. 9: Correlation heatmap among the items under four dimensions for Negative attitude

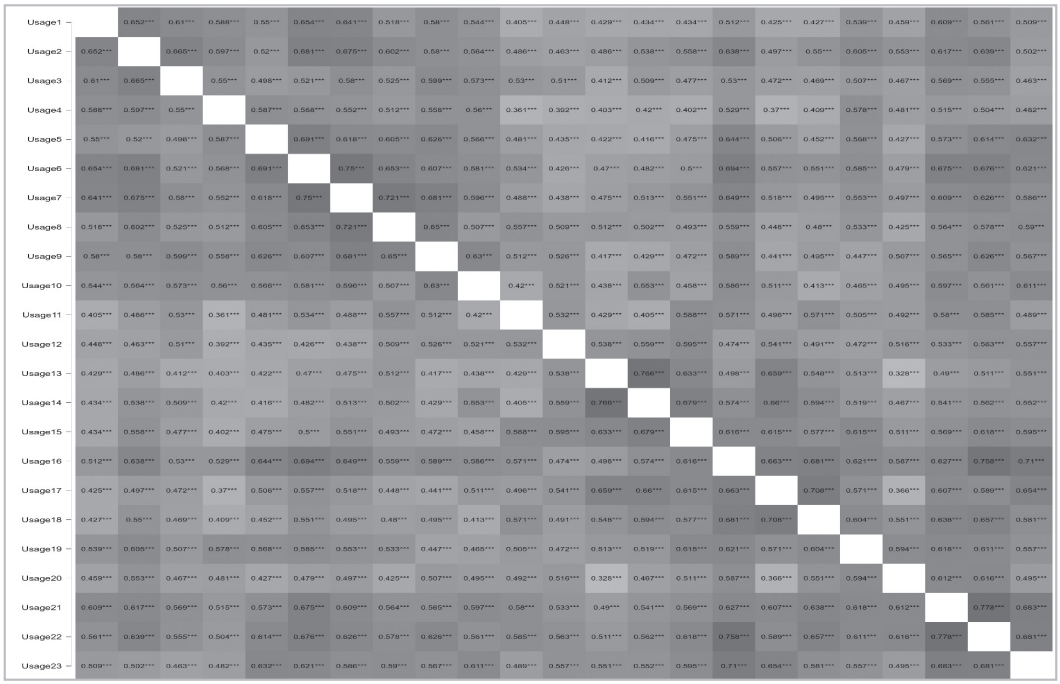

Fig. 10: Correlation heatmap among the items under four dimensions for Positive attitude

Table 7
Cronbach's Alpha Values of Four Factors in the Scale

Factors	Mean	SD	Cronbach's α	McDonald's ω
Competency	1.61	0.543	0.968	0.969
Positive attitude	2.66	0.374	0.868	0.887
Negative attitude	2.36	0.495	0.864	0.868
Usage	1.5	0.512	0.965	0.965

Discussion

This study examined teachers' readiness to integrate Information and Communication Technology (ICT) in rural government schools in India using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). The first objective focused on teachers' ICT competencies. The findings indicate that most teachers demonstrated proficiency in basic and mobile-based digital tasks, such as using smartphones, accessing social media, downloading applications, and performing basic computing functions. These results are consistent with studies conducted in similar rural and resource-constrained contexts (Dahri *et al.*, 2023; Esmat and Amasha, 2025;

Khlaisang *et al.*, 2023; Thedpitak and Somphong, 2021).

