DIGITAL THEORY, CULTURE & SOCIETY
https://journal.c-dics.com

DIGITAL THEORY, CULTURE & SOCIETY
ISSN 3031-707X
Center for Digital Culture Studies (C-DICS)

Volume 4, Issue 1, July 2026 **Page 1–18**

Assessing digital competence and inequalities among secondary school students in Sindh, Pakistan: Evidence from a mixed-methods study using DigComp 2.1

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DOI: https://doi.org/10.61126/dtcs.v4i1.127

ARTICLE INFO

Keywords:
digital literacy
secondary education
DigComp
digital divide
gender inequality

ABSTRACT

The rapid expansion of digital technologies has transformed the competencies required for education, employment, and civic participation. Although improvements in digital infrastructure across the Global South have reduced the first-level digital divide in access, disparities in digital skills continue to limit students' meaningful engagement with digital learning. Despite growing policy attention, empirical evidence on students' digital competencies in developing countries remains limited. This study examines the digital literacy competencies of secondary school students in Sindh, Pakistan. Using a convergent parallel mixed-methods design, Grade 10 students (n = 430) in Hyderabad were assessed using the DigComp 2.1 framework. Quantitative data were collected through a DigCompSAT-based questionnaire and complemented by semi-structured interviews with students (n = 47). The findings reveal a moderate level of digital literacy, with stronger competencies in information and data literacy but weaker skills in digital content creation, online collaboration, critical evaluation, safety, and problem-solving. Significant disparities were found across gender, geographic location, socioeconomic status, and access to digital resources, with male, urban, and higher socioeconomic status students demonstrating greater digital competence. Access to personal digital devices and reliable internet connectivity emerged as significant predictors of digital competence. These findings provide evidence of digital skill inequalities and inform policies to promote equitable digital literacy development in secondary education.

Citation suggestion:
Ali, T., & Aziz, N. (2026). Assessing digital competence and inequalities among secondary school students in Sindh, Pakistan: Evidence from a mixed-methods study using DigComp 2.1. *Digital Theory, Culture & Society, 4*(1), 1–18. https://doi.org/10.61126/dtcs.v4i1.127

Received 15 March 2026; Received in revised form 17 April 2026; Accepted 22 April 2026; Published online 25 July 2026.

Introduction

The 21st century has been marked by rapid technological advancement and globalization, transforming the skills required for education, employment, and active citizenship (OECD, 2019; UNESCO, 2013). In this evolving landscape, digital literacy has become a critical competency, involving the ability to access, evaluate, and critically analyze digital information while supporting knowledge creation and communication (Bawden, 2008; Martin & Madigan, 2006). Frameworks such as DigComp conceptualize digital literacy as a multidimensional construct, including information and data literacy, communication, collaboration, content creation, safety, and problem-solving. It is widely recognized as a key competency for lifelong learning, relevant across education, employment, and civic participation (Majumdar, Yang & Ogata, 2024).

Despite their conceptual strength, the applicability of such frameworks in contexts with limited infrastructure and socio-cultural constraints remains uncertain. In developing countries like Pakistan, digital competence is increasingly seen as a driver of transformation. National policies, including the National Curriculum (2022–2023) and Government initiatives (2018), emphasize coding, computational thinking, and problem-solving as essential for future readiness. However, Pakistan's context—characterized by access inequalities, gender disparities, and uneven technological integration—offers a critical setting to examine how digital literacy frameworks function under structural constraints. Developing these skills is essential for both academic success and equitable societal participation.

Digital literacy plays a central role in learning, teaching, and employability. It enables students to engage in critical inquiry, collaborate through digital platforms, and adapt to changing academic and labor market demands (Ervianti et al., 2023). Research shows that students with stronger digital competencies achieve better learning outcomes and are better prepared for academic and vocational pathways (Ervianti et al., 2023). As education systems increasingly integrate digital technologies, these competencies have become indispensable.

Pakistan's demographic profile, with approximately 64% of the population under 30, presents both opportunities and challenges (World Population Review, 2023). While this youth bulge could drive economic growth, inadequate digital skills risk turning it into a liability. Current indicators reflect

this concern, with low rankings in workforce and future-oriented skills (Schwab, 2018) and modest performance on the Digital Skills Gap Index (2021). Rapid advances in automation further threaten employability, with up to 30% of jobs at risk by 2030 (Dellot & Wallace-Stephens, 2017).

These challenges are compounded by systemic issues in education, including low public investment, infrastructural deficits, and persistent inequalities. Limited access to technology, especially in rural regions such as Sindh, highlights the urgent need to understand how digital literacy can be effectively developed within constrained environments.

