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Digital literacy in upper secondary education students: A multivariate analysis

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Abstract

Digital literacy has become a crucial competency for 21st-century students, especially following the rapid digital transformation triggered by the COVID-19 pandemic. This study analyzed factors associated with digital literacy levels among upper secondary students in southern Tamaulipas and surrounding areas, considering age, gender, and academic performance. A quantitative, cross-sectional, and correlational-analytical design was used, with a stratified sample of 581 students. A 30-item Likert scale based on the DigComp 2.2 framework ($\alpha = 0.91$) measured overall digital competencies. Results revealed generally high digital literacy levels, with no significant differences by gender or age. However, a significant positive correlation emerged between academic performance and digital literacy ($r = 0.140$, $p = 0.007$). These findings highlight the need to strengthen digital integration in upper secondary education and ensure equitable access to technology. Practical implications include the prioritization of digital competence as a curricular objective, especially in regions with unequal access. Schools should implement differentiated instruction, modern digital resources, and sustained teacher training. Since digital skills relate to academic performance, their integration should support critical thinking, autonomous learning, and collaboration. Addressing the digital divide through strategic investment is essential to preparing all students for success in an increasingly digital educational and professional landscape.

Keywords: Digital competencies, Digital literacy, Educational equity, Educational technologies, Upper secondary education.

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1. Introduction

Digital literacy encompasses the critical, safe, and efficient use of digital technologies to communicate, search for, manage, evaluate, and analyze information, as well as to solve problems in academic, professional, and everyday contexts.

Far from being limited to the operation of digital devices or the mastery of specific software, digital literacy today involves a complex set of cognitive, technical, and socio-emotional skills that enable individuals to navigate, contribute to, and thrive within increasingly digitalized societies.

Over the past decade, the concept has evolved significantly, shifting from a predominantly technical perspective to a more holistic and multidimensional approach. This evolution reflects the growing recognition that digital technologies permeate virtually every aspect of life, and thus require users not only to interact with digital tools but also to do so responsibly, critically, and adaptively. Contemporary definitions now emphasize competencies such as effective digital communication, critical engagement with online content, cybersecurity awareness, ethical data practices, and the capacity for autonomous and continuous learning in virtual environments [1-3].

Digital literacy should be understood not merely as technical proficiency, but as a dynamic, evolving literacy that integrates critical thinking, ethical reflection, and social responsibility. This comprehensive vision is embodied in the European Digital Competence Framework for Citizens, known as DigComp 2.2, which has emerged as a global reference point for defining and assessing digital competencies. The framework delineates five core areas: 1) information and data literacy, 2) digital communication and collaboration, 3) digital content creation, 4) cybersecurity, and 5) digital problem-solving [1, 3].

2. Research Problem

In educational contexts, digital competencies are typically grouped into technical skills, effective information management, digital communication and collaboration, innovative content creation, and efficient digital problem-solving [4, 5]. These dimensions have proven highly relevant for preparing young people to meet the demands of increasingly digitalized academic and professional environments [4, 6].

The DigComp framework has been widely adopted and adapted in recent studies on international education policy, demonstrating its value for guiding curriculum development and assessing digital competencies in both formal and informal learning contexts. Carretero et al. [7]. Calvani et al. [8] argue that DigComp 2.2 has provided a solid foundation for evaluating and promoting digital literacy across European and Latin American countries, enabling the identification of competency gaps and specific needs based on different socioeconomic and educational contexts.

Recent research has explored how individual factors such as gender, age, and academic performance influence the development of digital competencies Reddy et al. [9] for instance, found that academic performance significantly predicts digital literacy levels among secondary students, while Chen and Zhang [10] demonstrated gender differences in the critical and effective use of digital technologies, with important implications for inclusive education. Similarly, García-Holgado et al. [11] and Hatlevik and Christophersen [12] highlighted how age-related digital divides and access to technology affect digital literacy, emphasizing the need for education policies that consider these variables.

Current literature recognizes persistent digital divides related to both access to and effective use of digital technologies [13-15] which translates into significant educational inequalities, particularly evident in rural and socioeconomically disadvantaged areas. Recent studies in Latin America and Asia reveal how students in these regions face structural barriers that limit their ability to develop essential digital competencies, directly impacting their future academic and professional opportunities [14]. Addressing these inequalities through targeted public policies is therefore crucial for promoting equitable and inclusive education.

Digital literacy has become a fundamental component of 21st-century education, especially following the accelerated digital transformation driven by the COVID-19 pandemic. These digital competencies enable students to interact effectively with technological platforms, manage information critically, and participate actively in virtual learning environments [15, 16]. However, significant gaps remain in the equitable development of these skills, particularly in contexts of educational inequality [17, 18].

3. Significance of the Study

This study adopts the multidimensional digital literacy framework based on DigComp 2.2 and Bronfenbrenner's ecological systems theory, as this approach allows for the integration of both individual and contextual variables in the analysis. Using quantitative methods and multivariate statistical techniques, we aim to identify key predictive factors of digital literacy levels among upper secondary students.

The primary objective of this study is to analyze the key determinants of digital literacy among upper secondary students in southern Tamaulipas and surrounding areas, with a specific focus on individual factors including gender, age, and academic performance. The significance of this research lies in generating empirical evidence that can guide educational institutions in developing and implementing targeted pedagogical strategies to reduce the digital divide and enhance educational equity.

4. Research Methodology

This study employs a quantitative, cross-sectional, and correlational-analytical approach designed to identify and quantify the relationship between sociodemographic variables and digital literacy levels among upper secondary students. This methodological strategy not only enables the description of observable patterns but also facilitates the exploration of significant variable associations at a specific point in time, thereby supporting evidence-based educational decision-making [19].