However, a substantial skills gap was evident in advanced ICT competencies, including the use of Massive Open Online Courses (MOOCs), Open Educational Resources (OER), Virtual and Augmented Reality tools, and open-source content development. This gap reflects a persistent digital divide in the pedagogical application of ICT rather than in basic access or familiarity (Fonseca *et al.*, 2018; Mahbub *et al.*, 2024; Wang *et al.*, 2022). The EFA and CFA results validated three latent constructs—advanced digital pedagogical competency, basic ICT operational skills, and peripheral handling skills. Model fit indices (For example *RMSEA* = 0.126, *CFI* = 0.84) supported the structural validity of the competency framework. These findings highlight the need for professional development initiatives that extend beyond foundational ICT training and emphasise higher-order pedagogical skills aligned with twenty-first-century teaching and learning practices (Almazroa and Alotaibi, 2023; González-Salamanca *et al.*, 2020; Kong *et al.*, 2013; Ng *et al.*, 2023; Zhao *et al.*, 2023).

The second objective examined teachers' attitudes towards ICT integration. The results revealed generally positive attitudes, with teachers expressing strong beliefs in ICT's capacity to enhance learning outcomes, increase student engagement, improve academic performance, and promote learner autonomy. These findings align with earlier studies suggesting that teachers increasingly view ICT as a transformative pedagogical tool (Barak, 2006; Kale and Goh, 2014; Kong *et al.*, 2013; Moreira-Fontán *et al.*, 2019). Nevertheless, comparatively weaker agreement was observed regarding ICT's role in managing classroom diversity, fostering divergent thinking, and supporting the use of Free and Open-Source Software (FOSS), indicating limited awareness of ICT's broader pedagogical potential.

Negative attitudes were primarily associated with concerns that ICT integration is time-consuming, increases instructional complexity, reduces teaching confidence, and may encourage unethical practices (Singun, 2025). In contrast, apprehensions regarding the diminishing role of teachers or adverse health effects were less pronounced, suggesting that resistance stems more from self-efficacy and institutional constraints than from the ideological opposition to ICT (Howard, 2013). CFA confirmed the two-factor structure of attitudes—positive and negative—with acceptable model fit (*RMSEA* = 0.082 for positive attitudes and *RMSEA* = 0.111 for negative attitudes). These findings reinforce existing literature emphasising that teacher attitudes play a mediating role in ICT integration and are shaped by both facilitating and inhibiting

factors (Akram *et al.*, 2022; Ertmer *et al.*, 2012; Hew and Brush, 2007; Raygan and Moradkhani, 2022; Shen *et al.*, 2024).

The third objective assessed teachers' actual usage of ICT in teaching–learning processes. The results indicate frequent use of ICT for sourcing digital content, implementing blended and flipped learning approaches, developing instructional materials, and facilitating communication through email and digital calendars. These practices reflect a growing orientation towards pedagogical ICT use and professional collaboration. However, limited engagement with open-source tools, online presentation platforms, and administrative ICT applications — such as student admissions and fee management — suggests a narrow scope of ICT utilisation. This restricted usage pattern underscores structural and institutional barriers that constrain broader integration.

EFA identified two usage-related factors — pedagogical usage and administrative or professional usage — accounting for 59.81 per cent of the total variance. CFA results confirmed the adequacy of the model (*RMSEA* = 0.105, *CFI* = 0.861). High reliability indices (Cronbach's α and McDonald's (ω) values exceeding 0.86) and strong inter-item correlations further supported the robustness of the measurement instrument. Collectively, the findings suggest a state of partial readiness — while foundational skills and favourable attitudes are present, meaningful ICT integration remains limited by infrastructural deficits, insufficient technical support, and inadequate professional training. Addressing these challenges requires sustained capacity-building, institutional support mechanisms, and coherent policy implementation to enable effective ICT integration in rural education settings.

These findings align with the G20's 2023 priorities under India's presidency, which emphasise inclusive digital transformation through the development of Digital Public Infrastructure (DPI) in underserved regions (Ali and Kamraju, 2023; Kirton and Warren, 2018; Lyons *et al.*, 2019). Teachers' limited advanced ICT skills and low engagement with FOSS mirror priority areas identified by G20 initiatives, which advocate capacity-building, international collaboration, and inclusive pedagogical innovation through digital technologies. The presence of strong positive teacher attitudes offers a critical foundation for scalable interventions. Aligning national education strategies with G20-endorsed practices — such as strengthening digital infrastructure, embedding ICT in classroom pedagogy, and cultivating digital leadership among teachers — can accelerate India's transition towards a more equitable and digitally inclusive education system, consistent with the G20's vision of "One Earth, One Family, One Future."

