Development and Validation of a Digital Literacy Scale and the Evaluation of Post-Graduate Teacher Educators' Digital Literacy

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***Abstract*—The present study aimed to develop and validate a multidimensional Digital Literacy Scale (DLS) for Post Graduate (PG) teacher educators and evaluate their Digital Literacy (DL). A contextually relevant, updated scale needs to be developed for PG teacher educators in India. The scale focuses on the United Nations Educational, Scientific and Cultural Organization (UNESCO) DL Framework, which provides a holistic and standardized understanding through four key dimensions. Three-stage Scale development process followed; Item Development, Scale Refinement, and Scale Evaluation, resulting in 42 items across four dimensions. The expert validation yielded an average Content Validity Index (CVI) of 1.00, demonstrating excellent content validity. A cross-sectional survey of 370 PG teacher educators using convenience sampling confirmed the construct validity of the 42-item scale through item analysis and Confirmatory Factor Analysis (CFA), showing strong factor loadings and excellent model fit: Comparative Fit Index (CFI) = 0.951, Tucker-Lewis Index (TLI) = 0.949, Root Mean Square Error of Approximation (RMSEA) = 0.041, Standardized Root Mean Square Residual (SRMR) = 0.036, Goodness-of-Fit Index (GFI) = 0.938). The overall scale, Cronbach's Alpha (α) and Coefficient Omega (ω), was demonstrated to have excellent reliability (α = 0.901, ω = 0.903). The Heterotrait-Monotrait Ratio (HTMT) correlation values, all below 0.85, demonstrate good discriminant validity. The level of DL showed a moderate to high, with the highest mean in safety measures of digital tools (*M* = 4.04) and the lowest mean in creating digital content (*M* = 3.60). Significant differences were observed in DL based on academic stream, family income, experience, and purposes of using e-resources, whereas no significant differences were found for the other demographic variables. The psychometric analysis shows that the scale is reliable and valid; thus, it can be used to evaluate teacher educators' digital literacy.**

***Keywords*—digital literacy, digital tool proficiency, scale validation, teacher education**

I. Introduction

Digital tool proficiency is increasingly recognized as a fundamental component of digital literacy for teacher educators [1, 2]. As the educational landscape evolves with technology, effectively utilizing digital tools is essential for enhancing teaching practices and preparing future educators [2, 3]. This proficiency supports pedagogical strategies and fosters a more engaging learning environment [4]. Digital competence is crucial for teachers to navigate and integrate technology into their teaching methods, thereby improving educational outcomes [5]. The transition to digital education necessitates that teachers possess robust digital skills, which can be developed through various training methods, including online courses and peer collaboration [6].

Teacher education programs must prioritize digital literacy to equip pre-service teachers with the necessary skills to thrive in a technology-driven society [1]. Research indicates a growing emphasis on digital literacy in teacher education, highlighting its role in fostering responsible digital citizenship among future educators [7]. While integrating digital tools in teacher education is vital, challenges such as varying levels of access to technology and differing educational backgrounds can hinder the development of digital proficiency. Addressing these disparities is essential for ensuring equitable digital literacy among all educators [8].

The necessity of digital literacy in teacher education is widely recognized, but a gap exists in understanding how teacher educators develop and maintain proficiency in digital tools over time [9, 10]. Recent studies have highlighted educators' challenges in mastering these tools, often due to inadequate training or institutional support [11]. Moreover, the level of proficiency required can vary greatly depending on the specific digital tools in question, ranging from basic competence to advanced application of technology for innovative pedagogical practices. As such, it is crucial to examine the types of digital tools that teacher educators engage with and the stages of proficiency they must achieve to effectively integrate them into their teaching practices.

The present study draws upon the UNESCO (2018) Digital Literacy Framework as the foundational structure for developing and validating a Digital Literacy Scale (DLS) designed explicitly for postgraduate teacher educators (M.Ed. students) in West Bengal, India. This internationally recognized framework offers a holistic and standardized understanding of digital literacy, making it particularly suitable for educational research in contexts where technology integration is increasingly essential.

The development and validation of digital literacy scales for Postgraduate (PG) teacher educators remains a critical area of inquiry, with several key gaps identified in the existing body of research. While significant advancements have been made in creating digital literacy assessment tools across diverse educational settings, most existing instruments are either generalized or contextually misaligned with the unique roles, responsibilities, and challenges PG teacher educators face in India. These educators often operate as instructors and researchers, requiring advanced digital competencies beyond basic Information and Communication Technology (ICT) proficiency.

Many existing tools, such as those developed for digital

literacy, focus on digital literacy as a 21st-century skill for higher secondary students [12] and ICT literacy skills for higher educational contexts, and it focus primarily on ICT proficiency and information literacy without adequately addressing pedagogical or professional digital competencies [13, 14]. For instance, the 'Digital Pedagogy Competence Scale' includes skills of online learning, smart and mobile devices, online collaboration, social media, digital safety, and data protection validated with Undergraduate (UG) and Postgraduate (PG) general higher education, does not consider the professional teacher trainees specifically encountered by PG teacher educators [15]. Similarly, the Teachers Artificial Intelligence (AI)-Technological Pedagogical Content Knowledge 'AI-TPACK Scale' emphasizes technology integration into subject and pedagogy for teachers, but lacks a comprehensive view of broader digital literacy dimensions such as digital content creation and digital safety measures [16].

Other notable instruments, such as the 'Digital Literacy Scale' developed covering areas like digital attitudes, behavioural patterns, and digital transformation awareness for secondary school students, this scale does not fully capture the holistic construct of digital literacy necessary for PG educators [17]. The 'Digital Competence Scale for Teachers', designed for general teachers [18], and the 'e-Readiness Scale', which measures faculty preparedness for online teaching [19], similarly fall short in addressing the contextual, institutional, and pedagogical demands specific to PG teacher educators.

Furthermore, tools like the 'Critical Digital Pedagogy Scale' developed for English as a Foreign Language (EFL) teachers [20], and the 'Digital Competence Scale' for University Teachers (DCS-UT) validated with general university faculty, which includes digital literacy, digital interaction, digital skills, and technology integration [21], previous studies not highlighted holistic model of digital tool proficiency as a key of digital literacy which focused on UNESCO digital literacy framework, and most of the studies focuses school students, higher education students and general teachers not teacher educators. In light of these limitations, a clear and pressing need exists to develop and validate a Digital Literacy Scale tailored specifically for PG teacher educators in India. Such a scale would ensure contextual relevance and effectively capture the full range of digital competencies.

This article explores the critical role of digital tool proficiency as a cornerstone of digital literacy in preparing PG teacher educators. Analyzing existing research and case studies identifies key factors influencing the development of a digital literacy scale and evaluates teacher educators' current digital literacy levels. Aligned with India's New Education Policy (NEP-2020) objectives, the study proposes a conceptual framework emphasizing enhancing educators' digital competencies. It also highlights the challenges and opportunities in equipping teacher educators with essential digital skills. This article contributes to the ongoing discourse on empowering educators to integrate and utilize digital technologies in their professional practice by developing and validating a digital literacy scale and assessing PG teacher educators' digital literacy levels.

To maintain a clear focus and direction, the study is guided by the following research objective:

1) To develop and validate a Digital Literacy Scale for Post-Graduate teacher educators.
2) To evaluate the digital literacy of PG teacher educators across four dimensions and examine group differences in digital literacy based on gender, locality, type of institute, studying stage, academic stream, family income, computer and internet experience, experience of using e-resources, and purpose of using e-resources.

Based on the objective to examine group differences in digital literacy, the following Null Hypothesis (H_0) was formulated; Digital literacy of PG teacher educators do not significantly differ based on gender, locality, type of institute, studying stage, academic stream, family income, computer and internet experience, experience of using e-resources, and purpose of using e-resources.

II. Review of Related Literature

Digital tool proficiency is a core component of digital literacy, especially for educators who must effectively integrate technology into their teaching practices [22]. As digital tools become ubiquitous in educational settings, proficiently navigating, creating, sharing, and protecting digital content is essential for fostering a tech-savvy and adaptable educational environment [23, 24].

A. Communicating and Sharing Digital Content

Effective communication and sharing of digital content are foundational skills for teacher educators [25]. This dimension emphasizes using digital platforms for collaboration, information dissemination, and interaction with students and peers [26]. Research highlights that educators need to be proficient in various communication tools such as email, social media, and collaborative platforms like Google Drive or Microsoft Teams to engage effectively with learners and colleagues [27, 28]. Tools for communication are integral, not only for teaching but also for fostering a collaborative learning environment and enhancing professional development [29, 30]. Teachers can access, exchange, and reflect on educational content through digital platforms, which foster ongoing professional development. Social media, blogs, and forums are examples of platforms that assist teachers in staying current and involved with innovative teaching concepts [31]. Not all digital content that is shared is trustworthy or pedagogically sound. Instructors worry about user-generated or peer-shared content's appropriateness, correctness, and quality [32].

B. Creating Digital Content

The ability to create digital content, including multimedia resources such as videos, interactive presentations, and digital assessments, is another critical dimension of digital tool proficiency [33, 34]. Teacher educators are expected to develop educational materials that are engaging, accessible, and pedagogically effective [4, 11]. Studies show that proficiency in creating digital content is directly linked to teaching quality, enabling educators to produce personalized learning experiences and integrate technology in innovative ways [1, 6]. Some teacher educators express a lack of confidence in their technological skills when producing digital content creation; teacher educators may find digital

tools burdensome without the proper training or institutional support, which could result in underuse or a superficial adoption [35].

Moreover, the creation of digital content enhances teaching skills.

C. Access and Usage of Digital Content

Access and usage of digital content refers to an educator's ability to locate, evaluate, and apply digital resources effectively to support teaching and learning. This dimension of digital tool proficiency focuses on critical information literacy skills, knowing where to find credible digital resources, and how to integrate them into curricula [36]. Research has shown that teacher educators with strong digital literacy are better equipped to harness digital resources for diverse instructional purposes, ranging from lesson planning to real-time classroom support [37]. Accessing and using digital content also enables educators to keep pace with rapidly evolving technologies and pedagogical trends.