Literature Review

Digital literacy has evolved from a focus on basic technical skills to a complex, multidimensional construct encompassing cognitive, social, and emotional competencies. Early definitions emphasized the ability to navigate digital environments (Gilster, 1997), but later scholarship expanded the concept to include critical thinking and multiple literacies such as information, media, and computer literacy (Eshet, 2004; Bawden, 2001, 2008; Jones-Kavalier & Flannigan, 2006; Martin & Madigan, 2013). More recent perspectives incorporate creativity, collaboration, and responsible use of digital technologies (Hague & Payton, 2010; Ng, 2012). Ferrari's (2012, 2013) conceptualization of digital competence—comprising knowledge, skills, and attitudes across five domains (information, communication, content creation, safety, and problem-solving)—underpins the widely adopted DigComp framework (Vuorikari, Kluzer, & Punie, 2022).

Despite these comprehensive frameworks, access to digital competence remains uneven. The concept of the digital divide highlights that inequalities extend beyond physical access to include disparities in skills and outcomes. Hargittai (2010) distinguishes between first-level divides (access) and second-level divides (skills), while Wei et al. (2011) introduce a third-level "digital outcome divide," referring to unequal benefits such as educational and economic opportunities. More broadly, the digital divide encompasses systemic inequalities in access, knowledge, and usage (Castells, 2002; van Dijk, 2005, 2020; Aydin, 2021).

van Dijk's Resources and Appropriation Theory explains these inequalities by emphasizing the role of time, motivation, education, and social capital in shaping digital engagement, with education emerging as a critical factor (van Dijk, 2005, 2020). Expanding on this, van Deursen and van Dijk (2017) identify four interconnected dimensions of access: material, motivational, skills, and usage. These dimensions interact with broader social, economic, and cultural conditions to shape digital participation (Bruno et al., 2010; Aydin, 2021).

Socio-demographic factors such as education, gender, and income remain strong predictors of digital inequality (Scheerder et al., 2017). In developing contexts, these disparities are particularly pronounced. Rural populations and women often face compounded disadvantages, including limited access, inadequate training, and fewer opportunities for meaningful engagement. In Pakistan, these challenges are evident: only 37% of rural households own smartphones and just 13% have internet access, while rural women are significantly less likely to own digital devices, restricting their educational and economic participation (ASER, 2023; UNDP, 2024).

Educational contexts further reinforce these inequalities. Public and rural

schools often lack adequate infrastructure, trained teachers, and supportive learning environments, limiting students' opportunities to develop digital skills. Gendered patterns also persist: girls tend to perform better in information-related tasks, whereas boys often show greater confidence in technical domains such as problem-solving and digital security (Yildirim & Özturk, 2023). In Pakistan, socio-cultural norms and infrastructural barriers further restrict female participation, particularly in rural areas (Younus & Saleem, 2021).

Despite a growing body of research, significant gaps remain. Studies from countries such as Indonesia and Uganda suggest that students often possess basic digital skills, such as searching for information and communicating online, but lack higher-order competencies like critical analysis, content creation, and digital safety (Delita et al., 2022; Perdana et al., 2019). Similar trends are observed in Pakistan, where even university students struggle with critical evaluation and content production (Tunio et al., 2013). Although some improvements have been reported in communication and research skills (Rehman, Burki, & Khan, 2022), much of the existing literature remains focused on basic ICT competencies, overlooking advanced skills required for effective digital citizenship (Jan, 2018; Vuorikari, Kluzer, & Punie, 2022).

Furthermore, contextual factors such as gender norms and socio-economic barriers are insufficiently explored, despite their significant influence on digital engagement (Younus & Saleem, 2021). Much of the available research also predates the COVID-19 pandemic, which has accelerated digital transformation in education and highlighted the urgency of digital competence (Rehman, Burki, & Khan, 2022). Methodologically, many studies rely on self-reported measures, which may overestimate actual abilities (Aesaert et al., 2013). Additionally, emerging technologies such as artificial intelligence are reshaping digital literacy demands but remain largely absent from empirical research.

Empirical evidence on secondary school students' actual digital literacy in Pakistan, particularly in public schools, is therefore limited. This study addresses these gaps by applying the DigComp 2.1 framework and the DigCompSAT tool to assess Grade 10 students' digital literacy in Hyderabad, Sindh, alongside qualitative insights into their experiences. By examining a resource-constrained context, the study contributes to understanding how socio-cultural and institutional factors shape digital competence.

Aim and Research Questions

This study aims to assess the digital literacy of Grade 10 students in public secondary schools in Hyderabad, Sindh, using the DigComp 2.1 framework. A convergent parallel mixed-methods design is employed to capture both quantitative disparities and qualitative insights.