Conclusion

This study employed exploratory and confirmatory factor analysis to assess teachers' readiness to integrate Information and Communication Technology (ICT) in rural government schools in India. The analysis identified three key dimensions of readiness—ICT competency, teacher attitudes, and actual ICT usage. While many teachers demonstrated basic digital skills—such as operating smartphones and using simple applications—their proficiency declined while engaging with advanced technologies, including MOOCs, open-source software, and Virtual or Augmented Reality platforms. EFA revealed three underlying competency domains—foundational ICT literacy, advanced pedagogical competencies, and peripheral handling skills. CFA results confirmed the validity and reliability of this measurement model.

Teachers generally exhibited positive attitudes towards ICT, recognising its potential to enhance student engagement and learning outcomes. Nevertheless, concerns related to increased workload, reduced confidence, and classroom management complexities, indicate persistent psychological and institutional barriers. These mixed attitudes underscore the importance of policy approaches that simultaneously reinforce motivation and address structural constraints.

In terms of practice, ICT usage remained largely confined to pedagogical functions such as accessing digital content and employing blended learning approaches, with limited adoption of administrative and higher-order instructional applications. This disparity between positive attitudes and constrained usage suggests that teachers' readiness is shaped not only by willingness but also by the availability of resources, training opportunities, and institutional support.

Overall, the study reveals a partial yet promising level of ICT readiness among teachers in rural government schools. Advancing beyond basic ICT use requires a comprehensive strategy encompassing targeted capacity-building, improved infrastructure, continuous professional development, and systemic institutional support. Such integrated efforts are essential for fostering meaningful, sustained, and contextually relevant ICT integration in rural education systems in India.

Policy Recommendations

To address the challenges associated with ICT integration in rural and resource-constrained educational contexts, the following globally relevant policy recommendations are proposed:

Implement Globally Aligned ICT Training Programmes

Governments should introduce structured ICT training programmes

for teachers and school leaders aligned with international frameworks, such as UNESCO's ICT Competency Framework. These programmes should prioritise pedagogical integration and digital leadership, with particular attention to rural and marginalised settings.

Mainstream Free and Open-source Software (FOSS)

Integrate FOSS training into national ICT programmes to ensure cost-effective digital access. Free & Open-Source Software (FOSS) refers to its systematic integration into teacher training. School ICT infrastructure and classroom practices as a cost-effective alternative to proprietary software. This includes equipping teachers with the skills to use and adapt open tools (For example, GeoGebra, Audacity) for pedagogical purposes, therby enhancing accessibility and flexibility in resource constrained setting. Furthermore, promoting South-South cooperation involves fastering collaboration among developing countries to share knowledge, best practices and Scalablke models for FOSS adoption, ensuring contextually relevant and sustainable digital integration in education system.

Ensure Equitable ICT Access through Partnerships

Bridging the rural–urban digital divide requires a sustained investment in affordable digital infrastructure, such as smartphones, tablets, and low-bandwidth technologies. Governments should leverage public–private partnerships and international development assistance to expand ICT access in underserved regions.

Promote Context-sensitive ICT Pedagogical Research

Policymakers should support evidence-based research on digital pedagogical models, including blended, flipped, and mobile learning, to assess their effectiveness across diverse educational and cultural contexts and to inform adaptive ICT policies.

Harness Positive Teacher Attitudes for ICT Adoption

Teachers' favourable attitudes towards ICT should be strategically leveraged to drive adoption. Linking attitudinal readiness with skill development initiatives can inform the design of responsive professional development programmes and infrastructure policies tailored to varied educational contexts.

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