D. Safety Measures of Digital Tools

Safety measures for digital tools involve understanding the risks associated with digital technologies and implementing practices that ensure online resources' secure and ethical use [38]. As the use of digital tools in education grows, so does the need for educators to manage issues like data privacy, cyberbullying, and digital footprint management [32]. Studies indicate that teacher educators must be proficient in using digital tools and aware of the ethical considerations and potential hazards that accompany them. Training in digital safety is essential for educators to model responsible online behaviour and protect both themselves and their students from cyber risks [39].

Each of these four dimensions represents a critical aspect of digital tool proficiency, and together, they form a comprehensive framework for assessing the digital literacy of teacher educators. Previous research has shown that teacher educators' proficiency in these areas can significantly enhance their ability to integrate technology into their teaching, thereby improving student outcomes and fostering a digitally literate generation of learners. However, gaps remain in developing validated tools designed to assess digital tool proficiency among teacher educators, especially regarding reliable measurement and the ability to determine proficiency across multiple dimensions. This article aims to fill this gap by developing a robust tool to assess these four dimensions of digital tool proficiency and to evaluate the level of digital literacy among postgraduate teacher educators.

III. Materials and Methods

A. Method

The present study attempts to develop and validate a Digital Literacy Scale (DLS) and explore the digital literacy status among postgraduate teacher educators in India. A context-specific scale was developed based on systematic methodology, including item generation, scale refinement, and evaluation [40, 41]. A total of 55 items were initially developed based on existing digital literacy frameworks, validated tools, and relevant empirical studies, which included four core dimensions of digital literacy and were structured on a five-point Likert scale. Four experts in educational technology reviewed a list of the items for content validity and clarity, and a 45-item scale was refined out of 55 items. The 45-item questionnaire was administered to 370 PG teacher educators using a cross-sectional survey design and convenience sampling method. This survey design is especially fit for scale validation and assessing the level of digital tool proficiency, which prompted the formulation of the instruments' patterns, relationships, and psychometric properties [42]. After collecting data, it was used to test the reliability and validity of the scale through item-total statistics and Confirmatory Factor Analysis (CFA). Following the scale validation, the PG teacher educators DL were evaluated through descriptive statistics and null hypothesis testing techniques.

The questionnaire development steps and evaluation of PG teacher educators' digital literacy are described as follows.

B. Item Development and Expert Evaluation

A literature review was done with the help of previous research, journal articles, and online resources for a conceptual framework and available tools on digital literacy. The item pool developed for the questionnaire was based on the conceptual framework of UNESCO (2018) across four dimensions and literature. The dimensions and underlying statements were defined so that the newly developed questionnaire or items could be framed to fit the PG teacher educator's context.

Initially 55 items (Table 1), were developed based on existing literature [12, 15, 17, 19, 26, 29, 33, 43–46], and expert consultations, which is crucial for new tool development [40]. To ensure the validity of the newly developed scale, a panel of subject matter experts (N = 4) from educational technology backgrounds assessed the content relevance of each item using a 4-point Likert scale: 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, and 4 = highly relevant. This approach, widely used for calculating the Item-Level Content Validity Index (I-CVI). The I-CVI for each item was computed by dividing the number of experts who rated the item as 3 or 4 by the total number of experts. An I-CVI threshold of 0.78 was considered acceptable for a panel of four experts [47]. Based on these evaluations, 10 items were removed due to I-CVI values falling below the threshold. Following item removal, the remaining 45 items demonstrated an average CVI value of 1.00, indicating excellent content validity [47]. This expert validation process ensured that the scale items were both theoretically sound and contextually appropriate.

Subject experts assessed each item's clarity, relevance, and representativeness concerning the construct. This expert-driven refinement process is qualitative judgment and aligns with best practices in scale development [40].

After expert refinement of the scale, 45 out of 55 items were subjected to 370 teacher-educators using a five-point Likert scale (Always = 5, to Never = 1). By selecting the most suitable answers, the respondents can score their answers depending on the intensity of responses by measuring the frequency, such as "Always," "Often," "Sometimes," "Very Rarely," and "Never," which are used for possible answers. A five-point Likert scale served as the basis for each of these claims.

Table 1. DLS Item-wise content validity index (I-CVI) based on evaluation by subject experts ($N = 4$)

Sl. No.	DIMENSIONS AND STATEMENT	Expert 1	Expert 2	Expert 3	Expert 4	I-CVI*	Decision
	Dimension 1: Communicating and Sharing Digital Content						
1	I quickly locate various files in a computer system.	3	4	4	4	1	Accepted
2	I prefer communicating, accessing, sending, and receiving messages through email.	4	3	3	4	1	Accepted
3	I effectively use the internet to send, access, and receive emails.	2	4	1	2	0.25	**Removed**
4	I effectively access the online library/digital library for my study purposes.	4	4	4	4	1	Accepted
5	I critically verify the accuracy of digital content before sharing it.	3	4	3	4	1	Accepted
6	I ensure authenticity before sharing someone else's digital content.	3	2	1	1	0.25	**Removed**
7	I acknowledge the original creator when sharing digital content.	4	3	4	3	1	Accepted
8	I access news and current events through email/websites/blogs/social media, etc.	3	4	3	4	1	Accepted
9	I create and share content on Blogs/Vlogs for academic activities.	4	4	3	4	1	Accepted
10	I use private settings when sharing digital content on social media platforms.	3	3	2	3	0.75	**Removed**
11	I share digital content to raise awareness of educational issues among my classmates/friends.	4	3	4	3	1	Accepted
12	I actively engage in online discussions and share relevant content across various platforms.	4	3	4	3	1	Accepted
13	I effectively create a readable format of information online.	4	4	3	3	1	Accepted
	Dimension 2: Creating Digital Content						
14	I actively engage in creating digital content when the need arises.	4	3	4	4	1	Accepted
15	I consider feedback from others to improve my digital content.	3	4	4	3	1	Accepted
16	I create online websites/web pages for personal or professional use.	1	2	3	2	0.25	**Removed**
17	I quickly create and edit videos, audio files, and recordings for professional use.	4	3	4	4	1	Accepted
18	I effectively use multimedia elements like images, videos, or audio in my digital content.	3	4	3	4	1	Accepted
19	I make digital content depending on specific situations or projects.	3	4	3	3	1	Accepted
20	I review and revise my digital content before publishing or sharing it.	4	4	4	4	1	Accepted
21	I use appropriate software or tools to create my digital content.	4	4	3	4	1	Accepted
22	I collaborate with others when creating digital content.	3	4	4	3	1	Accepted
23	I include citations or references in my digital content.	4	4	4	4	1	Accepted
24	I seek feedback from peers or teachers on my digital content.	3	3	4	3	1	Accepted
25	I consider the target audience when creating digital content.	4	3	4	4	1	Accepted
	Dimension 3: Access and Usage of Digital Content						
26	I connect to the Wi-Fi/Ethernet/hotspot for academic access.	2	2	1	2	0	Removed
27	I connect with audio/videoconferencing for professional development.	4	3	4	3	1	Accepted
28	I access and utilize digital content depending on my interests and needs.	4	3	4	3	1	Accepted
29	I scan images/doc files/ and post them on online platforms.	4	3	4	4	1	Accepted
30	I utilize collaborative tools like Google Drive, Microsoft Teams, or online whiteboards.	4	4	3	3	1	Accepted
31	I efficiently clear history, cookies, cache, and more from the laptop/mobile/computer system.	3	4	4	3	1	Accepted
32	I am familiar with Clearing history, cookies, cache, and more from the computer system.	3	4	3	3	1	Accepted
33	I check for spelling errors or statements on Grammarly software.	1	2	2	3	0.25	**Removed**
34	I use the browser to show content in preferred languages.	4	4	3	4	1	Accepted
35	I have applied Google Translator to translate content from one language to another.	3	4	4	3	1	Accepted
36	I access and utilize digital content as a primary source.	4	3	3	4	1	Accepted
37	I keep a digital record for the reference.	3	4	3	4	1	Accepted
38	I find filters from the search engine to obtain specific and relevant information.	4	3	4	4	1	Accepted
39	I engage with online lectures, discussion forums, and digital study materials.	3	4	3	4	1	Accepted
	Dimension 4: Safety Measures of Digital Tools						

Sl. No.	DIMENSIONS AND STATEMENT	Expert 1	Expert 2	Expert 3	Expert 4	I-CVI*	Decision
40	I am very much concerned about safety issues with digital tools/resources.	4	3	4	4	1	Accepted
41	I understand copyright issues and privacy policies about information/data.	3	4	3	4	1	Accepted
42	I ensure that my digital information/data is secure.	2	1	2	2	0	**Removed**
43	I prevent receiving unwanted messages and emails.	4	4	3	4	1	Accepted
44	I keep my logins and passwords private and share none.	3	3	4	3	1	Accepted
45	I follow ethical principles while using content in the digital environment.	4	4	4	3	1	Accepted
46	I protect my computer/digital devices by using antivirus packages.	3	4	4	4	1	Accepted
47	I clear all cache history and cookies in the browser.	3	2	2	1	0.25	**Removed**
48	I update privacy settings for social media accounts to prevent online threats.	4	4	3	4	1	Accepted
49	I report negative posts on social media instantly.	4	3	4	4	1	Accepted
50	I evaluate web information critically and then use it.	1	2	2	1	0	**Removed**
51	I use Google Password Manager to create, save, and manage device passwords.	3	4	4	4	1	Accepted
52	I choose strong passwords for secure computer systems/mobile devices.	4	3	4	3	1	Accepted
53	I am aware of the privacy settings and privacy policies of computer systems.	2	2	1	3	0.25	**Removed**
54	I access reputed and reliable online tools for academic activity.	3	4	3	4	1	Accepted
55	I evaluate and confirm the reliability of digital sources before using/sharing digital content.	4	4	3	3	1	Accepted

Note: The serial numbers (Sl. No.) in the table represent item numbers only. After removing the 10 bold-marked items, the remaining 45 items are renumbered sequentially from 1 to 45. Items marked in bold were removed based on subject expert judgment (evaluation by 4 experts) due to I-CVI values falling below the acceptable threshold of 0.78. *I-CVI = Number of experts giving a rating of 3 or 4 (on a 4-point scale) / Total number of experts.

