Structural Relationships among ICT Competencies of Secondary School Teachers: A CFA-SEM Analysis

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***Abstract*—This study examines Information and Communication Technology (ICT) competency levels and variations among secondary school teachers in West Tripura, India, where policy emphasis on digital education contrasts with reported skills gaps. Using a stratified random sample of 100 teachers across gender, subject background, and school location, multiple ICT competency dimensions were assessed through a structured survey instrument. Findings reveal predominantly low to moderate ICT competency, with only 22% of teachers demonstrating high proficiency. Contrary to some prior studies reporting demographic differences, no significant variations emerged by gender, subject background (Science vs. Arts), or urban-rural location. These results highlight systemic barriers, including inadequate training and infrastructure, that appear to constrain competency development uniformly across teacher groups. The study emphasizes the urgent need for targeted, context-specific professional development programs, peer mentorship by high-competency teachers, and equitable infrastructure investment. These interventions are essential for bridging the digital divide and equipping secondary teachers to effectively integrate ICT into their teaching practices, preparing students for a technology-driven future.**

***Keywords*—Information and Communication Technology (ICT) competency, Confirmatory Factor Analysis (CFA), Structural Equation Modelling (SEM), secondary teachers, digital skills, Technological Pedagogical Content Knowledge (TPACK)**

I. INTRODUCTION

The rapid advancement of Information and Communication Technology (ICT) has become a defining force in reshaping educational systems globally, necessitating both policy innovation and grassroots capacity-building among teachers [1, 2]. ICT competency, which encompasses the ability to use digital tools for lesson planning, classroom instruction, assessment, and professional growth, is now regarded as an essential qualification for teachers in the 21st century. In the Indian context, this has become particularly urgent, given ambitious initiatives such as the National Education Policy 2020 and Digital India, both of which underscore the strategic role of teachers in leveraging technology to deliver equitable, high-quality education [3].

Despite increased investment and formal mandates, evidence suggests that significant gaps persist in teachers' ICT skills, especially at the secondary school level [4, 5]. The present study was designed to empirically assess the ICT competency of secondary school teachers in the West Tripura district of Tripura state. Specifically, it investigates not only the overall competency levels of these teachers but also variations based on gender, subject background, and school location, dimensions shown to influence technology adoption in previous studies [6, 7]. To guide this study, the following objectives are framed.

(1) To validate the eight-factor structure (Word Processing, Presentation, Spreadsheet, E-mail, Digital Tools, Internet/Networking, Communication, Professional) of the ICT Competency Scale using Confirmatory Factor Analysis (CFA).
(2) To examine the structural relationships and predictive paths among ICT competency domains using Structural Equation Modelling (SEM).
(3) To assess the overall ICT competency levels of secondary school teachers in West Tripura.
(4) To investigate differences in ICT competency levels with reference to gender, subject background (Science vs. Arts), and school location (urban vs. rural).

Addressing these objectives is crucial for informing targeted professional development initiatives and for bridging capacity gaps that still divide urban and rural, male and female, and science and arts teachers, as highlighted in both national and international research [1, 8, 9]. By systematically identifying areas of deficiency and strength, this study aims to support policymakers, school leaders, and teacher education providers in crafting responsive, data-driven interventions. Ultimately, understanding these dynamics is fundamental to preparing teachers and, by extension, students for a digital, knowledge-driven society.

II. LITERATURE REVIEW

A growing body of research highlights the uneven state of ICT competency among secondary school teachers, shaped by contextual factors such as access to infrastructure, training opportunities, policy implementation, and individual motivation. In the Indian context, despite strong policy emphasis through initiatives such as Digital India and the National Education Policy 2020, empirical studies frequently report gaps between policy intentions and classroom-level ICT use. For example, Choudhary [4] found that digital competence among secondary school teachers in Jammu was higher among female and private school teachers, suggesting that institutional context and gender can influence access to and use of ICT resources. By contrast, Reang and Mohalik [5] observed generally low ICT skills among secondary school teachers in Tripura, with limited variation across gender, academic background, or location, suggesting that structural constraints may suppress differences observed in better-resourced settings.

International studies also show considerable variability. Farisa *et al.* [10] in Indonesia and Ikwuka *et al.* [11] in

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Nigeria reported that teachers often possess basic operational skills yet lack higher-order competencies related to pedagogical integration, digital content creation, or data-driven teaching, largely due to insufficient training and support. Systematic work by Novoa-Echaurren *et al.* [12] comparing Finnish and Chilean schools demonstrates that even where infrastructure is relatively strong, gaps persist between ambitious ICT policies and teachers' everyday practices, particularly when professional learning is fragmented or overly technical. Their findings underline that the impact of national ICT strategies depends heavily on how teachers are supported in adopting and adopting technologies within their specific school cultures and classrooms.