The study addresses the following research questions: (i) What is the perceived level of digital literacy among secondary school students in Hyderabad, Sindh, Pakistan? (ii) How do socio-demographic factors such as gender, school context, and access to technology influence these perceptions?

This study contributes in three important ways. First, it provides context-specific evidence on second-level digital divides among secondary students in Sindh, a region underrepresented in research. Second, by applying the DigComp 2.1 framework through the DigCompSAT tool, it offers a structured assessment of digital competencies beyond basic ICT skills,

including problem-solving, content creation, and online safety. Third, it generates gender-responsive and domain-specific insights to inform curriculum design, teacher training, and targeted interventions.

From a policy perspective, the findings support integrating digital literacy into secondary curricula in line with Pakistan's National Curriculum (2022–23) and Digital Pakistan Policy (2018). By highlighting socio-economic, gender, and geographic disparities, the study also contributes to advancing digital equity and achieving SDG 4.7.

Method

This study employed a convergent parallel mixed-methods design (Creswell & Clark, 2008) to assess secondary school students' digital literacy by integrating quantitative and qualitative data to capture both measurable competencies and contextual influences. The study was conducted in eight public secondary schools in Hyderabad district, Sindh, selected through multi-stage cluster sampling to ensure representation across urban–rural and gender strata. The quantitative sample included 430 Grade 10 students, while a purposive subsample of 47 students participated in qualitative interviews.

Quantitative data were collected using a cross-sectional survey adapted from the validated DigCompSAT self-assessment tool (Clifford et al., 2020). The instrument measured five DigComp 2.1 domains—Information Literacy, Communication, Content Creation, Safety, and Problem-Solving—using a 5-point Likert scale (Carretero et al., 2017). The Digital Literacy Assessment Questionnaire (DLAQ) was pilot-tested for validity and reliability, yielding a Cronbach's alpha of 0.908, indicating excellent internal consistency.

Quantitative data were analyzed using SPSS version 23. Descriptive statistics summarized participants' demographic characteristics, while inferential analyses, including ANOVA, examined differences in digital literacy across gender, location, and technology access. Effect sizes were calculated using eta-squared (η^2) for ANOVA and Cohen's r for t-tests. Qualitative data were transcribed, translated into English, and analyzed through thematic analysis guided by the DigComp domains. This enabled identification of key patterns and themes that complemented and explained the quantitative results.

Using a convergent parallel mixed-methods design, both data types were collected simultaneously, analyzed separately, and integrated at the interpretation stage. Integration involved comparing survey and interview findings across DigComp domains. Quantitative results identified disparities in digital literacy, while qualitative insights explained these patterns through students' lived experiences and contextual constraints.

Ethical approval was obtained from the Aga Khan University Ethical Review Committee. Permissions were secured from relevant authorities and school principals. Informed assent was obtained from students, with headteachers providing parental consent. Anonymity, confidentiality, and the right to withdraw were ensured throughout.

Results and Discussion

Findings

Quantitative findings

The quantitative analysis examined students' demographic characteristics, overall digital literacy levels, and variations by gender, geographical context, educational support, and technology access.

Table 1. Reliability test of DLAQ

Constructs	No. of items	Cronbach's Alpha
Information and Data Literacy	6	0.643
Communication and Collaboration	9	0.776
Digital Content Creation	5	0.746
Safety	6	0.743
Problem Solving Skills	4	0.768
Overall	30	0.908

Note: Qualitative data were gathered through semi-structured interviews guided by the DigComp framework.

Table 2. Participant Profile

	Demographics	No. of Students (%)
School Gender n (%)	Boy's School (3)	88 (20%)
	Girl's School (3)	140 (32%)
	Co-Education (2)	202 (47%)
Geographical Context n (%)	Urban (6)	228 (53%)
	Rural (4)	202 (47%)
Student Gender n (%)	Boys	205 (47.7%)
	Girls	225 (52.3%)
Overall	8 Schools	430 Students

Analysis employed descriptive statistics, independent-samples t-tests, and ANOVA, with a significance level set at $p < .05$. Effect sizes (r or η^2) are reported to indicate the magnitude of observed differences.

Participant profile

This study surveyed 430 Grade 10 students from eight selected public schools in the Hyderabad district of the Sindh province of Pakistan. Table 2 provides a detailed overview of the demographic characteristics of the respondents.

Sociodemographic and technology access characteristics

Further demographic and technology access characteristics, disaggregated by school location and gender, are presented in Table 3. Significant disparities were observed across both domains.