C. Sample

Data were collected from 370 Postgraduate (PG) teacher educators representing various colleges and universities across West Bengal, India. The study's participants were chosen using a convenience sampling technique because of its practical benefits, especially in reaching postgraduate teacher educators who were accessible and willing to participate throughout the data-collecting period [48]. The sample included 127 male participants (34.3%) and 243 female participants (65.7%). Regarding locality, 180 respondents (48.6%) were from rural areas, while 190 (51.4%) were from urban areas. Regarding their study stage, 208 participants (56.2%) were in their first year, and 162 (43.8%) were in their second year. Additionally, based on the type of institution, 245 participants (66.2%) were affiliated with government institutions, while 125 (33.8%) were from government-aided institutions.

In-person distribution of paper-based surveys was used to gather data, improving the accuracy and consistency of participant responses. This method improved the overall quality and completeness of the data by enabling the researchers to address any doubts or ambiguities immediately. Respondents were reassured that their information would be kept private and anonymous, the purpose of the study was explained in detail to promote candid participation, and the questionnaire was written neutrally to prevent any biased or lead-informed responses.

IV. Results and Discussion

A. Item Analysis

Item analysis was done using the "Corrected item-total correlation" method in SPSS (version 22). This method evaluates inter-item, item-total correlations, and Cronbach's Alpha to determine the consistency of scale items, aiding decisions on item retention, modification, or removal [49]. During the item refinement, item 29 was removed due to a low item-total correlation, falling below the threshold of 0.30 [40], to increase the homogeneity between items. However, item no 7 retains a slightly low (0.290) item correlation; the item is theoretically important and aligns with the construct [40, 50], and that item significantly loaded in the respective factor ($p < 0.05$), contributing meaningfully to the dimension. Table 2 shows that, after removing item 29 due to low item-total correlation and items 4 and 5 due to low factor loadings, the item-total correlation values ranged from 0.290 to 0.497, and Cronbach's alpha ranged from 0.898 to 0.901. Overall Scale Cronbach's alpha 0.901 indicates excellent reliability of the scale. Removing the items to improve the reliability and validity of the scale. Regarding the assessment of scale development processes, several researchers removed items from their measures to increase the often-reported metric of coefficient alpha. None of the "alpha if item deleted" values exceed the total alpha [40].

Table 2. Summary of the reliability of the digital literacy (DL) scale

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.901	0.902	42

Item-Total Statistics

Item No of DL	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Item 1	156.532	457.117	0.365	0.270	0.899
Item 2	156.627	458.413	0.376	0.314	0.899
Item 3	156.738	457.972	0.345	0.268	0.900
Item 6	156.195	458.179	0.439	0.376	0.899

Item 7	157.957	456.762	0.290	0.408	0.901
Item 8	156.754	455.503	0.400	0.301	0.899
Item 9	157.049	453.905	0.416	0.382	0.899
Item 10	157.314	454.590	0.377	0.412	0.899
Item 11	157.070	457.095	0.353	0.360	0.900
Item 12	156.743	449.481	0.497	0.435	0.898
Item 13	157.054	449.542	0.441	0.370	0.898
Item 14	156.478	452.982	0.456	0.411	0.898
Item 15	156.881	453.092	0.435	0.345	0.898
Item 16	156.619	451.218	0.440	0.459	0.898
Item 17	156.695	452.890	0.404	0.429	0.899
Item 18	157.065	455.741	0.356	0.294	0.900
Item 19	156.768	449.014	0.472	0.413	0.898
Item 20	156.900	449.733	0.461	0.439	0.898
Item 21	156.997	452.051	0.423	0.418	0.899
Item 22	156.895	450.864	0.446	0.341	0.898
Item 23	156.246	455.828	0.469	0.368	0.898
Item 24	156.303	455.393	0.413	0.383	0.899
Item 25	156.473	454.055	0.445	0.368	0.898
Item 26	156.511	458.251	0.329	0.275	0.900
Item 27	156.508	457.286	0.355	0.298	0.900
Item 28	156.430	456.799	0.394	0.272	0.899
Item 30	156.681	458.001	0.378	0.318	0.899
Item 31	156.908	453.141	0.449	0.364	0.898
Item 32	156.803	449.834	0.516	0.430	0.897
Item 33	156.605	452.267	0.465	0.350	0.898
Item 34	156.303	456.857	0.420	0.393	0.899
Item 35	156.535	457.453	0.355	0.319	0.900
Item 36	156.614	458.043	0.314	0.331	0.900
Item 37	156.251	456.980	0.343	0.393	0.900
Item 38	156.341	460.529	0.308	0.404	0.900
Item 39	156.324	458.382	0.342	0.315	0.900
Item 40	156.411	452.113	0.460	0.392	0.898
Item 41	156.803	453.595	0.371	0.274	0.899
Item 42	156.449	454.736	0.376	0.307	0.899
Item 43	156.124	457.665	0.414	0.385	0.899
Item 44	156.462	457.068	0.425	0.311	0.899
Item 45	156.532	456.927	0.383	0.325	0.899

B. Confirmatory Factor Analysis (CFA)

After the refinement of the scale and deletion of items, the Confirmatory Factor Analysis (CFA) was conducted with 370 PG teacher educators' data using JASP (version 0.19.3.0) with the **LAVAAN** package. **CFA** is a **statistical technique** used to **validate the factor structure of a measurement scale** by testing **how well-observed variables represent underlying latent constructs** [51]. When conducting CFA for tool validation, it is essential to report and analyze key values related to factor loadings, model fit, reliability, and validity. CFA is used to confirm the factor structure of a measurement tool and establish its construct validity [52]. For reliability and validity, the factor loadings, model fit indices, and Cronbach's Alpha and Omega coefficients were reported to ensure the tool's psychometric soundness. After deleting one item (item number 29) because of low item-total correlation, two items were deleted due to low factor loadings (Item numbers 4 and 5) during CFA analysis. Removing weak items improves and **ensures the construct measures** [52].

To assess the suitability of the data for factor analysis, the Kaiser-Meyer-Olkin (KMO) measure was conducted, yielding a value of 0.874, confirming the data's suitability for factor analysis. This value confirms the adequacy of the sample size, as KMO values above 0.60 are generally considered acceptable [53]. The computed Bartlett's test of Sphericity is significant ($\chi^2 = 4313.000$, df = 861, $p < .001$), so it is appropriate for factor analysis. Table 2 shows CFA parameter estimates and standardized factor loadings, demonstrating that the digital literacy scale comprises four distinct factors (dimensions). Factor loadings (std. estimate) represent the **strength** of **the relationship** between an item and its latent construct [54]. Standardized factor loadings (correlations) can be observed in Fig. 1 of the CFA results. Table 3 shows, **Factor 1, named 'Communicating and Sharing Digital Content',** includes seven items (Items 1, 2, 3, 6, 7, 8, 9) with loadings ranging from 0.382 to 0.537. **Factor 2, named 'Creating Digital Content',** consists of 13 items (Items 10–22) with loadings between 0.439 and 0.599. **Factor 3 indicates that 'Access and Usage of Digital Content'** contains 11 items (23–28 and 30–34) with loadings from 0.385 to 0.604. **Factor 4 indicates that 'Safety Measures of Digital Tools'** comprises 11 items (Items 35–45) with loadings ranging from 0.378 to 0.581. All (42) items significantly ($p < 0.001$) loaded onto their respective latent factors (dimensions), which indicates the construct validity of the scale [52].

Table 3. CFA parameter estimates (Std. factor loadings)

Factor	Indicator	Std. estimate	Std. Error	z-value	p	Lower	Upper
Factor 1	Item 1	0.468	0.059	7.879	<0.001	0.351	0.584
	Item 2	0.487	0.050	9.834	<0.001	0.390	0.584
	Item 3	0.444	0.051	8.636	<0.001	0.343	0.545
	Item 6	0.537	0.050	10.796	<0.001	0.439	0.634
	Item 7	0.382	0.059	6.440	<0.001	0.266	0.498
	Item 8	0.517	0.053	9.679	<0.001	0.413	0.622

	Item 9	0.537	0.047	11.456	<0.001	0.446	0.629
	Item 10	0.444	0.047	9.457	<0.001	0.352	0.536
	Item 11	0.439	0.054	8.093	<0.001	0.332	0.545
	Item 12	0.599	0.042	14.236	<0.001	0.516	0.681
	Item 13	0.538	0.042	12.817	<0.001	0.456	0.620
	Item 14	0.563	0.049	11.412	<0.001	0.466	0.659
	Item 15	0.528	0.057	9.245	<0.001	0.416	0.640
Factor 2	Item 16	0.531	0.047	11.240	<0.001	0.438	0.623
	Item 17	0.498	0.048	10.431	<0.001	0.404	0.591
	Item 18	0.441	0.051	8.636	<0.001	0.341	0.541
	Item 19	0.572	0.048	11.848	<0.001	0.478	0.667
	Item 20	0.555	0.044	12.678	<0.001	0.469	0.641
	Item 21	0.513	0.046	11.137	<0.001	0.422	0.603
	Item 22	0.541	0.045	11.965	<0.001	0.452	0.630
	Item 23	0.539	0.045	12.024	<0.001	0.451	0.627
	Item 24	0.483	0.049	9.891	<0.001	0.387	0.579
	Item 25	0.525	0.042	12.589	<0.001	0.443	0.607
	Item 26	0.385	0.053	7.291	<0.001	0.281	0.488
	Item 27	0.422	0.050	8.367	<0.001	0.323	0.521
Factor 3	Item 28	0.457	0.046	9.908	<0.001	0.367	0.548
	Item 30	0.426	0.051	8.415	<0.001	0.326	0.525
	Item 31	0.514	0.051	10.116	<0.001	0.414	0.613
	Item 32	0.604	0.040	15.144	<0.001	0.526	0.682
	Item 33	0.544	0.044	12.471	<0.001	0.458	0.629
	Item 34	0.484	0.051	9.502	<0.001	0.385	0.584
	Item 35	0.436	0.055	7.908	<0.001	0.328	0.544
	Item 36	0.400	0.054	7.398	<0.001	0.294	0.506
	Item 37	0.441	0.054	8.144	<0.001	0.335	0.547
	Item 38	0.378	0.055	6.935	<0.001	0.271	0.485
	Item 39	0.433	0.054	8.086	<0.001	0.328	0.539
Factor 4	Item 40	0.581	0.041	14.004	<0.001	0.500	0.662
	Item 41	0.462	0.050	9.233	<0.001	0.364	0.560
	Item 42	0.469	0.051	9.113	<0.001	0.368	0.570
	Item 43	0.529	0.050	10.604	<0.001	0.431	0.627
	Item 44	0.535	0.046	11.519	<0.001	0.444	0.627
	Item 45	0.485	0.051	9.553	<0.001	0.385	0.584

Note: 95% Confidence Interval.