Within India and similar contexts, several studies underscore the importance of sustained professional development and infrastructure, especially in rural and under-resourced schools. Kumari and Dsouza [6]; Laxmi and Jabin [7] found that teachers with repeated exposure to ICT-related training and better school-level facilities tended to report higher competence, though evidence for systematic gender or urban-rural differences is mixed. Some works, such as those by Briones [8], Kundu [13], Payal and Kanvaria [14], further highlight challenges, including inconsistent policy implementation, teacher resistance, and a persistent digital divide in terms of both access and pedagogically meaningful use of technology.

Recent systematic reviews confirm persistent gaps; Domínguez-González *et al.* [1] analyzed 19 studies finding teachers low in digital competence and highlighting the need to develop training programs for the improvement of teacher digital competence. On the other hand, Pham *et al.* [15] report that there is good skill in DigCompEdu-based digital competence among Hanoi (Vietnam) secondary teachers, while their performance is weakest in the assessment domain. Research by Tzafilkou *et al.* [16] validated the 20-item DC scale (6 components), revealing inefficiency in digital competence among teachers in Greece. Primary school teachers reported significantly lower scores in Professional development, Teaching delivery, and students' support. Female teachers reported significantly lower scores in innovation in education and school development, but they reported higher scores in Professional development. Moreover, Antonietti *et al.* [17] found that digital competence predicts Technology Acceptance Model (TAM) among Swiss vocational teachers, while Lucas *et al.* [18] verified that gender and age differences were found, but the number of tools used for teaching and learning was the strongest predictor of teachers' digital competence. Another systematic review analyzed by Revuelta-Domínguez *et al.* [19] found that there is still no common, performance-based way to implement and evaluate teachers' digital competence.

Overall, prior research shows that secondary teachers' ICT competencies are often low to moderate, with mixed evidence regarding gender, subject background, and urban-rural differences. However, most studies either focus on single dimensions of ICT use, do not examine the interrelationships among different ICT competencies (e.g., office skills, spreadsheets, communication, networking), or pay limited attention to less-studied regions such as Northeast India and Tripura. Few studies simultaneously explore how basic office skills, spreadsheets, communication, networking, and digital tools combine to shape teachers' overall professional ICT competence.

The present study addresses these gaps by analyzing multiple ICT competency dimensions together and testing whether overall competence differs by gender, subject background, and school location among secondary school teachers in West Tripura. Based on the mixed findings regarding background differences and the structural constraints documented in Tripura, it is plausible that systemic constraints affect all teacher groups similarly, leading to no substantial differences in overall ICT competency across these factors.

III. Theoretical Framework

The present study is grounded in three complementary frameworks that together explain teachers' ICT competency development and variation: Technological Pedagogical Content Knowledge (TPACK), the Technology Acceptance Model (TAM), and Diffusion of Innovations Theory.

TPACK provides the conceptual foundation for understanding teachers' multidimensional ICT competencies. According to Mishra and Koehler [20], effective ICT use requires the intersection of technological knowledge (e.g., office skills, spreadsheets, networking), pedagogical knowledge (communication, digital tools), and content knowledge (subject background). This framework directly informs the study's analysis of the interrelationships among ICT competency dimensions (H_{01}–H_{04}) and explains why subject background (Science vs. Arts) may influence overall competence through differential demands on content knowledge.

TAM, Davis [21] elucidates how teachers' perceived ease of use and perceived usefulness of ICT tools shape competency development. Teachers who find basic office skills and digital tools easy to use (H_{01}, H_{02}) are more likely to develop advanced communication and professional competencies (H_{03}). TAM thus guides the regression analyses testing predictive relationships among competencies and helps interpret why systemic barriers in Tripura may limit perceived usefulness across all teacher groups.

Diffusion of Innovations Theory, as articulated by Rogers [22], contextualizes variation (or lack thereof) in ICT adoption across teacher profiles. The theory predicts that early adopters (often younger, urban teachers) progress more quickly through the innovation stages, while late adopters face relative disadvantages. However, in resource-constrained settings like West Tripura, uniform structural barriers may suppress these expected differences, supporting H_{05}'s prediction of no significant variation by gender, subject background, or location.

These frameworks generate the following hypotheses.

H_{01}: Basic office skills (Word Processing and Presentation) positively predict Spreadsheet competency among secondary school teachers.

H_{02}: Spreadsheet and Digital tools competencies positively predict Email competency.

H_{03}: Communication competency positively influences Digital skills and overall Professional ICT competency.

H_{04}: Internet and Networking competency has a non-significant effect on Digital skills among secondary school teachers.

H_{05}: There are no significant differences in overall ICT competency based on gender, subject background (Science vs. Arts), and school location (Urban vs. Rural).