Urban–rural differences were pronounced. Parents of urban students were more likely to be educated (fathers: 78.9% vs. 63.4%; mothers: 57.9% vs. 39.6%, $p < .001$) and fathers had higher employment rates (92.8% vs. 79.6%, $p < .001$). Urban students were more likely to live in nuclear families (62.3% vs. 36.1%, $p < .001$) and showed greater technology engagement, including higher Wi-Fi access (30.4% vs. 6.8%, $p < .001$), more frequent internet use exceeding five hours daily (26.6% vs. 15.9%, $p < .001$), and higher levels of online interaction (72.9% vs. 55.1%, $p = .002$).

Gender-based differences were also significant. Fathers of female students were

Table 3. Sociodemographic and Technology Access by School Location and Gender

Variable	Rural %	Urban %	P (Location)	Male %	Female %	p (Gender)
Father Educated	63.4	78.9	< .001	65.4	77.3	.006
Mother Educated	39.6	57.9	< .001	45.9	52.4	ns
Father Employed	79.6	92.8	< .001	81.3	91.3	.003
Mother Employed	12.4	14.0	ns	10.2	16.0	ns
Nuclear Family	36.1	62.3	< .001	35.6	63.1	< .001
Tuition (Yes)	30.7	31.6	ns	38.5	24.4	.002
Favorite Subject: Arts	42.3	38.8	ns	32.0	48.8	.001
IT Gadget Access	87.1	93.9	.016	94.6	87.1	.007
Wi-Fi Access	6.8	30.4	< .001	17.0	22.4	.008
Daily Internet >5 hrs	15.9	26.6	< .001	19.1	24.5	.043
Personal Device Ownership	44.9	52.4	ns	64.7	33.5	< .001
Computer Training	10.2	17.3	.046	18.0	10.2	.026

Note: Values are column percentages. ns = not significant.

more likely to be educated (77.3% vs. 65.4%, p = .006) and employed (91.3% vs. 81.3%, p = .003), and females were more likely to belong to nuclear families (63.1% vs. 35.6%, p < .001). However, male students reported greater access to IT devices (94.6% vs. 87.1%, p = .007), higher personal device ownership (64.7% vs. 33.5%, p < .001), and more access to training and tuition, while females relied more on shared devices (66.5% vs. 35.3%, p < .001).

Overall digital literacy

Urban students showed higher parental education and employment, greater nuclear family prevalence, and significantly better technology access, including Wi-Fi use, daily internet engagement, and online interaction (p < .01). Gender differences were also evident. Female students had more educated and employed fathers and were more likely to live in nuclear families, but male students had greater access to IT devices, personal ownership, and training opportunities. In contrast, female students more often relied on shared devices, indicating unequal access to digital resources across both gender and location.

Table 4 shows descriptive statistics for digital literacy across DigComp domains. The overall mean digital literacy was moderate (M = 3.53, SD = 0.60). Students demonstrated higher competence in Information and Data Literacy (M = 4.04, SD = 0.63) compared to Communication and Collaboration (M = 3.37, SD = 0.76), Digital Content Creation (M = 3.11, SD = 0.83), Safety (M = 3.54, SD = 0.71), and Problem-Solving Skills (M = 3.66, SD = 0.81), suggesting that foundational digital skills are stronger than higher-order skills such as content creation.

Gender-based differences in digital literacy

Independent sample t-tests showed significant gender differences in most domains. Males scored higher in Communication and Collaboration, Digital Content Creation, Safety, and Problem-

Table 4. Descriptive Statistics for Digital Literacy Constructs

Item	Digital Literacy	Min	Max	Mean	SD
1.	Information and Data Literacy	1.0	5.0	4.04	0.63
2.	Communication and Collaboration	1.0	5.0	3.37	0.76
3.	Digital Content Creation	1.0	5.0	3.11	0.83
4.	Safety	1.0	5.0	3.54	0.71
5.	Problem-Solving Skills	1.0	5.0	3.66	0.81
	Overall	1.0	5.00	3.53	0.60

Note: Detailed item-level statistics for each construct are available in the supplementary tables (S1–S5), which also align with the qualitative interview themes (see Appendix A).

Solving, with small to medium effect sizes. No difference was found in Information and Data Literacy. Overall, males (M = 3.75, SD = 0.56) outperformed females (M = 3.31, SD = 0.56), $t(383) = 7.69$, $p < .001$, $r = .37$.

Geographic differences in digital literacy

No significant difference in overall digital literacy was found between urban (M = 3.56, SD = 0.56) and rural students (M = 3.49, SD = 0.64), $t(383) = -1.17$, $p = .241$. However, urban students scored higher in digital content creation and safety, with small effect sizes; other domains showed no meaningful differences (Table 6).

Digital literacy proficiency levels and types by gender

No significant difference in overall digital literacy was found between urban (M = 3.56, SD = 0.56) and rural students (M = 3.49, SD = 0.64), $t(383) = -1.17$, $p = .241$. However, urban students scored higher in digital content creation and safety, with small effect sizes, while other domains showed no meaningful differences (Table 6).