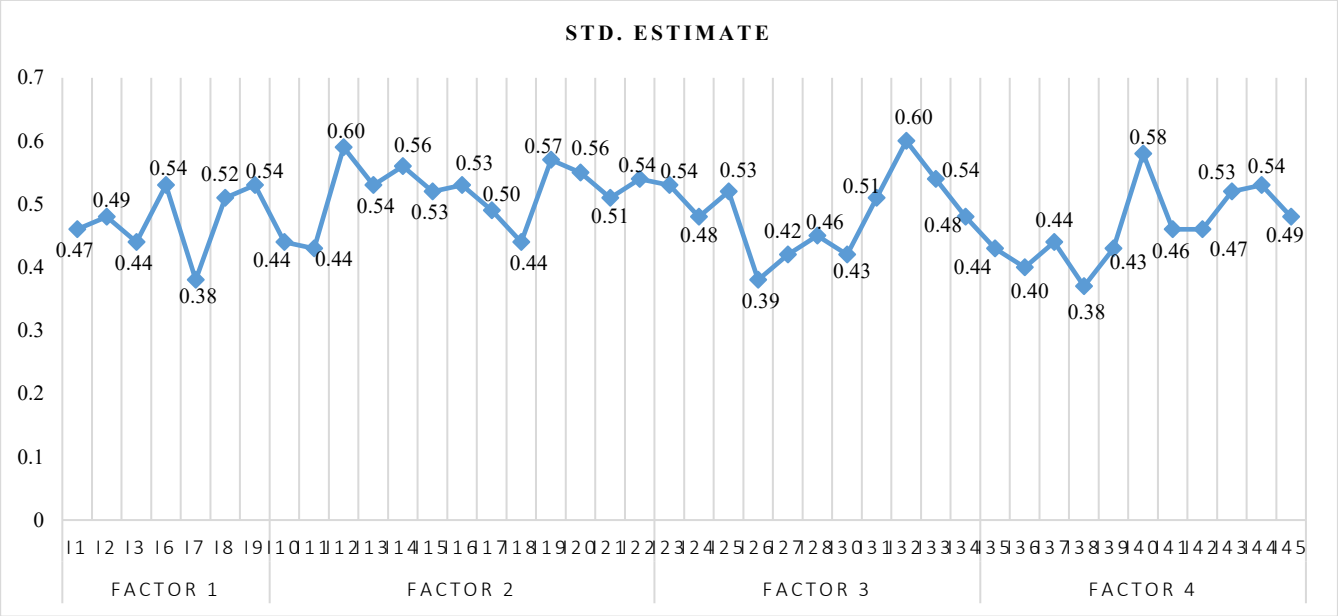

Fig. 1. CFA parameter Std. estimate of the 4-factor (total 42 items) structure of DLS.

Table 4. Heterotrait-monotrait (HTMT) ratio table

Factor 1	Factor 2	Factor 3	Factor 4
1.000			
0.698	1.000		
0.644	0.556	1.000	
0.480	0.474	0.807	1.000

In Table 4, **the Heterotrait-Monotrait ratio of correlations** (HTMT) matrix demonstrates acceptable discriminant validity among the constructs, as all off-diagonal values are below the commonly accepted threshold of 0.85 [55]. The diagonal (1.000) represents self-comparisons, which are always 1. The HTMT ratio is a recent and widely recommended technique for assessing discriminant validity. The HTMT test evaluates discriminant validity by calculating the average correlations between constructs and dividing this value by the geometric mean of the average correlations between items within the same construct [55]. The HTMT ratios range from 0.474 to 0.807, indicating that while there is some correlation between the factors, they are empirically distinct. The highest value, 0.807, observed between Factor 3 and Factor 4, remains within the acceptable range, further supporting the validity of the

construct measurements. Overall, the results confirm that the factors are sufficiently distinct, ensuring the theoretical integrity of the model.

Table 5. CFA model fit indices (to validate the scale structure)

Fit Index	Value	Acceptable Threshold	Supporting Reference
X^2/DF (CMIN/DF)	1.61	≤ 3, ≤ 2 (Good Fit)	[52, 56]
Comparative Fit Index (CFI)	0.951	≥ 0.90 (acceptable), ≥ 0.95 (good)	[57–59]
Tucker-Lewis Index (TLI)	0.949	≥ 0.90 (acceptable), ≥ 0.95 (good)	[50, 58]
Root Mean Square Error of Approximation (RMSEA)	0.041	≤ 0.08 (acceptable), ≤ 0.06 (good)	[51, 58, 59]
Standardized Root Mean Square Residual (SRMR)	0.066	≤ 0.08 (good)	[51]
Goodness of Fit Index (GFI)	0.938	≥ 0.90 (good)	[57, 60]
Incremental Fit Index (IFI)	0.952	≥ 0.90 (acceptable), ≥ 0.95 (good)	[57]

Table 5, presents model fit indices of the Confirmatory Factor Analysis (CFA) for the Digital Literacy Scale (DLS). The **Chi-square (X^2) test** was statistically significant **X^2 = 1,312.265, Degree of Freedom (DF) = 813, p < 0.001)**; however, given that the **Chi-square statistic is highly sensitive to large sample sizes,** its interpretation should be approached with caution [50]. The relative Chi-square (**X^2**/DF = 1.61) was examined to address this limitation, indicating a **good model fit**. Further support for model adequacy is provided by additional fit indices, including the **Comparative Fit Index (CFI = 0.951) indicates good model fit, Tucker-Lewis Index (TLI = 0.949) acceptable, Root Mean Square Error of Approximation (RMSEA = 0.041) good model fit, and Standardized Root Mean Square Residual (SRMR = 0.066) good** model **fit**. These values meet the recommended thresholds **(CFI, TLI, GFI > 0.90; RMSEA, SRMR < 0.08**), confirming that the **DLS measurement model demonstrates strong construct validity and an adequately specified structure.** The results indicate that the model effectively captures the underlying digital literacy constructs, supporting its use as a reliable and valid assessment tool.

The finalized **DLS consists of four factors with 42 items. The reliability was** assessed using **Cronbach's Alpha (α) and Coefficient Omega (ω). Cronbach's Alpha (α)** is a widely used measure of internal consistency; it assumes **tau-equivalence**, implying that all items contribute equally to the construct [61]. In contrast, **Coefficient Omega (ω)** considers **unequal factor loadings**, providing a **more precise reliability estimate** in CFA-based measurement models [61]. Table 6 shows that at the factor level reliability, **Factor 2 (ω = 0.824, α = 0.829)** demonstrated the highest reliability, followed by **Factor 3 (ω = 0.765, α = 0.779)** and **Factor 4 (ω = 0.737, α = 0.758)**, all of which met established reliability thresholds traditionally suggested as (α/ω ≥ 0.7) acceptable [62–64]. However, **Factor 1 (ω = 0.660, α = 0.676)** exhibited relatively lower reliability, but the **overall (ω = 0.903, α = 0.901**) indicates **excellent reliability.**

Table 6. Reliability of digital literacy scale (DLS)

Factor	Cronbach's Alpha (α)	Coefficient Omega (ω)
Factor 1	0.676	0.660
Factor 2	0.829	0.824
Factor 3	0.779	0.765
Factor 4	0.758	0.737
Overall Scale	0.901	0.903

The findings of the study suggest that Digital Literacy Scale (DLS) is a valid and reliable research tool that can be used with a broader population of PG teacher educators in different institutions: government, government-aided, and Private. It can be used for academic purposes and professional teacher education programs to examine the role of digital literacy in teacher educators' performance and effectiveness, as well as the productivity of the institutions.

C. PG Teacher Educators Digital Literacy Level

After validating the Digital Literacy Scale (DLS), the next step was identifying the levels based on the four dimensions of digital tool proficiency as a key component of digital literacy among PG teacher educators. Find out the levels between the factors (dimensions) of Digital Literacy (DL) and the demographic variables like gender, locality, type of institute, studying stage, academic stream, family income, computer experience, internet experience, experience of using e-resources, and purpose of using e-resources. We employed SPSS statistical software (version 22) to analyze the levels of Mean (M) and Standard Deviation (SD) calculated at the factor and item level. The Mann–Whitney U test (also known as the Wilcoxon rank-sum test) was employed to compare two groups. This test is used when the assumptions of normality for the independent samples t-test are unmet. **The Kruskal–Wallis H test was employed to compare more than two groups, and the post hoc test was used to identify significant group differences**.