Together, these frameworks justify the study's dual focus: (1) predictive relationships among ICT competencies (regression analyses for H_{01}–H_{04}), and (2) group differences testing (t-tests for H_{05}). They provide both theoretical grounding for variable selection and interpretive lenses for understanding results within Tripura's unique educational context.

IV. Methodology

A. Research Design

This study employed a quantitative survey method supplemented by advanced psychometric analysis to examine ICT competency levels and their structural relationships among secondary school teachers. Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) were used to validate the measurement model and test hypothesised relationships among ICT skill domains. Data collection involved field visits for direct survey administration in the West Tripura district, Northeast India.

B. Population, Sample and Sampling Method

The population consisted of secondary-level school teachers from various schools across the West Tripura district. This geographic area comprises a mix of urban and rural settings, enabling analysis of location-based differences in ICT competency.

A total of 100 secondary school teachers were selected using stratified random sampling. Stratification was based on three key demographic variables: gender (male/female), subject background (Science/Arts), and school location (urban/rural). This approach aimed to ensure representative subgroup coverage and reduce sampling bias.

C. Research Instrument

Data were collected using the ICT Competency Scale developed by Reang and Mohalik [5], consisting of 52 items across eight domains: Word Processing, Presentation, Spreadsheet, E-mail, Internet and Networking, Communication, Digital Tools, and Professional competencies. Items were rated on a three-point Likert scale indicating levels of competency: High (3), Moderate (2), and Low (1). The scale demonstrated strong internal consistency, with Cronbach's $\alpha = 0.96$ overall. Surveys were administered in paper form during school hours. The complete instrument is provided in Table A1.

D. Data Collection Procedure and Data Analysis

The investigator personally toured many schools in the West Tripura district, Tripura state. Upon receiving approval, the investigator clarified the study's objective, provided detailed information about the instruments to the teachers, and then gave them a copy of the tool for completion. In this manner, information was gathered from all the secondary school teachers. Following data collection, the data were systematically entered into SPSS for analysis. Descriptive and inferential statistics, including mean, standard deviation, and t-test, were conducted using SPSS software, and interpretations were subsequently made.

Collected data were entered into SPSS for initial descriptive and inferential analyses, such as means, standard deviations, and t-tests to examine demographic differences in ICT competency. For measurement validation and theory testing, JASP software (version 0.95.4.0) was used to conduct CFA and SEM using the lavaan package with the Diagonally Weighted Least Squares (DWLS) estimator suitable for ordinal data. Model fit was assessed using chi-square, Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). Structural relationships among ICT competencies were evaluated through standardised path coefficients, with significance determined at $p < 0.05$. Details of SEM syntax are provided in Table A2.

V. Results

Result sections are divided into three segments: the Measurement Model (CFA), Structural Equation Modelling, and Descriptive and Comparative Analysis.

A. Measurement Model (CFA)

A confirmatory factor analysis (CFA) was performed to evaluate the measurement model of the eight ICT competency factors, utilizing the DWLS estimator, suitable for ordinal Likert-type items. The factor model produced a notable chi-square ($\chi^2 = 5587.823$, df = 1224, $p < 0.001$). Fig. 1 presents the CFA model diagram, showing standardized factor loading across all eight ICT competency domains, Table 1 summarizes Composite Reliability (CR) and Average Variance Extracted (AVE) values.

B. CFA Model Diagram

The majority of items exhibited robust and statistically significant standardized loadings on their designated factors, especially for Word Processing Competency (e.g., WP1–WP7 ≈ 0.63–0.92), Presentation Competency (PC1–PC5 ≈ 0.84–0.90), and Spreadsheets Competency (SS1–SS9 ≈ 0.73–0.93), suggesting that these observed variables served as effective indicators of their underlying constructs. In line with expectations, these areas showed strong composite reliability (Word Processing Competency = 0.898, Presentation Competency = 0.922, Spreadsheets Competency = 0.937) and satisfactory average variance extracted (AVE; 0.646, 0.730, and 0.674 respectively), surpassing the widely advised benchmarks (CR ≥ 0.70, AVE ≥ 0.50), indicating robust internal consistency and convergent validity for these elements.

The E-mail competency and Digital Tools competency factors also showed acceptable measurement quality, with moderate to high factor loadings (mostly above 0.60) and composite reliability around 0.80 (E-mail CR = 0.803; Digital CR = 0.800), while their AVE values were at or very close to the recommended level (E-mail AVE = 0.501; Digital AVE = 0.499), suggesting adequate but somewhat weaker convergent validity compared to the office-related domains. In contrast, the Internet and Networking competency, and Communication competency factors displayed lower standardized loadings for several items and much weaker AVE (Internet AVE = 0.204; Communication AVE = 0.315) alongside low composite reliability (Internet

CR ≈ 0.44; Communication CR ≈ 0.63), indicating that these constructs are measured less reliably and do not capture a high proportion of common variance among their items.