For digital literacy types, males outperformed females in Knowledge (4.04 vs. 3.54), Skills (3.67 vs. 3.22), and Attitudes (3.74 vs. 3.45) (Table 8).

Technology access and digital literacy

Access to technology was positively associated with digital literacy. Students with personal devices scored significantly higher overall (M = 3.70, SD = 0.70) than those using shared devices (M = 3.34, SD = 0.67), $t(377) = 6.30$, $p < .001$, $r = .31$ (see Table 9).

Analysis of variance showed a significant effect of internet access type on digital literacy, $F(2, 377) = 7.75$, $p = .001$, $\eta^2 = .04$. Post hoc results indicated that students with both Wi-Fi and mobile data (M = 3.75, SD = 0.63) scored higher than those with Wi-Fi only (M = 3.52, SD = 0.54; $p = .032$) or mobile data only (M = 3.45, SD = 0.58; $p < .001$), with no difference between the latter two groups.

Overall, findings indicate moderate digital literacy among secondary students, with significant gender disparities favoring males and slight urban advantages in specific domains. Access to personal devices, internet connectivity, and educational support were consistently associated with higher digital literacy, highlighting the role of structural and socio-cultural factors in shaping competency. Quantitative analysis identified key patterns and influencing variables, while qualitative data further explored the contextual and environmental conditions shaping students' learning experiences, providing

a more comprehensive understanding that complements the statistical findings.

Qualitative findings

This section presents findings from interviews with 47 students (26 boys, 21 girls) across eight urban and rural schools, analyzed using the DigComp 2.1 framework. The qualitative phase aimed to validate survey-based competencies and explore students lived experiences with digital technologies. Alongside the five DigComp domains, cross-cutting factors such as gender norms, access to resources, and learning opportunities were identified as key influences on digital practices.

Information and data literacy

Quantitative results indicated high self-reported confidence (M > 4.0), particularly in searching and organizing information. However, interviews revealed gaps in critical evaluation and advanced digital management. Students relied heavily on Google and YouTube, often using voice search for convenience. As one noted, "If I do not know the spelling, I give a voice command" (SSI 13).

YouTube was widely used for academic tasks, with students extracting information directly from videos. While some attempted verification, methods were superficial, such as checking multiple platforms or asking family members. Digital content management was basic, relying on screenshots and mobile notes, with limited use of cloud storage. Overall, reported competence exceeded actual critical and organizational skills. For assignments, YouTube was widely used as one participant noted, "We search on YouTube for videos and then note down the information" (SSI 3; 21/05/2024).

While some students show awareness of verification, their methods are often superficial, relying on family input or cross-checking across platforms. For instance, one student stated, "I will check on two to three platforms" (SSI 2; 21/05/2024). In managing digital content, students utilize basic strategies like screenshots and mobile notes but lack familiarity with cloud services. One student shared, "If I do not know how to save it, I will take a screenshot" (SSI 4; 21/05/2024).

Communication and collaboration

Students reported moderate competence, relying primarily on WhatsApp for communication and group work. Formal collaboration tools such as Zoom or Google Meet were largely unfamiliar. As one student stated, "I am comfortable on WhatsApp, but I have not used Zoom" (SSI 3). WhatsApp groups are commonly used for collaboration:

Table 5. Digital Literacy Levels by Gender (Independent Sample t-Test Results)

Digital Literacy	Male Mean (SD)	Female Mean (SD)	t-value	p-value	Effect Size r
Information and Data Literacy	4.08 (0.66)	4.01 (0.59)	1.02	0.309	0.05
Communication and Collaboration	3.70 (0.71)	3.05 (0.66)	9.15	<0.001	0.42
Digital Content Creation	3.38 (0.79)	2.85 (0.79)	6.54	<0.001	0.32
Safety	3.78 (0.66)	3.29 (0.67)	7.26	<0.001	0.35
Problem-Solving Skills	3.84 (0.75)	3.48 (0.83)	4.46	<0.001	0.22
Overall	3.75 (0.56)	3.31 (0.56)	7.69	<0.001	0.37

Table 6. Digital Literacy Levels by Geographical Context

Digital Literacy	Rural Mean (SD)	Urban Mean (SD)	t-value	p-value	Effect Size r
Information and Data Literacy	3.99 (0.72)	4.09 (0.54)	-1.55	0.122	0.08
Communication and Collaboration	3.41 (0.83)	3.34 (0.70)	0.92	0.356	0.05
Digital Content Creation	3.00 (0.77)	3.20 (0.88)	-2.35	0.019	0.12
Safety	3.43 (0.77)	3.62 (0.65)	-2.59	0.010	0.13
Problem-Solving Skills	3.69 (0.72)	3.64 (0.88)	0.56	0.576	0.03
Overall	3.49 (0.64)	3.56 (0.56)	-1.17	0.241	0.06

"I create a group on WhatsApp and share everything there" (SSI 2; 21/05/2024).