The DL levels of PG teacher educators were examined across four dimensions focused on digital tool proficiency, with findings indicating a generally positive level of competence. As presented in Table 7, the mean scores for all DL dimensions exceeded 2.5, ranging from 2.53 to 4.36, suggesting that the participants demonstrated a moderate to high level of digital literacy. Among the dimensions, "Safety Measures of Digital Tools" dimension 4 (11 items) received the highest mean score (M = 4.04), highlighting that students were particularly aware of choosing strong passwords for secure computer systems/mobile devices, evaluate and confirm the reliability of digital sources, protect computer/digital devices by using antivirus packages, and understand copyright issues and privacy policies about information/data. These findings align with previous studies [14, 39, 65], emphasizing the growing importance of digital safety, evaluating the credibility of information sources and resources, and security as a fundamental component of digital literacy. Conversely, dimension 2 (13 items), "Creating Digital Content," received the lowest average score (M = 3.60), particularly a lack of competence in creating a readable format of information online (M = 3.17), collaborating with others when creating digital content (M = 3.42). These findings align with previous studies that have consistently identified content creation as a challenging area. For instance, while learners often possess the basic operational skills needed for digital tool engagement, they struggle with higher-order skills like content production or

creation, collaborative digital work, and creativity ([33, 66]). Regarding dimension 3 (11 items), "Access and Usage of Digital Content" (*M* = 3.96), this second-highest student demonstrated high proficiency, particularly in accessing and utilizing digital content depending on interests and needs (M = 4.24) and collaborative tools like Google Drive, Microsoft Teams, or online whiteboards (*M* = 4.01). However, their skills in keeping a digital record for reference (*M* = 3.57) and finding filters from the search engine to obtain specific and relevant information (*M* = 3.68) were relatively weaker, indicating a need for enhanced proficiency in keeping digital records and using search engines to obtain specific and relevant information. In the "Communicating and Sharing Digital Content" dimension 1 (7 items) (*M* = 3.65), students scored higher in attitudinal components, such as accessing news and current events through email/websites/blogs/social media, etc. (*M* = 4.29) and quickly locate various files in a computer system (*M* = 3.95). However, their actual evaluation skills were comparatively underdeveloped, as reflected in lower scores for creating and sharing content on Blogs/Vlogs for academic activities (*M* = 2.53), engaging in online discussions, and sharing relevant content across various platforms (*M* = 3.44). Several studies have shown that students are generally proficient in accessing, using, and retrieving digital content. They are often comfortable using search engines, educational platforms, and digital libraries to find information [36, 67]. Students generally access and use digital platforms like learning management systems, email, websites, blogs or vlogs, and social media to communicate and share ideas. Despite active access and usage of digital sources, some studies highlighted that online communication is often informal and lacks academic or professional depth [23, 26, 68].

Table 7. Retain finalized (42) items statement with 4 dimensions, mean (M), and Standard Deviation (SD)

	DL Dimensions and Item Statements	Mean (M)	Std. Deviation (SD)
	Dimension 1: Communicating and Sharing Digital Content (7 items)	3.65	0.668
Item 1	I quickly locate various files in a computer system.	3.95	1.143
Item 2	I prefer communicating, accessing, sending, and receiving messages through email.	3.86	1.039
Item 3	I effectively access the online library/digital library for my study purposes.	3.75	1.147
Item 6	I access news and current events through email/websites/blogs/social media, etc.	4.29	0.917
Item 7	I create and share content on Blogs/Vlogs for academic activities.	2.53	1.410
Item 8	I share digital content to raise awareness of educational issues among my classmates/friends.	3.73	1.138
Item 9	I actively engage in online discussions and share relevant content across various platforms.	3.44	1.181
	Dimension 2: Creating Digital Content (13 items)	3.60	0.709
Item 10	I effectively create a readable format of information online.	3.17	1.250
Item 11	I actively engage in creating digital content when the need arises.	3.42	1.177
Item 12	I consider feedback from others to improve my digital content.	3.74	1.201
Item 13	I quickly create and edit videos, audio files, and recordings for professional use.	3.43	1.334
Item 14	I effectively use multimedia elements like images, videos, and audio in my digital content.	4.00	1.132
Item 15	I make digital content depending on specific situations or projects.	3.60	1.176
Item 16	I review and revise my digital content before publishing or sharing it.	3.87	1.254
Item 17	I use appropriate software or tools to create my digital content.	3.79	1.265
Item 18	I collaborate with others when creating digital content.	3.42	1.247
Item 19	I include citations or references in my digital content.	3.72	1.280
Item 20	I seek feedback from peers or teachers on my digital content.	3.59	1.272
Item 21	I consider the target audience when creating digital content.	3.49	1.258
Item 22	I connect with audio/videoconferencing for professional development.	3.59	1.257
	Dimension 3: Access and Usage of Digital Content (11 items)	3.96	0.616
Item 23	I access and utilize digital content depending on my interests and needs.	4.24	0.973
Item 24	I scan images/doc files/ and keep them on online storage for learning.	4.18	1.113
Item 25	I utilize collaborative tools like Google Drive, Microsoft Teams, or online whiteboards.	4.01	1.105
Item 26	I find a history bar on Google Chrome to reuse or remove previous search data.	3.97	1.178
Item 27	I efficiently clear history, cookies, cache, and more from the laptop/mobile/computer system.	3.97	1.159
Item 28	I use the browser to show content in preferred languages.	4.05	1.084
Item 30	I access and utilize digital content as a primary source.	3.80	1.059
Item 31	I keep a digital record for the reference.	3.57	1.140
Item 32	I find filters from the search engine to obtain specific and relevant information.	3.68	1.147
Item 33	I engage with online lectures, discussion forums, and digital study materials.	3.88	1.146
Item 34	I am very concerned about safety issues with digital tools/online resources.	4.18	1.022
	Dimension 4: Safety Measures of Digital Tools (11 items)	4.04	0.625
Item 35	I understand copyright issues and privacy policies about information/data.	3.95	1.151
Item 36	I prevent receiving unwanted messages and emails.	3.87	1.241
Item 37	I keep my logins and passwords private and share none.	4.23	1.212
Item 38	I follow ethical principles while using content in the digital environment.	4.14	1.099
Item 39	I protect my computer/digital devices by using antivirus packages.	4.16	1.131
Item 40	I update privacy settings for social media accounts to prevent online threats.	4.08	1.163
Item 41	I report negative posts on social media instantly.	3.68	1.323
Item 42	I use Google Password Manager to create, save, and manage device passwords.	4.04	1.244
Item 43	I choose strong passwords for secure computer systems/mobile devices.	4.36	0.992
Item 44	I access reputed and reliable online tools for academic activity.	4.02	0.999
Item 45	I evaluate and confirm the reliability of digital sources before using/sharing digital content.	3.95	1.104

Following the overall analysis of digital tool proficiency across dimensions, the comparison was conducted to find differences in digital literacy levels and demographic and behavioural groups. The results, presented in Table 8, revealed significant differences at a 0.05 significance level in digital literacy scores based on the **stream of study** and **annual family income,** the experience of using e-resources, and the purpose of using e-resources, indicating that these variables play a crucial role in shaping digital literacy levels. However, no statistically significant differences were

observed based on gender, locality, type of institute, studying stage, computer experience, and internet experience, suggesting that these factors do not substantially impact digital literacy within the sample. These findings are detailed as follows.

Table 8. Digital literacy level: mean rank, Sig. value ($N = 370$)

Demographic Variables	Characteristics	N	Mean Rank	Sig. (2-tailed)	Decision
Gender	Male	127	177.02	0.270	Retain the Null Hypothesis
	Female	243	189.93		
Locality	Rural	180	185.59	0.987	Retain the Null Hypothesis
	Urban	190	185.41		
Type of Institute	Govt.	245	183.89	0.685	Retain the Null Hypothesis
	Govt. Aided	125	188.66		
Studying Stage	1st Year	208	178.85	0.175	Retain the Null Hypothesis
	2nd Year	162	194.04		
Academic Stream	Arts	321	179.96	0.029	Reject the Null Hypothesis
	Science	44	217.82		
	Commerce	5	256.60		
Family Income	Bellow 2L	272	181.99	0.018	Reject the Null Hypothesis
	Above 2L	67	175.91		
	Above 5L	31	237		
Computer	Low Experience	156	171.09	0.068	Retain the Null Hypothesis
	Medium Experience	167	193.32		
	High Experience	47	205.55		
Internet	Low Experience	68	159.39	0.073	Retain the Null Hypothesis
	Medium Experience	271	192.46		
	High Experience	31	181.95		
Experience of Using E-resources	Yes	347	191.21	0.000	Reject the Null Hypothesis
	No	23	99.39		
Purpose of Using E-Resources	Academic	61	165.93	0.003	Reject the Null Hypothesis
	Personal	10	89.45		
	Both	299	192.70		

Note: Hypotheses testing table: N = Number of participants; Sig. = Significance value

H_0.1: There is no significant difference in digital literacy level between **male and female** PG teacher educators.

Fig. 2 shows that the mean rank for male postgraduate teacher educators (177.02) was slightly lower than that of females (189.93). However, the *p*-value of 0.270 indicates no significant difference in digital literacy levels between genders at a 0.05 significance level. Thus, the null hypothesis that gender does not influence digital literacy is retained.

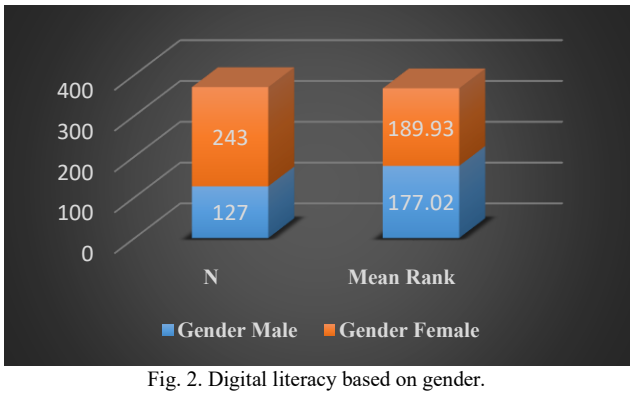

Fig. 2. Digital literacy based on gender.

H_0.2: There is no significant difference in digital literacy between **rural** and urban localities.

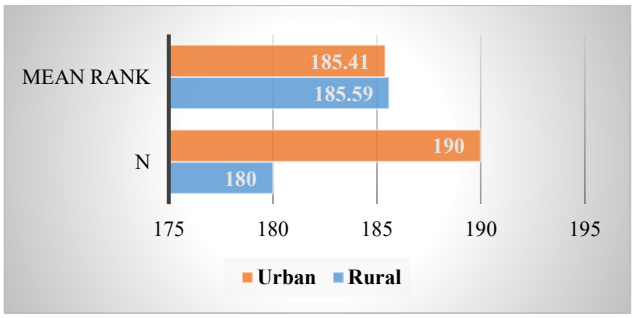

Fig. 3. Digital literacy based on locality.

Fig. 3 shows that the rural participants had a mean rank of 185.59, closely matching the urban participants' mean rank 185.41. The *p*-value of 0.987 indicates no significant difference at the 0.05 significance (Sig. = 0.05) level in digital literacy based on locality, supporting the null hypothesis that locality does not influence digital literacy.