The Professional competency domain showed a mixture of moderate and strong item loadings (around 0.45–0.75), yielding acceptable composite reliability (CR = 0.812) but only a borderline AVE (0.421), suggesting reliable yet moderately convergent measurement. R-squared values also indicated that items in Word Processing, Presentation, Spreadsheet, E-mail, Digital Tools, and parts of Professional competency generally explained a substantial proportion of variance, whereas several items in Internet and Networking competency, and Communication competency had low R-squared values.

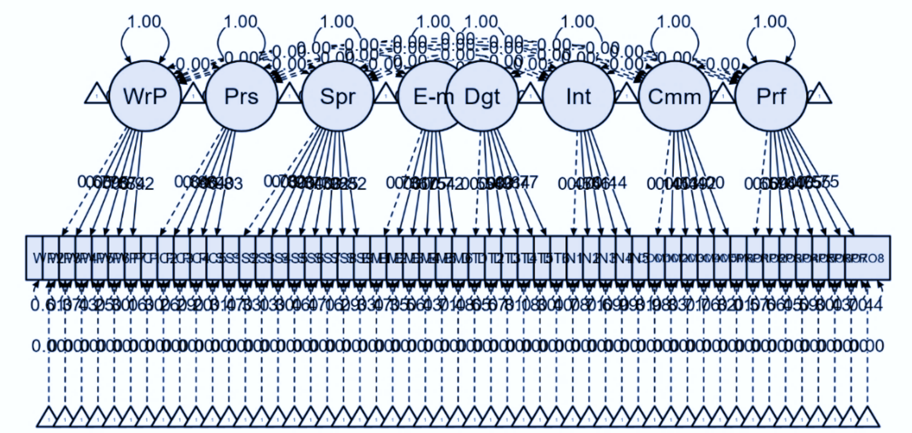

Fig. 1. CFA model.

Table 1. Confirmatory factor analysis results for ICT competency scale

Factor/Domain	Standardized Loading	Composite Reliability	Average Variance Extracted (AVE)
Word Processing Competency	0.794	0.898	0.646
Presentation Competency	0.895	0.922	0.730
Spreadsheets Competency	0.932	0.937	0.674
E-mail Competency	0.806	0.803	0.501
Digital Tools Competency	0.907	0.800	0.499
Internet and Networking Competency	0.536	0.444	0.204
Communication Competency related to ICT	0.535	0.631	0.315
Professional Competency related to ICT	0.740	0.812	0.421

Table 1 shows that the Confirmatory Factor Analysis (CFA) for the ICT Competency Scale reveals a structure with eight distinct factors capturing teachers' ICT competencies: Word Processing (loading = 0.794, CR = 0.898, AVE = 0.646), Presentation (loading = 0.895, CR = 0.922, AVE = 0.730), Spreadsheets (loading = 0.932, CR = 0.937, AVE = 0.674), E-mail (loading = 0.806, CR = 0.803, AVE = 0.501), Digital Tools (loading = 0.907, CR = 0.800, AVE = 0.499), Internet/Networking (loading = 0.536, CR = 0.444, AVE = 0.204), Communication (loading = 0.535, CR = 0.631, AVE = 0.315), and Professional (loading = 0.740, CR = 0.812, AVE = 0.421), where high standardized loadings (>0.5) and composite reliabilities (mostly >0.7 except Internet = 0.444 and Communication = 0.631) indicate reliable measurement for core factors, though lower composite reliability may suggest potential

C. Structural Equation Modelling Results

1) SEM structural model plot

Fig. 2 presents the structural equation model path diagram. The SEM results (estimated with DWLS) confirm hypothesized relationships, with core ICT skills (Word Processing, Presentation, Spreadsheet, Digital Tools, E-mails) forming reliable latent variables and Communication playing a central predictive role for Digital skills, E-mail use, and Professional competence.

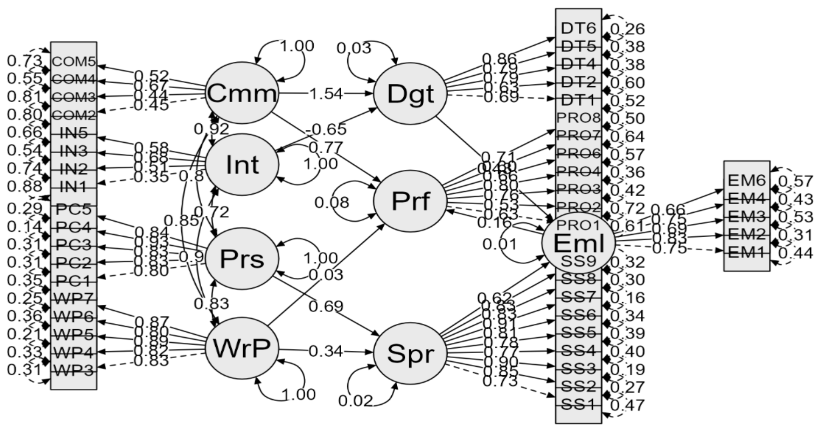

Fig. 2. Structural model diagram.