Collaboration was informal and unstructured, with limited exposure to tools like Google Docs. Urban students viewed digital platforms as opportunities for education and earning, while rural students emphasized cautious or value-based use. Ethical considerations influenced sharing behavior, with some students filtering content based on cultural or religious norms.

Collaboration through digital tools remains largely informal, with most students unfamiliar with advanced tools like Google Docs. They express awareness of responsible online behavior, linking sharing practices with values and ethics: "If a post contains valuable knowledge, I might share it, but if it is against Islam, I would not" (SSI 41; 24/05/2024). Overall, students demonstrate proficiency with social and messaging apps but lack experience with formal collaboration tools and structured netiquette.

Digital content creation

Students demonstrated basic content creation skills, particularly in short video editing for social media platforms such

Table 7. Comparison of proficiency levels in gender

Digital Literacy Level	Male Mean (SD)	Female Mean (SD)	t-value	p-value	Effect Size r
Foundation	3.96 (0.61)	3.55 (0.60)	6.71	<0.001	0.32
Intermediate	3.72 (0.60)	3.26 (0.56)	7.80	<0.001	0.37
Advance	3.41 (0.79)	3.00 (0.82)	5.12	<0.001	0.25
Overall	3.70 (0.56)	3.27 (0.60)	7.29	<0.001	0.35

Table 8. Comparison of gender

Digital Literacy Type	Male Mean (SD)	Female Mean (SD)	t-value	p-value	Effect Size r
Knowledge	4.04 (0.66)	3.54 (0.68)	7.43	<0.001	0.35
Skill	3.67 (0.58)	3.22 (0.58)	7.70	<0.001	0.37
Attitude	3.74 (0.69)	3.45 (0.63)	4.34	<0.001	0.22
Overall	3.82 (0.56)	3.40 (0.56)	7.30	<0.001	0.35

Table 9. Comparison of Digital Literacy Based on Device Ownership

Digital Literacy	Personal Mean (SD)	Shared Mean (SD)	t-value	p-value	Effect Size r
Information and Data Literacy	4.13 (0.57)	3.95 (0.66)	2.90	.004	.15
Communication and Collaboration	3.61 (0.74)	3.12 (0.70)	6.70	< .001	.33
Digital Content Creation	3.31 (0.83)	2.90 (0.78)	4.92	< .001	.25
Safety	3.75 (0.67)	3.32 (0.68)	6.11	< .001	.30
Problem Solving Skills	3.78 (0.79)	3.54 (0.82)	2.98	.003	.15
Overall	**3.70 (0.70)**	**3.34 (0.67)**	**6.30**	< .001	**.31**

Table 10. Analysis of Variance for Internet access

Variable	N	Mean	SD	Source of difference	Effect Size η^2
Internet access	380	3.53	0.59		0.04
Wi-Fi	77	3.52	0.54	Significant: Wi-Fi < Both Wi-Fi and Mobile Data (p = 0.032)	
Mobile data	225	3.45	0.58		
Both Wi-Fi and mobile data	78	3.75	0.63	Significant: Both Wi-Fi and Mobile Data > Mobile Data (p < .001)	
F= 7.746 and p = 0.001					

as TikTok. However, formal skills in presentations, documents, and programming were limited. One student admitted, "I do not know how to create presentations" (SSI 20).

Copyright awareness was minimal and often confused. Some students equated it with unrelated concepts, while others had only vague awareness of restrictions on content use. Advanced skills such as coding or structured multimedia design were rare, indicating a strong gap between informal creative use and academic digital production skills.

However, skills in formal content creation were limited. "I do not know how to create presentations" (SSI 20; 22/05/2024). Content remixing was basic, usually adding music or filters. Awareness of copyright and licensing was minimal with responses like, "I know about copyright strikes for unauthorized use" (SSI 1; 21/05/2024). Overall, students display functional skills in basic video editing but lack proficiency in advanced content creation, presentation skills, copyright awareness, and programming.

Digital safety

Students reported moderate awareness of digital safety, mainly limited to passwords, fingerprints, and fac e locks. While most understood basic protection strategies, deeper knowledge of privacy, data protection, and terms of service was weak. Some students described experiences

with scams or suspicious apps, showing partial awareness. One explained rejecting an app after realizing it requested excessive personal data.