H_0.3: There is no significant difference in digital literacy between **Govt. and** Govt**.-aided institutions.**

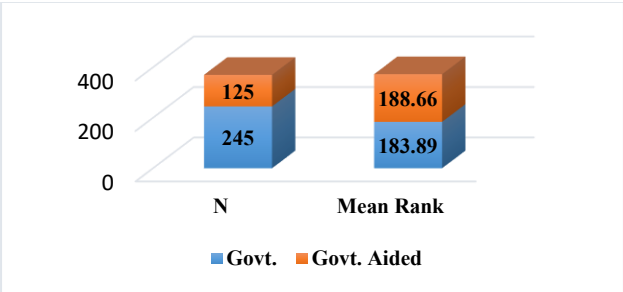

Fig. 4. Digital literacy based on institute types.

Government institution participants had a mean rank of 183.89, while government-aided institution participants had a slightly higher mean rank of 188.66 (Fig. 4). The *p*-value of 0.685 indicates no significant difference in digital literacy levels based on the type of institution, leading to the retention of the null hypothesis.

H_0.4: There is no significant difference in digital literacy level between educators at different **studying stages** (1st year and 2nd year).

First-year participants had a mean rank (low) of 178.85, compared to 194.04 for second-year participants (Fig. 5). However, the *p*-value of 0.175 indicates no statistically significant difference (Sig. = 0.05) in digital literacy levels between the two study stages, resulting in the retention of the null hypothesis.

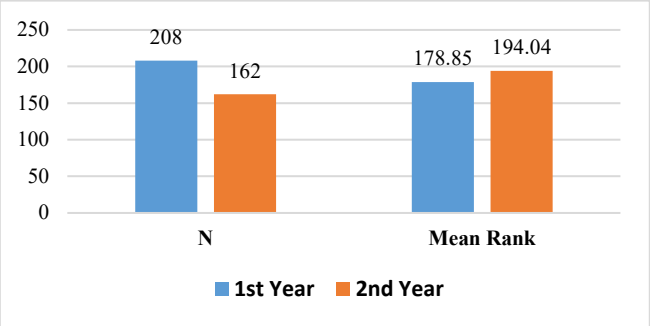

Fig. 5. Digital literacy level based on the studying stage.

H₀.5: There is no significant difference in digital literacy level among educators from different academic **streams** (arts, science, and commerce).

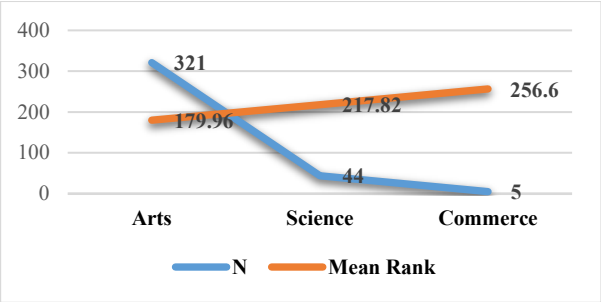

Fig. 6. Digital literacy based on different academic streams.

The mean ranks for digital literacy across academic streams indicate that commerce students (256.60) have the highest scores, followed by science students (217.82) and arts students (179.96) (Fig. 6). The *p*-value of 0.029 suggests a statistically significant difference (Sig. = 0.05) in digital literacy levels across streams. Thus, the null hypothesis is rejected, indicating that the stream of study significantly influences digital literacy. This may be attributed to varying levels of exposure to technology and e-resources in different academic disciplines. Post-hoc pairwise comparisons show that arts and science had a significant difference *p*-value of 0.028.

H₀.6: There is no significant difference in digital tool proficiency across **annual family income levels** (low, medium, high).

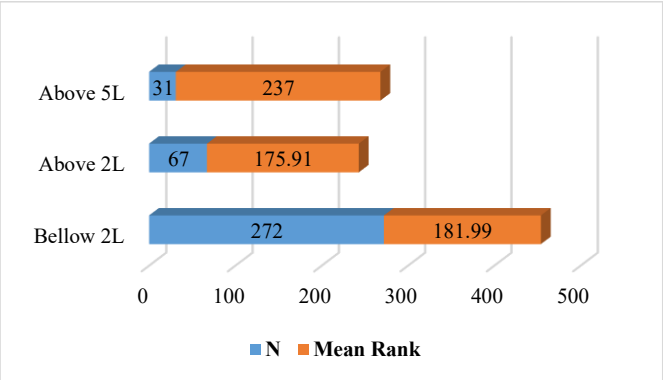

Fig. 7. Digital literacy based on annual family income.

Fig. 7 shows that the Participants with annual family incomes below 2 Lakh have a mean rank of 181.99, those between 2 Lakh and 5 Lakh have a mean rank of 175.91, and participants above 5 Lakh have the highest mean rank of 237. The *p*-value of 0.018 indicates a statistically significant difference in digital literacy levels (Sig. = 0.05) based on family income. Consequently, the null hypothesis is rejected. Post-hoc pairwise comparisons observed that below 2 Lakh and above 5 Lakh is a significant p-value of 0.020, and above 2 Lakh and above 5 Lakh is a significant *p*-value of 0.026 at a 0.05 significance level. This finding suggests that higher income groups may have greater access to digital tools and resources, leading to higher digital literacy.

H₀.7: There is no significant difference in digital tool proficiency across levels of **computer experience** (low, medium, high).

Participants with low computer experience have the lowest mean rank (171.09), followed by those with medium experience (193.32) and high experience (205.55) (Fig. 8). However, the *p*-value of 0.068 is greater than sig. level (<0.05), indicating no statistically significant difference in digital literacy levels based on computer experience. Thus, the null hypothesis is retained. This suggests that while a more excellent computer experience may trend toward higher digital literacy, the differences are not statistically significant in this sample.

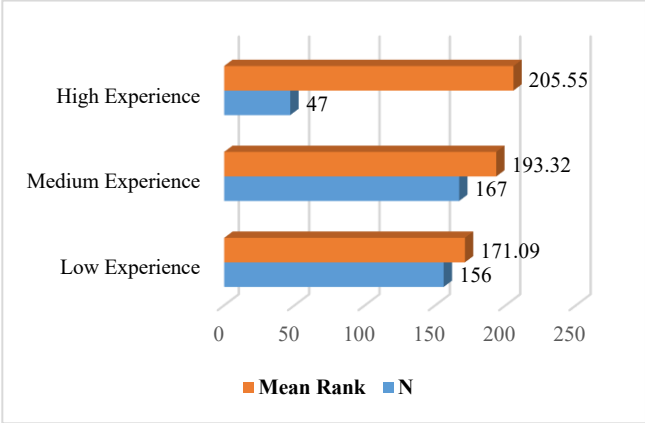

Fig. 8. Digital literacy based on computer experience.

H₀.8: There is no significant difference in digital literacy across levels of **internet experience** (low, medium, high).

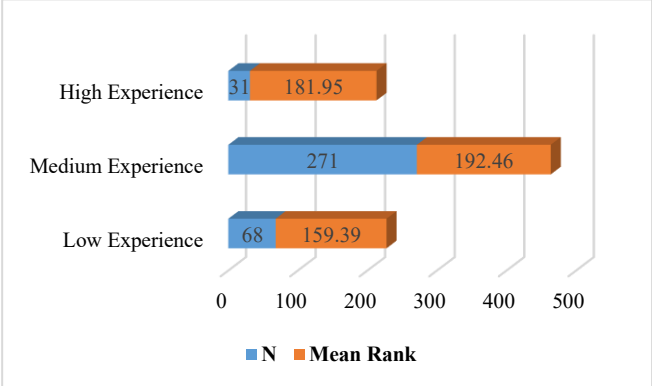

Fig. 9. Digital literacy based on the internet experience.

Fig. 9 shows that the Participants with low internet experience had the lowest mean rank (159.39), followed by high internet experience (181.95) and medium experience (192.46). The *p*-value of 0.073 exceeds the 0.05 threshold, indicating no statistically significant difference in digital literacy levels based on internet experience. Thus, the null hypothesis is retained. This suggests that internet usage alone may not be a decisive factor in determining digital literacy

levels.

H_o.9: There is no significant difference in digital tool proficiency between the experience **of using e-resources**.

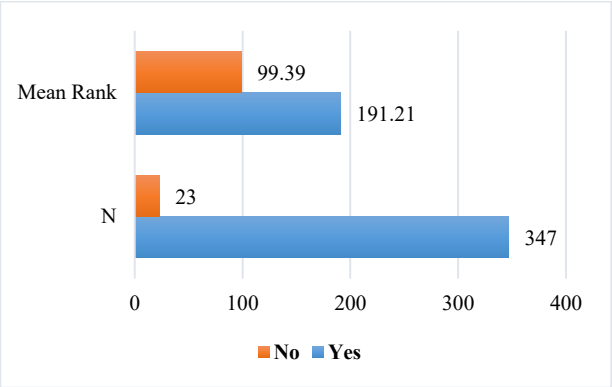

Fig. 10. Digital literacy based on experience of using e-resources.

Participants (those who marked yes) with experience using e-resources scored a significantly higher mean rank of 191.21 than those (who marked no) without experience, a mean rank of 99.39 (Fig. 10). The *p*-value of 0.000 indicates a highly significant difference in digital literacy levels based on e-resource usage experience. The null hypothesis is rejected, showing that experience with e-resources is a critical determinant of digital literacy. This finding highlights the importance of familiarity with digital tools in enhancing digital competencies.

H_o.10: There is no significant difference in digital literacy level based on the **purpose of using e-resources** (academic, personal, and both).

Participants using e-resources for both academic and personal purposes scored the highest mean rank, 192.70, followed by those using them exclusively for academic purposes, with a mean rank of 165.93, and personal purposes, with a mean rank = 89.45 (Fig. 11). The *p*-value of 0.003 indicates a statistically significant difference in digital literacy levels based on the purpose of e-resource usage. The null hypothesis is rejected (Sig. = 0.05). Post-hoc pairwise comparisons (Fig. 11) indicate personal and both (academic and personal) *p*-value 0.008, its significant (Sig. = 0.05), suggesting that using e-resources for multiple purposes (both academic and personal) contributes to higher digital literacy levels.