2) Model fit and measurement quality

- The SEM was estimated with DWLS and retains the previously validated eight-factor measurement model (Word Processing, Presentation, Spreadsheet, E-mail, Digital, Internet, Communication, Professional). Standardized factor loadings for Word Processing, Presentation and Spreadsheet are high (mostly ≥0.80), and the AVEs for these domains are strong (0.709, 0.719, 0.683), indicating good convergent validity.
- E-mail and Digital also show acceptable loadings and AVE (Email AVE = 0.545; Digital AVE = 0.573), whereas Internet and Communication have low AVE (0.297 and 0.279) and lower reliability, suggesting these two latent variables remain weaker and should be interpreted with caution.

3) Structural model and key paths (regression coefficients)

- Spreadsheet is strongly predicted by Presentation ($\beta = 0.691$, $p < 0.001$) and moderately by-Word Processing ($\beta = 0.337$, $p < 0.001$), indicating that higher basic document and presentation skills are associated with higher spreadsheet competence.
- E-mail is positively predicted by the Spreadsheet ($\beta = 0.622$, p < 0.001), Digital skills ($\beta = 0.433$, $p < 0.001$), Word Processing (indirect via Spreadsheet; total effect ≈ 0.210, $p = 0.003$), and Presentation (total effect ≈ 0.430, $p < 0.001$), showing that office and general digital skills substantially increase teachers' effective use of e-mail systems.
- Digital skills are significantly predicted by Communication ($\beta = 1.543$, $p = 0.001$), while the path from Internet to Digital is negative and non-significant ($\beta = -0.647$, $p = 0.177$), implying that perceived communication-related competencies, rather than Internet skills alone, drive broader digital competence.
- Professional competence is significantly predicted by Communication (β = 0.772–0.881 depending on section, both $p \leq 0.012$), whereas direct paths from Word Processing, Digital, E-mail, and Internet to Professional are small and non-significant, highlighting Communication as the main determinant of professional ICT competence in this model.

4) Indirect and total effects

- Presentation and Word Processing have notable indirect effects on E-mail (via Spreadsheet), with total effects of $\beta = 0.430$ (Presentation) and $\beta = 0.210$ (Word Processing), both statistically significant ($p \leq 0.003$), indicating that improving basic office skills can indirectly strengthen teachers' email usage.
- Communication shows a significant indirect effect on E-mail through Digital skills ($\beta = 0.668$, $p = 0.009$), and a positive but non-significant indirect effect on Professional competence via Digital and E-mail, confirming its central mediating role in the technology-use network.

Table 2. Key direct, indirect, and total effects among latent variables in the structural model

From (Predictor)	To (Outcome)	Type of effect	Std. beta (β)	Significance
Word Processing	Spreadsheet	Direct	0.34	$p < 0.001$
Presentation	Spreadsheet	Direct	0.69	$p < 0.001$
Spreadsheet	E-mail	Direct	0.62	$p < 0.001$
Digital	E-mail	Direct	0.43	$p < 0.001$
Communication	Digital	Direct	1.54	$p = 0.001$
Communication	E-mail	Direct	0.67	$p = 0.009$
Communication	Professional	Direct	0.88	$p = 0.001$
Word Processing	E-mail	Indirect via Spreadsheet	0.21	$p = 0.003$
Presentation	E-mail	Indirect via Spreadsheet	0.43	$p < 0.001$

Table 2 shows that the Structural Equation Model reveals a clear progression of ICT competencies among secondary teachers where Word Processing directly boosts Spreadsheet competency ($\beta = 0.34$, p <0.001), while Presentation has an even stronger direct effect on Spreadsheet ($\beta = 0.69$, $p < 0.001$); Spreadsheet and Digital skills then directly enhance E-mail proficiency (β = 0.62 and 0.43, both $p < 0.001$), with Word Processing and Presentation contributing indirectly via Spreadsheet (β = 0.21 and 0.43, p = 0.003 and <0.001); Communication emerges as pivotal, strongly predicting Digital skills ($\beta = 1.54$, $p = 0.001$), E-mail use ($\beta = 0.67$, $p = 0.009$), and Professional competency ($\beta = 0.88$, $p = 0.001$), confirming its central role in advanced ICT integration.

D. Descriptive and Comparative Analysis

Table 3 illustrates ICT competency levels among the 100 secondary school teachers surveyed, 22% (22 teachers) achieved high ICT competency with scores above 118; 33% (33 teachers) demonstrated moderate competency scoring 100–118; while 45% (45 teachers) showed low competency below 100, highlighting substantial digital skills gaps where nearly half lack adequate proficiency for effective classroom technology integration despite national education policy initiatives.