However, most students lacked knowledge of reporting mechanisms or cybersecurity protocols, highlighting a narrow and reactive understanding of digital safety. As one student shared, "I use a password, fingerprint, pattern, or face lock" (SSI 15; 22/05/2024). While many recognize the importance of protecting personal data, their understanding of "Terms and Conditions" and privacy risks remains limited. Some describe experiences with suspicious apps, indicating partial awareness, with one explaining, "I downloaded a scanner app. It kept showing on TikTok, so I decided to try it out. It asked for my first name, last name, mobile number, email ID, home address, student or business status, and more."

Problem solving

Quantitative findings showed relatively high problem-solving scores (M = 3.66), but interviews revealed differences in autonomy. Urban students were more independent, often using YouTube or Google to troubleshoot issues. One stated, "I try to fix it myself first… otherwise I go to the computer shop" (SSI 13). Another added, "For homework, I write on ChatGPT and it gives me information" (SSI 7; 22/05/2024).

Some also used AI tools such as ChatGPT for academic support. In contrast, rural students relied more on external help and expressed lower confidence in troubleshooting. "No, I cannot solve it" (SSI 25; 23/05/2024), while others make efforts to learn through tutorials, such as, "I would first try to solve it myself, or watch a tutorial video to follow the steps and fix it" (SSI 41; 24/05/2024). A few expressed limited interests, saying, "I am not very interested in updating myself in technology" (SSI 4; 21/05/2024).

Access to technology and gendered constraints

Significant disparities in access emerged, particularly along gender and geographic lines. Urban boys often had personal smartphones, while many girls relied on shared devices. Rural girls faced the most severe limitations, including lack of smartphones and financial constraints. One participant noted, "My father is a laborer, so we cannot afford it" (SSI 38).

Cultural restrictions also influenced access, with some girls discouraged from owning or freely using mobile devices. Rural boys had slightly better access but still faced affordability barriers. These patterns highlight strong gendered and socio-economic digital divides.

Some students gained digital skills through courses or self-directed online learning. Urban boys noted learning programming and web design: "I am currently taking a course at SMIT Center" (SSI 45; 25/05/2024) and "I learned HTML, CSS, JavaScript, PHP, SQL" (SSI 2; 21/05/2024). Rural girls highlighted office and design skills: "I have learned MS Word and PowerPoint. I will learn Excel next" (SSI 43; 24/05/2024) and "I practice graphic designing on my laptop" (SSI 41; 24/05/2024). Overall, both formal and informal learning appear to enhance students' skills across office applications, programming, and online business, though these observations were not systematically examined.

Overall, students perceived digital competence often exceeded actual practice. While basic skills such as searching and messaging were common, higher-order competencies—critical evaluation, structured collaboration, content creation, safety, and problem-solving—remained underdeveloped.

Access to technology and socio-cultural context strongly shaped outcomes. Male and urban students demonstrated higher engagement, while rural and female students faced structural constraints limiting skill development. These findings confirm that digital literacy gaps are driven more by access and context than by formal instruction alone.

Discussion

This study assessed the digital literacy of Grade 10 students in Hyderabad, Sindh, revealing moderate overall proficiency (M = 3.53). Students showed relative strength in Information and Data Literacy (M = 4.04), but weaker performance in Digital Content Creation (M = 3.11). This indicates that while students can locate and interpret information, they lack higher-order competencies such as multimedia production, programming, and copyright awareness.

The findings suggest that exposure to digital technologies alone does not ensure competence. Skill development is uneven across domains, particularly in advanced competencies. Gender, geographic location, socioeconomic status, and access to devices and internet significantly shape outcomes, with male, urban, and higher-SES students consistently outperforming peers.

Students demonstrated strong basic search and retrieval skills, but weaknesses emerged in evaluating credibility and managing digital content. Urban students occasionally cross-checked sources, while rural students relied more on family or peers, reflecting limited critical evaluation skills (Umar & Jalil, 2012).

Many students used screenshots and mobile notes rather than structured tools such as cloud storage, indicating limited digital organization skills (Perdana et al., 2019). Although students reported confidence in this domain, actual practices suggest only foundational competence.

Male students outperformed females in communication and collaboration skills, while urban–rural differences were less pronounced. Students relied heavily on informal platforms such as WhatsApp, Instagram, and Facebook, whereas formal collaboration tools like Google Docs and Zoom were rarely used (Yildirim & Öztürk, 2023).

Male and urban students demonstrated relatively stronger content creation skills, particularly in multimedia production, although overall proficiency remained basic. Students frequently used consumer applications such as TikTok and CapCut, but lacked advanced abilities in presentation design, programming, and professional tools (Perdana et al., 2019).

Awareness of copyright and licensing was minimal and often confused. While some students recognized restrictions on content use, many held incomplete or inaccurate understanding. This highlights a significant gap in ethical and professional digital content creation skills.