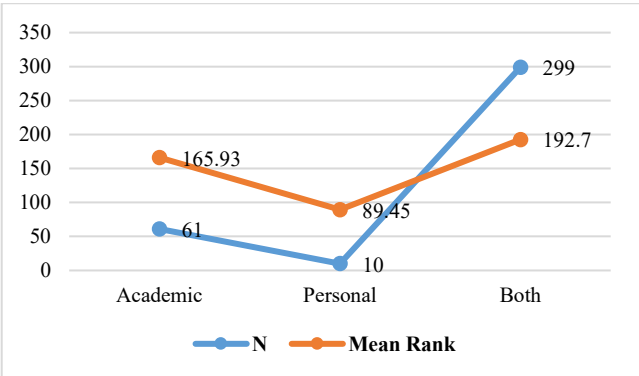

Fig. 11. Digital literacy based on the purpose of using e-resources.

Overall, the findings reflect that PG teacher educators possess foundational digital tool proficiency, particularly regarding safety measures of digital tools, and access and usage of digital content, which is essential for effective and responsible digital engagement. However, targeted support is needed in digital content creation, Communicating, and Sharing Digital Content in engaging in online discussions and sharing relevant content across various platforms.

The analysis also revealed that digital tool proficiency of PG teacher educators shows significant differences based on their stream of study, annual family income, e-resource usage experience, and the purpose of using e-resources, with commerce stream participants and those with higher incomes showing the highest mean ranks. Conversely, participants with low experience using e-resources and those using them solely for personal purposes had the lowest mean ranks.

These findings correspond with previous studies on how socioeconomic status and educational background affect digital proficiency. Studies revealed curriculum integration and real-world uses of digital technologies; students in disciplines like science and commerce who have more exposure to technology typically have higher levels of digital skills [69]. Furthermore, people from higher-income families tend to have better access to digital devices, better internet connectivity, and more opportunities for digital engagement [70]. Additionally, the previous research found that participants who had previously used e-resources and those who used digital tools for personal and academic purposes had considerably higher levels of digital literacy [67], highlighting the importance of regular and varied digital exposure in developing digital competence. Students who use digital resources in various settings gain enhanced and flexible digital skills.

However, results show that gender, locality, institution type, study stage, computer experience, and internet experience were not statistically significant, indicating minimal impact on digital literacy levels. These findings underscore the importance of academic discipline, socioeconomic status, and purposeful e-resource usage in shaping digital literacy.

These findings align with several recent studies that have questioned the influence of fundamental demographic factors on digital literacy, especially as digital access becomes more widespread, gender differences in ICT literacy are narrowing, suggesting that both male and female students are equally capable of increasing digital skills in an inclusive digital environment [71]. Similarly, research showed that while access to technology was a barrier in rural versus urban settings, this gap has diminished in many regions due to increased internet penetration and the integration of digital tools in urban and rural educational institutions [45, 72]. In addition, some studies have highlighted that factors such as years of computer or internet use do not automatically equate to higher digital literacy [69], the quality and context of digital engagement, such as guided practice, purposeful use, and access to meaningful digital content, play a more significant role.

V. Conclusion

This study has developed a robust scale for evaluating PG teacher educators' Digital Literacy (DL). The findings validated the predicted four dimensions supported by the UNESCO digital literacy framework (2018) and literature. The digital literacy scale initially developed 55 items. In the iterative scale development and validation procedure, we

removed 13 items and retained 42 items with four factors (dimensions). The DLS was analyzed through 370 participants, demonstrating good construct and discriminant validity through rigorous statistical analysis, including the item-total correlation method and confirmatory factor analysis. Scale reliability is confirmed through **Cronbach's Alpha (α) and Coefficient Omega (ω)**, demonstrating excellent reliability.

Furthermore, PG teacher educators' digital literacy levels were evaluated in four-dimensional proficiency areas: the highest proficiency in "Safety Measures of Digital Tools" and the lowest in "Creating Digital Content." The survey found that participants had moderate to high levels of digital literacy. Notable differences corresponded to the study stream, annual family income, previous e-resource usage, and the purpose for utilizing digital tools; participants in the commerce stream and those with higher incomes and more varied digital involvement had stronger skills. However, there was no discernible effect of factors like gender, location, type of institution, study stage, computer, and internet experience, indicating that digital proficiency is not solely determined by access, emphasizing the importance of meaningful digital use and educational background in developing digital literacy.

These findings highlight the need to enhance content creation, communication, and sharing digital skills while reinforcing the role of meaningful digital use and educational background in shaping digital literacy. It can be used for academic purposes and professional teacher education programs to examine the role of digital literacy in teacher educators' performance and effectiveness, as well as the productivity of the institutions.

VI. Limitations and Suggestions

The digital literacy scale's findings are subject to certain limitations. The sample was restricted to teacher educators from government and government-aided institutions in West Bengal, India, which may limit the generalizability of the results to other regions or types of institutions, such as private colleges or universities. Additionally, the study focused solely on first-year and second-year teacher educators, excluding those at other career stages, which may have provided a broader perspective on digital literacy levels. To compare the results of digital literacy of PG teacher educators among the demographic variables, we conducted a non-parametric test for the non-normal data. Future research could address these limitations by including a more diverse sample to enhance the applicability of the findings.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Md Mujahid Alom contributed to the study's design, conducted the survey, performed data analysis, and drafted the initial manuscript. Vijaykumar Ramalingappa contributed critical revisions. Both authors reviewed and approved the final version of the manuscript.

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Informed Consent

The teacher educators were approached in person after obtaining permission from the respective college or university authorities. Participants were provided with a clear explanation of the survey's purpose and objectives. Informed consent was obtained from all participants.

References

[1] E. Instefjord and E. Munthe, "Preparing pre-service teachers to integrate technology: An analysis of the emphasis on digital competence in1 teacher education curricula," *European Journal of Teacher Education*, vol. 39, no. 1, pp. 77–93, 2015.

[2] G. V. Joseph *et al.*, "Impact of digital literacy, use of AI tools and peer collaboration on AI assisted learning: Perceptions of the university students," *Digital Education Review*, no. 45, pp. 43–49, June 2024.

[3] S. Nurzhanova *et al.*, "Investigation of future teachers' digital literacy and technology use skills," *International Journal of Education in Mathematics, Science and Technology*, vol. 12, no. 2, pp. 387–405, 2024.

[4] I. Engeness, "Developing teachers' digital identity: Towards the pedagogic design principles of digital environments to enhance students' learning in the 21st century," *European Journal of Teacher Education*, vol. 44, no. 1, pp. 96–114, 2020.

[5] R. J. Krumsvik, "Teacher educators' digital competence," *Scandinavian Journal of Educational Research*, vol. 58, no. 3, pp. 269–280, 2012.

[6] P. Ernest *et al.*, "Online teacher development: Collaborating in a virtual learning environment," *Computer Assisted Language Learning*, vol. 26, no. 4, pp. 311–333, 2012.

[7] B. Vajen, S. Kenner, and F. Reichert, "Digital citizenship education—Teachers' perspectives and practices in Germany and Hong Kong," *Teaching and Teacher Education*, vol. 122, 103972, Feb. 2023.

[8] E. J. Instefjord and E. Munthe, "Educating digitally competent teachers: A study of integration of professional digital competence in teacher education," *Teaching and Teacher Education*, vol. 67, pp. 37–45, Oct. 2017.

[9] M. Benali and M. Ally, "Towards a conceptual framework highlighting mobile learning challenges," *International Journal of Mobile and Blended Learning*, vol. 12, no. 1, pp. 51–63, 2020.

[10] C. Mouza and T. Barrett-Greenly, "Bridging the app gap: An examination of a professional development initiative on mobile learning in urban schools," *Computers & Education*, vol. 88, pp. 1–14, Oct. 2015.

[11] H. Beetham and R. Sharpe, *Rethinking Pedagogy for A Digital Age: Principles and Practices of Design*, New York: Routledge, 2019.

[12] P. Reddy *et al.*, "Essaying the design, development and validation processes of a new digital literacy scale," *Online Information Review*, vol. 47, no. 2, pp. 371–397, 2023.

[13] N. Hübner *et al.*, "What predicts students' future ICT literacy? Evidence from a large-scale study conducted in different stages of secondary school," *Computers & Education*, vol. 203, 104847, Oct. 2023.

[14] D. Appiah, C. Kwaah, and N. Asiedu, "Assessing information literacy skills of teacher trainee students: Experiences from a Ghanaian college of education," *International Journal of Information Science and Management (IJISM)*, vol. 21, no. 4, pp. 149–164, 2023.

[15] K. Tzafilkou, M. Perifanou, and A. A. Economides, "Development and validation of students' digital competence scale (SDiCoS)," *Int. J. Educ. Technol. High Educ.*, vol. 19, p. 30, 2022.

[16] Y. Ning *et al.*, "Teachers' AI-TPACK: Exploring the relationship between knowledge elements," *Sustainability*, vol. 16, no. 3, p. 978, Jan. 2024.

[17] E. Avinç and F. Doğan, "Digital literacy scale: Validity and reliability study with the rasch model," *Educ. Inf. Technol.*, vol. 29, pp. 22895–22941, 2024.

[18] M. M. Gümüş and V. Kukul, "Developing a digital competence scale for teachers: Validity and reliability study," *Educ. Inf. Technol.*, vol. 28, pp. 2747–2765, 2022.

[19] P. S. C. Goh and D. Blake, "E-readiness measurement tool: Scale development and validation in a Malaysian higher educational context," *Cogent Education*, vol. 8, no. 1, 1883829, 2021.

[20] M. M. Masood and M. M. Haque, "From critical pedagogy to critical digital pedagogy: A prospective model for the EFL classrooms," *Saudi Journal of Language Studies*, vol. 1, no. 1, pp. 67–80, 2021.

[21] S. Ličen and M. Prosen, "Strengthening sustainable higher education with digital technologies: Development and validation of a digital competence scale for university teachers (DCS-UT)," *Sustainability*, vol. 16, no. 22, 9937, Nov. 2024.

[22] L. Amhag, L. Hellström, and M. Stigmar, "Teacher educators' use of digital tools and needs for digital competence in higher education," *Journal of Digital Learning in Teacher Education*, vol. 35, no. 4, pp. 203–220, 2019.