Table 3. Levels of ICT competency

SL No	Score Range	Number & Percent of Teachers	Level of ICT Competency
1	118 above	22 (22%)	High Competency
2	100 to 118	33 (33%)	Moderate Competency
3	Below 100	45 (45%)	Low Competency
	Total	100	

ICT competency levels, which is graphically presented in Fig. 3.

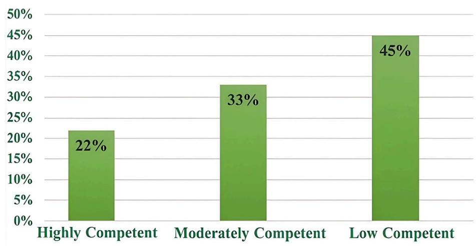

Fig. 3. Levels of ICT competency.

Table 4. Comparison of the ICT competency of male and female secondary school teachers

SL No	Gender	N	Mean	SD	df	*t* value	Level of Significance
1	Male	50	104.0000	23.60474	98	1.291	0.200
2	Female	50	97.4400	27.08879			

The calculated "*t*" value is smaller than the table value 1.98 at the 0.05 level, and the "*p*" value is greater than 0.05. So, it is not significant, and thereby the null hypothesis is accepted. In other words, there is no significant difference between Male and Female teachers in terms of ICT competency at the secondary level of teaching, as shown in Table 4.

Table 5. Comparison of the ICT competency of science and arts teachers

SL No	Subject Background	N	Mean	SD	df	*t* value	Level of Significance
1	Science	50	100.96	26.77	98	0.094	0.926
2	Arts	50	100.48	24.42			

The calculated "*t*" value is smaller than the table value 1.98 at the 0.05 level, and the "*p*" value is greater than 0.05. Hence, the null hypothesis is accepted. In other words, there is no significant difference between Science and Arts teachers in terms of ICT competency at the secondary level of teaching, as detailed in Table 5.

Table 6. ICT competency of urban and rural teachers

SL No	Location	N	Mean	SD	df	*t* value	Level of Significance
1	Urban	50	101.36	23.35	98	0.250	0.803
2	Rural	50	100.08	27.69			

Calculated "*t*" value is less than the table value 1.98 at 0.05 levels, and "*p*" value is greater than 0.05. Hence, it is not significant, and thereby the null hypothesis is accepted. In other words, there is no significant difference between Urban and Rural teachers in terms of ICT competency at the secondary level of teaching, as mentioned in Table 6.

E. Major Findings

The CFA-SEM analysis revealed:

(1) CFA Validation: Strong measurement for office skills (Word Processing CR = 0.898, AVE = 0.646; Presentation CR = 0.922, AVE = 0.730; Spreadsheet CR = 0.937, AVE = 0.674) but weak for Internet (AVE = 0.204) and Communication (AVE = 0.315).

(2) SEM Paths Confirmed: H_{01}: Presentation (β = 0.691, $p < 0.001$) → Spreadsheet; Word Processing (β = 0.337, $p < 0.001$) → Spreadsheet; H_{02}: Spreadsheet (β = 0.622, $p < 0.001$) → Email; Digital (β = 0.433, $p < 0.001$) → E-mail; H_{03}: Communication → Digital (β =1.543, $p < 0.001$), Professional (β = 0.881, $p < 0.001$); H_{04}: Internet → Digital (β = −0.647, p = 0.177, not significant)

(3) Competency Levels: 22% high, 33% moderate, 45% low competency overall.

(4) No Demographic Differences: Gender (p = 0.200), subject (p = 0.926), location (p = 0.803)—H_{05} supported.

VI. Discussion of Results

The present study comprehensively examined ICT competency among secondary school teachers in West Tripura through advanced psychometric analysis (CFA/SEM) alongside descriptive profiling, revealing both structural insights and persistent skill gaps. Only 22% of teachers achieved high competency, 33% moderate, and a concerning 45% low proficiency, indicating substantial deficiencies in digital readiness despite national initiatives like Digital India and NEP 2020. CFA validated robust measurement for foundational office skills (Word Processing CR = 0.898, AVE = 0.646; Presentation CR = 0.922, AVE = 0.730; Spreadsheet CR = 0.937, AVE = 0.674), confirming these as reliable constructs, while Internet/Networking (CR = 0.444, AVE = 0.204) and Communication (CR = 0.631, AVE = 0.315) showed poor convergent validity, suggesting scale refinement needs.