Students reported moderate digital safety awareness (Yildirim & Öztürk, 2022; Khan & Vuopala, 2019). Most relied on basic protective measures such as passwords, PINs, fingerprints, and face recognition. However, understanding of privacy policies, terms and conditions, and cybersecurity risks remained limited.

Some students reported encountering suspicious apps or scam messages, indicating partial awareness of online risks. However, knowledge of reporting mechanisms, phishing detection, and data protection strategies was weak (Jan, 2018). Overall, digital safety understanding remained reactive rather than preventive. Male and urban students demonstrated stronger problem-solving abilities, often using

YouTube, Google, or peer support to resolve technical issues (Ehlers & Steinert, 2016). Some also used AI tools such as ChatGPT for academic support.

In contrast, rural students relied more on external help and showed lower confidence in troubleshooting independently. A few students expressed limited interest in improving their digital skills, indicating motivational and access-related barriers. These disparities highlight uneven development of independent learning capabilities.

Persistent disparities emerged across gender and geography, reflecting structural inequalities in access, supervision, and cultural expectations. Male students consistently outperformed females in communication, content creation, safety, and problem-solving, reflecting global patterns of gendered digital engagement (Yildirim & Öztürk, 2023). Historically, males have had greater access to personal devices and unmonitored usage, while females often rely on shared or restricted access, limiting practice opportunities. These constraints reinforce long-standing digital skill gaps.

Urban students generally performed better in content creation and safety due to greater access to digital tools and exposure. Rural students, by contrast, relied more on peers or family support, reflecting limited opportunities for independent learning (Yildirim & Öztürk, 2023). These findings align with research showing that infrastructure influences the depth rather than the existence of digital skills.

Although not a primary focus, interview data indicated that formal training and self-directed learning influenced skill development. Students enrolled in courses in MS Office, programming, or graphic design demonstrated stronger competencies in communication, collaboration, and problem-solving (Shoufan & Mohamed, 2022). Informal learning platforms such as YouTube also supported skill acquisition, particularly for troubleshooting and technical learning (Shoufan & Mohamed, 2022). However, access to such opportunities was uneven, reinforcing existing disparities. Integrating structured digital learning across subjects remains essential for equitable skill development.

Access to technology emerged as the strongest determinant of digital literacy. Students with personal devices and stable internet—particularly those with both Wi-Fi and mobile data—demonstrated the highest competency levels (Yildirim & Öztürk, 2023). Conversely, students with shared or limited access struggled in advanced domains such as content creation and problem-solving. These inequalities reflect broader socio-economic and cultural constraints (Hargittai, 2010). The findings reinforce the persistence of the digital divide and its role in shaping educational inequality (van Dijk, 2017).

A key finding is the mismatch between students' perceived confidence and actual competence. While students often reported high confidence in digital skills, their practical abilities were largely limited to basic operations. Advanced skills remained uneven and socially patterned. Without systemic intervention, digital literacy risks reinforcing rather than reducing inequality. Structural investment in infrastructure, teacher training, and curriculum reform is essential to ensure equitable skill development (van Dijk, 2017).

Conclusion

The study shows that Grade 10 students in Hyderabad possess moderate digital literacy but significant inequalities exist in higher-order competencies, including content creation, collaboration, safety, problem-solving, and critical evaluation.

These disparities are strongly shaped by gender, geography, and access rather than individual ability.

Female and rural students are particularly disadvantaged due to limited access to devices, restricted autonomy, and socio-cultural constraints. Male and urban students consistently outperform peers, reinforcing structural inequality patterns. To address these gaps, coordinated interventions are required across infrastructure, pedagogy, and curriculum. Key recommendations include improving access to affordable devices and internet, strengthening teacher training aligned with DigComp 2.1, and embedding digital literacy across all subjects rather than limiting it to computer studies.

Structured digital tasks, collaborative learning, and safety-focused instruction should be integrated into classroom practice. Gender-sensitive policies must ensure safe and equitable access for female students, while community and parental engagement should support inclusive digital participation. Informal learning platforms such as YouTube can complement formal instruction, particularly in resource-constrained contexts. Digital literacy is essential not only for academic achievement but also for future employment and civic participation, making equitable access a critical development priority.

Future research should expand to other regions of Pakistan and include teacher digital literacy for comparative analysis. Longitudinal and performance-based studies are needed to track skill development over time.

Despite limitations of cross-sectional and self-reported data, this study highlights the urgent need for systemic investment in access, pedagogy, and curriculum reform to prevent digital literacy from reinforcing existing inequalities.

Declaration of Ownership

This article is our original work.

Conflict of Interest

There is no conflict of interest to declare in this article.

Ethical Clearance

This study was approved by the institution.

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