[23] H. Almazroa and W. Alotaibi, "Teaching 21st century skills: Understanding the depth and width of the challenges to shape proactive teacher education programmes," *Sustainability*, vol. 15, no. 9, 7365, Apr. 2023.

[24] M. Carrier, R. M. Damerow, and K. M. Bailey, *Digital Language Learning and Teaching: Research, Theory, and Practice*, New York: Routledge, 2017.

[25] L. B. Johanson *et al.*, "Competence in digital interaction and communication—A study of first-year preservice teachers' competence in digital interaction and communication at the start of their teacher education," *The Teacher Educator*, vol. 58, no. 3, pp. 270–288, 2022.

[26] A. M. Rodríguez-García *et al.*, "Communicating and collaborating with others through digital competence: A self-perception study based on teacher trainees' gender," *Education Sciences*, vol. 12, no. 8, p. 534, 2022.

[27] H. Bicen, F. Ozdamli, and H. Uzunboylu, "Online and blended learning approach on instructional multimedia development courses in teacher education," *Interactive Learning Environments*, vol. 22, no. 4, pp. 529–548, 2012.

[28] G. Falloon, "From digital literacy to digital competence: The Teacher Digital Competency (TDC) framework," *Education. Tech. Research Dev.*, vol. 68, pp. 2449–2472, 2020.

[29] A. Sangwan, A. Sangwan, and P. Punia, "Development and validation of an attitude scale towards online teaching and learning for higher education teachers," *TechTrends*, vol. 65, pp. 187–195, 2020.

[30] S. Tutkyshbayeva and A. Zakirova, "Analysing IoT digital education: Fostering students' understanding and digital literacy," *Int. J. Eng. Ped.*, vol. 14, no. 4, 2024.

[31] A. Lantz-Andersson, M. Lundin, and N. Selwyn, "Twenty years of online teacher communities: A systematic review of formally-organized and informally-developed professional learning groups," *Teaching and Teacher Education*, vol. 75, pp. 302–315, Oct. 2018.

[32] F. Martin *et al.*, "Teacher and school concerns and actions on elementary school children digital safety," *TechTrends*, vol. 67, pp. 561–571, 2022.

[33] J. C. Désiron, M. L. Schmitz, and D. Petko, "Teachers as creators of digital multimedia learning materials: Are they aligned with multimedia learning principles," *Tech. Know. Learn.*, vol. 30, Aug. 2024.

[34] D. Herro, D. Kiger, and C. Owens, "Mobile technology: Case-based suggestions for classroom integration and teacher educators," *Journal of Digital Learning in Teacher Education*, vol. 30, no. 1, pp. 30–40, 2014.

[35] R. Scherer, F. Siddiq, and J. Tondeur, "The Technology Acceptance Model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education," *Computers & Education*, vol. 128, pp. 13–35, Jan. 2019.

[36] H. Dahlström, "Digital writing tools from the student perspective: Access, affordances, and agency," *Educ. Inf. Technol.*, vol. 24, pp. 1563–1581, 2018.

[37] O. Oseghale, "Digital information literacy skills and use of electronic resources by humanities graduate students at Kenneth Dike Library, University of Ibadan, Nigeria," *Digital Library Perspectives*, vol. 39, no. 2, pp. 181–204, 2023.

[38] Ł. Tomczyk, "What do teachers know about digital safety?" *Computers in the Schools*, vol. 36, no. 3, pp. 167–187, 2019.

[39] F. D. Guillén-Gámez *et al.*, "Digital competences in cybersecurity of teachers in training," *Computers in the Schools*, vol. 41, no. 3, pp. 281–306, Jul. 2024.

[40] G. O. Boateng *et al.*, "Best practices for developing and validating scales for health, social, and behavioral research: A primer," *Front. Public Health*, vol. 6, 149, 2018.

[41] R. F. DeVellis, *Scale Development: Theory and Applications*, New York: SAGE Publications Inc., 2016.

[42] S. Hunziker and M. Blankenagel, *Research Design in Business and Management: A Practical Guide for Students and Researchers*, Wiesbaden: Springer Fachmedien Wiesbaden, 2024.

[43] R. J. Garg, V. Kumar, and Vandana, "Factors affecting usage of e-resources: Scale development and validation," *Aslib Journal of Information Management*, vol. 69, no. 1, pp. 64–75, 2017.

[44] X. Tan, X. Lin, and R. Zhuang, "Development and validation of a secondary vocational school students' digital learning competence scale," *Smart Learn. Environ.*, vol. 11, 37, Aug. 2024.

[45] E. Kormos and K. Wisdom, "Digital divide and teaching modality: It's role in technology and instructional strategies," *Educ. Inf. Technol.*, vol. 28, no. 8, pp. 9985–10003, Aug. 2023.

[46] J. Yoon *et al.*, "Development and validation of digital health technology literacy assessment questionnaire," *J. Med. Syst.*, vol. 46, 13, 2022.

[47] D. F. Polit, C. T. Beck, and S. V. Owen, "Is the CVI an acceptable indicator of content validity? Appraisal and recommendations," *Research in Nursing & Health*, vol. 30, no. 4, pp. 459–467, 2007.

[48] S. J. Stratton, "Population research: Convenience sampling strategies," *Prehosp. Disaster med.*, vol. 36, no. 4, pp. 373–374, Aug. 2021.

[49] X. Fan, "Item response theory and classical test theory: An empirical comparison of their item/person statistics," *Educational and Psychological Measurement*, vol. 58, no. 3, pp. 357–381, 1998.

[50] R. B. Kline, *Principles and Practice of Structural Equation Modeling*, New York: The Guilford Press, 2023.

[51] D. McNeish and M. G. Wolf, "Dynamic fit index cutoffs for confirmatory factor analysis models," *Psychological Methods*, vol. 28, no. 1, pp. 61–88, 2023.

[52] J. F. Hai *et al.*, *Multivariate Data Analysis*, Boston: Cengage, 2019.

[53] H. F. Kaiser, "An index of factorial simplicity," *Psychometrika*, vol. 39, pp. 31–36, Mar. 1974.

[54] P. Rogers, "Best practices for your confirmatory factor analysis: A JASP and lavaan tutorial," *Behavior Research Methods*, vol. 56, pp. 6634–6654, Mar. 2024.

[55] J. Henseler, C. M. Ringle, and M. Sarstedt, "A new criterion for assessing discriminant validity in variance-based structural equation modeling," *Journal of the Academy of Marketing Science*, vol. 43, pp. 115–135, 2014.

[56] B. G. Tabachnick and L. S. Fidell, *Using Multivariate Statistics*, London: Pearson, 2018.

[57] K. Groskurth, M. Bluemke, and C. M. Lechner, "Why we need to abandon fixed cutoffs for goodness-of-fit indices: An extensive simulation and possible solutions," *Behavior Research Methods*, vol. 56, pp. 3891–3914, 2023.

[58] Y. Xia and Y. Yang, "RMSEA, CFI, and TLI in structural equation modeling with ordered categorical data: The story they tell depends on the estimation methods," *Behavior Research Methods*, vol. 51, pp. 409–428, 2018.

[59] C. DiStefano *et al.*, "Examination of the weighted root mean square residual: Evidence for trustworthiness?" *Structural Equation Modeling: A Multidisciplinary Journal*, vol. 25, no. 3, pp. 453–466, 2017.

[60] G. Cho *et al.*, "Cutoff criteria for overall model fit indexes in generalized structured component analysis," *Journal of Marketing Analytics*, vol. 8, pp. 189–202, 2020.

[61] D. McNeish, "Thanks coefficient alpha, we'll take it from here," *Psychological Methods*, vol. 23, no. 3, pp. 412–433, 2018.

[62] E. C. Davenport *et al.*, "Reliability, dimensionality, and internal consistency as defined by Cronbach: Distinct albeit related concepts," *Educational Measurement: Issues and Practice*, vol. 34, no. 4, pp. 4–9, 2015.

[63] M. T. Kalkbrenner, "Choosing between Cronbach's coefficient alpha, McDonald's coefficient omega, and coefficient *H*: Confidence intervals and the advantages and drawbacks of interpretive guidelines," *Measurement and Evaluation in Counseling and Development*, vol. 57, no. 2, pp. 93–105, 2024.

[64] T. C. Zortea, C. M. Gray, and R. C. O'Connor, "Adult attachment: Investigating the factor structure of the relationship scales questionnaire," *Journal of Clinical Psychology*, vol. 75, no. 12, pp. 2169–2187, 2019.

[65] Ł. Tomczyk, "Skills in the area of digital safety as a key component of digital literacy among teachers," *Educ. Inf. Technol.*, vol. 25, pp. 471–486, 2019.

[66] T. Volkmann, I. Miller, and N. Jochems, "Addressing fear and lack of knowledge of older adults regarding social network sites," in *Proc. Human Aspects of IT for the Aged Population. Technology and Society*, 2020, pp. 114–130.

[67] M. Carabregu-Vokshi *et al.*, "21st century digital skills of higher education students during Covid-19—Is it possible to enhance digital skills of higher education students through e-learning?" *Educ. Inf. Technol.*, vol. 29, pp. 103–137, 2024.

[68] R. E. Potter *et al.*, "Digital communication, health & wellbeing in universities: A double-edged sword," *Journal of Higher Education Policy and Management*, vol. 44, no. 1, pp. 72–89, 2021.

[69] E. S. Troll, M. Friese, and D. D. Loschelder, "How students' self-control and smartphone-use explain their academic performance," *Computers in Human Behavior*, vol. 117, 106624, Apr. 2021.

[70] S. Anrijs *et al.*, "Excluded from essential internet services: Examining associations between digital exclusion, socio-economic resources and internet resources," *Technology in Society*, vol. 73, 102211, May 2023.

[71] F. Siddiq and R. Scherer, "Is there a gender gap? A meta-analysis of the gender differences in students' ICT literacy," *Educational Research Review*, vol. 27, pp. 205–217, June 2019.

[72] A. J. V. Deursen and J. A. V. Dijk, "The first-level digital divide shifts from inequalities in physical access to inequalities in material access," *New Media & Society*, vol. 21, no. 2, pp. 354–375, 2018.

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