SEM results provided novel evidence of skill hierarchies: Presentation (β = 0.69, $p < 0.001$) and Word Processing (β = 0.34, $p < 0.001$) strongly predict Spreadsheet competency, supporting H_{01} and aligning with TPACK's progression from basic technological knowledge to integrated application. Spreadsheet (β = 0.62) and Digital skills (β = 0.43) drive E-mail use (H_{02} confirmed), while Communication emerges as pivotal, predicting Digital (β = 1.54, p = 0.001), E-mail (β = 0.67, p = 0.009), and Professional competency (β = 0.88, p = 0.001; H_{03} supported). Notably, the Internet showed no significant effect on Digital (β = −0.65, p = 0.177; H_{04} supported), indicating perceived connectivity skills contribute minimally to broader competence, consistent with Reang and Mohalik [5] who documented similar gaps in Tripura using the same scale.

These structural findings extend prior descriptive work by Laxmi and Jabin [7] and Choudhary [4], who noted modest office skill strengths but did not conduct path analysis. The centrality of Communication resonates with international evidence: Farisa *et al.* [10] in Indonesia and Ikwuka *et al.* [11] in Nigeria found interpersonal digital skills as key mediators, while Domínguez-González *et al.* [1]'s systematic review emphasizes communication-pedagogy integration for TPACK efficacy. Indirect effects further illuminate progression: basic skills indirectly boost E-mail via Spreadsheet (Word Processing β = 0.21, Presentation β = 0.43; both $p \leq 0.003$), suggesting scaffolded training models.

No demographic differences emerged (gender p = 0.200, subject p = 0.926, location p = 0.803; H_{05} supported), mirroring Reang and Mohalik [5] but contrasting Choudhary [4]'s gender effects in Jammu, likely due to Tripura's uniform public-school context and infrastructure constraints. This uniformity underscores systemic barriers over individual differences, aligning with Briones [8] and Kundu [13] on policy implementation gaps.

While situated in West Tripura, these findings resonate with global patterns in resource-constrained educational systems. The observed skill hierarchy, with basic office tools predicting advanced competencies, parallels scaffolded learning progressions documented across Indonesia, Farisa *et al.* [10], Nigeria, Ikwuka *et al.* [11], and even policy-practice gaps in Finland/Chile, Novoa-Echaurren *et al.* [12]. Uniform demographic effects further suggest that in low-infrastructure contexts, systemic training deficits overwhelm individual differences, offering a cautionary insight for Digital India and similar initiatives worldwide. Future research in other Indian states or regions of the Global South could test whether targeted interventions elevate competency ceilings across teacher profiles. The CFA-SEM findings reveal a clear ICT skill hierarchy among West Tripura secondary teachers, guiding targeted interventions for the 45% with low competency.

- **Tiered Training Programs:** Prioritize office basics (Word Processing/Presentation → Spreadsheet) for foundational skills (CR > 0.89, AVE > 0.64), then Communication-Digital integration (β = 1.54, $p < 0.001$) for advanced proficiency.
- **NEP 2020 Policy:** Mandate annual TPACK-aligned ICT certification and mentorship pairing high-competency (22%) with low-competency teachers to address uniform gaps across gender/subject/location ($p > 0.05$).

VII. Conclusion

This study has highlighted critical gaps in ICT competency among secondary school teachers in West Tripura, nearly half demonstrate low proficiency, while only a minority achieve high competency. The absence of significant differences relating to gender, subject background, or location suggests systemic challenges rather than isolated demographic effects. These findings highlight the urgent need for targeted, sustained professional development and institutional support to equip teachers with the digital skills necessary for effective pedagogical integration.

Building on parallels with previous research nationally and internationally, this study underscores the importance of creating context-sensitive training programs, mentorship opportunities led by highly competent teachers, and equitable infrastructure investment to bridge the digital divide in education. Policymakers and school leaders must prioritize strategic initiatives that foster digital literacy, ensuring that all teachers can confidently harness ICT to enhance student learning outcomes and prepare learners for a rapidly evolving digital society.

Future research should explore the longitudinal effects of tailored ICT training interventions and investigate how competency development translates into classroom practice and student achievement, to further inform evidence-based educational reforms.

Appendix

Table A1. ICT competency scale Reang and Mohalik [5]

SL No	Domain/ Dimension	No of Items	Items/ Indicators
1.	Word Processing	7	I can create learning material colourful using pictures and text in MS Word.
			I can store work on both an internal and external drive.
			I can make a PDF file from MS Word.
			I can use MS Office Word for lesson planning and exam papers.
			I can check spelling, grammar and word usage in Microsoft Word.
			I can print a word document into a hardcopy.
			I can bold, italicize, and underline a letter or word.
2.	Presentation Competency	5	I know how to create a title page by using charts, pictures and graphs on a PowerPoint.
			I can prepare a PowerPoint presentation on a computer.
			I can add common mathematical equations on a PowerPoint.
			I can insert video or audio learning material on a PowerPoint.
			I can use a PowerPoint presentation to present a class.
3.	Spreadsheet Competency	9	I can open, minimize, maximize and close Microsoft Excel.
			I can create a student achievement chart and graph using a spreadsheet.
			I know how to create a Microsoft Excel file.
			I can use the SUM, MAX, MIN, and AVERAGE on Microsoft Excel.
			I can format numbers to display them as currency, dates, percentages and decimals.
			I can analyse assessment data in spreadsheets and statistical applications.
			I can change worksheets margin/orientation on Excel.
			I can insert and delete cells, rows and columns.
			I can add and modify headers and footers on Microsoft Excel.
4.	E-mail	6	I can email the learning material attachments file from Google Drive.
			I can use email to conduct online research or gather information.
			I know about Cc (Carbon Copy) and Bcc (Blind Carbon Copy) of Gmail.
			I can make a Group Email in Gmail.
			I can compose, send and receive email.
			I can create a default signature to be added to all outgoing email messages.
5.	Internet and Networking	5	I can download and install various types of software on a computer.
			I can find useful learning resources on the Internet.
			I can connect an Internet hotspot to a computer.
			I know how to use different types of computer networks i.e., LAN, MAN, WAN.
			I can create a Bookmark in Chrome.
6.	Communication	6	I can share notes with students online.
			I can collect links of resources available at DIKSHA, ePathshala for teaching.
			I know how to use a web camera in the teaching-learning process.
			I can make multiple choice questions using Book Widgets and Quizlet apps.
			I can assign tasks/activities using Google Classroom app.
			I can use ICT to get feedback/access to students' learning.

7.	Digital Tools	6	I know digital games (Gcompris) for encouraging participation and promoting joyful learning.
			I can use the Bhuvan tool in teaching-learning.
			I can conduct online classes using any of the video conferencing tools i.e. Cisco Webex, Zoom, Google Meet.
			I can provide a virtual tour learning environment using an art and culture app.
			I can create concept maps by using mapping tools.
			I can edit audio and video material.
8.	Professional	8	I can detect plagiarism in students' work.
			I can plan and promote a safe and sound technology supported learning environment.
			I can design online materials and activities that engage students in collaborative problem solving and research.
			I can use Free and Open-Source Software in the teaching-learning process and development of e- content.
			I can join online communities, subscribe to relevant online journals.
			I can use ICT for blended learning.
			I can use Mobile applications such as DIKSHA in teaching and learning.
			I can create Google Form for collecting information.

Table A2. Structural equation model syntax summary

Items	**Component**	**Specification**	**Items/Factors**	**Std. β (p-value)**	**95% CI**
Measurement Model	Word Processing	=~	WP1- WP7	0.63–0.92 (all $p < 0.001$)	[0.47–0.99]
	Presentation Competency	=~	PC1-PC5	0.84–0.90 (all $p < 0.001$)	[0.74–0.96]
	Spreadsheet	=~	SS1-SS9	0.73–0.93 (all $p < 0.001$)	[0.61–0.97]
	Email	=~	EM1-EM6	0.54–0.81 (all $p < 0.001$)	[0.34–0.93]
	Digital Tools	=~	DT1-DT6	0.44–0.91 (all $p < 0.001$)	[0.24–1.03]
	Internet and Networking	=~	IN1-IN5	0.11-0.68 ($p = 0.004$–0.487)	[−0.20-0.90]
	Communication	=~	COM1-COM6	0.14–1.00 ($p = 0.273$–0.001)	[−0.11–1.21]
	Professional	=~	PRO1-PRO8	0.45–0.75 (all $p < 0.001$)	[0.25–0.91]
Structural Paths	H_{01}: Spreadsheet	~	Word Processing + Presentation	0.337 (0.001), 0.691 (0.001)	[0.16–0.85]
	H_{02}: Email	~	Spreadsheet + Digital Tools	0.622 (0.001), 0.433 (0.001)	[0.23–0.80]
	H_{03}: Digital Tools	~	Communication	1.543 (0.001)	[0.63–2.45]
Non-significant	Digital Tools	~	Internet and Networking	−0.647 (0.177)	[−1.59–0.29]
	Correlations	~~	Word Proc-Pres, Word Proc-Comm, etc.	0.72–0.95 (all $p < 0.001$)	[0.55–1.08]
	Estimation	DWLS, ordinal	N=100	$\chi^2 = 5587.82$ (df = 1224)	CFI > 0.90

ETHICAL APPROVAL

The Director, Secondary Education, Government of Tripura, India, gave the ethical clearance for the study. Research Ethics Approval Reference Number: 13 (2–6) SE/GL-I/2024 dated: 09-12-2024.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Sreekanta Das wrote the main manuscript text, and Biswajit Chakraborty reviewed and edited the manuscript. All authors had approved the final version of the manuscript.

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