The target population consisted of upper secondary education students from diverse public and private educational institutions. To ensure robust representation of key subgroups (gender and institution type) and enhance the external validity of the findings [20], a stratified cluster probability sampling method was employed.

The sample size was calculated using finite population formulas with the following parameters: 95% confidence level, 5% margin of error, and expected proportion of high digital competency set at 50% (to maximize variance robustness in the calculation). The final sample comprised 581 participants, providing sufficient statistical power for meaningful explanatory analyses. This sampling approach strengthens the generalizability of results while maintaining methodological rigor in assessing digital literacy across different student demographics.

Variables were selected based on prior empirical evidence and established digital literacy frameworks, operationalized as follows:

- Age: Ordinal variable categorized into 15-16, 17-18, and 19+ years, included due to potential associations between age and technological familiarity.
- Gender: Dichotomous nominal variable (male/female), considering given documented gender differences in ICT access, use, and confidence.
- Academic Performance: Continuous variable derived from official academic records, included as a potential predictor of digital competency levels.
- Digital Literacy Level: Primary study variable assessed through a 30-item Likert scale based on the DigComp 2.2 framework. Items were scored from 1 (none) to 5 (highly competent), with total scores categorized as low, medium, or high. The scale demonstrated:
- Expert-validated content
- High internal consistency (Cronbach's $\alpha = 0.91$).

All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Data collection was conducted during the second semester of 2024, following prior approval from the institutional research and ethics committees. A self-administered digital questionnaire was employed, ensuring data confidentiality through the use of anonymous codes and obtaining informed consent from all participants, in accordance with the ethical principles outlined in the Declaration of Helsinki [21].

The data were processed and analyzed using IBM SPSS Statistics version 28. Descriptive analyses were performed, including frequencies, means, and standard deviations. The Kolmogorov–Smirnov test was applied to assess normality. Pearson's bivariate correlations were used for continuous variables, and analysis of variance (ANOVA) was conducted to determine statistically significant differences in digital literacy levels according to age group, gender, and overall academic performance. A significance level of $p < 0.05$ was established for all inferential analyses.

5. Research Results

The study sample consisted of 581 students enrolled in upper secondary education, selected from a diverse range of public and private educational institutions located in southern Tamaulipas and surrounding areas. This stratified sampling approach ensured representation across institutional types and socioeconomic contexts, providing a broader perspective on the digital literacy levels present in the student population. In terms of gender distribution, the sample comprised 372 female students (64%) and 209 male students (36%), resulting in a sufficiently heterogeneous composition that enabled comparative analyses with a reasonably balanced gender representation. This demographic distribution also reflects enrollment trends typically observed in the upper secondary education level within the region.

Regarding age, the participants ranged from 15 to 25 years, with the modal age groups being 17 and 18 years, corresponding to the final grades of upper secondary education. While a small proportion of older students were present, likely due to academic interruptions or delayed entry into the education system, the overall age distribution was consistent with national patterns. For the purpose of inferential statistical analysis, age was categorized into ordinal groups, allowing for the examination of trends without compromising data integrity due to outliers.

In relation to academic performance, the mean grade point average across the sample was 90 on a 0–100 scale, with a moderate standard deviation, indicating that a significant proportion of the students demonstrated high academic achievement. This variable was utilized as a proxy indicator of general academic performance and served as a key metric in the correlational analyses undertaken in the study. The distribution of grades further supports the internal validity of the research, as it minimizes floor or ceiling effects and provides a reliable basis for examining associations with digital literacy levels.

Digital literacy was assessed using a 30-item Likert-type scale, developed and validated according to psychometric standards, with a reliability coefficient of $\alpha = 0.91$. The theoretical total score ranged from 30 (minimal proficiency) to 150 (maximum proficiency). In this study, the observed mean was 131.2 points, with a standard deviation of 14.8, a median of 134, and a range from 34 to 150 points. This distribution reflects a high level of digital competence among participants, with scores concentrated in the upper range, suggesting a well-established familiarity with technological tools used in both academic and personal contexts.

5.1. Pearson Correlation

In order to identify associations between individual variables and the level of digital literacy, a Pearson correlation analysis was conducted among the following quantitative variables: age, overall academic performance, and the total score obtained on the digital literacy scale (Table 1).

The results indicate no statistically significant relationship between age and digital literacy level (r = 0.085, p = 0.103), suggesting that, within the studied sample, age does not appear to be linearly associated with the development of digital competencies. This lack of correlation may be attributed to the age homogeneity of the sample, which consisted primarily of adolescents and young adults who share a similar digital exposure environment.

In contrast, a low but statistically significant positive correlation was found between overall academic performance and digital literacy level (r = 0.140, p = 0.007). This finding suggests that students with higher academic achievement tend to exhibit greater levels of digital competence, although the strength of the association is modest. This relationship aligns with previous evidence linking effective use of digital tools to enhanced organizational skills, access to information, and autonomous learning management factors that may contribute to improved academic performance [22, 23].

Table 1.
Pearson Correlations Between Quantitative Variables and Overall Digital Literacy.

Variable	r	p-value	Interpretation
Age	0.085	0.103	Not significant
Overall academic performance	0.140	0.007	Low positive correlation, statistically significant

5.2. Gender Differences (ANOVA)

To determine whether significant differences exist in digital literacy levels between male and female students, a one-way analysis of variance (ANOVA) was conducted, with gender as the independent variable and the total digital literacy score as the dependent variable.

Prior to performing the ANOVA, the assumptions of normality and homogeneity of variances were tested using the Kolmogorov–Smirnov and Levene's tests, respectively. The assumptions were satisfactorily met, allowing for the application of the ANOVA model (Figure 1).

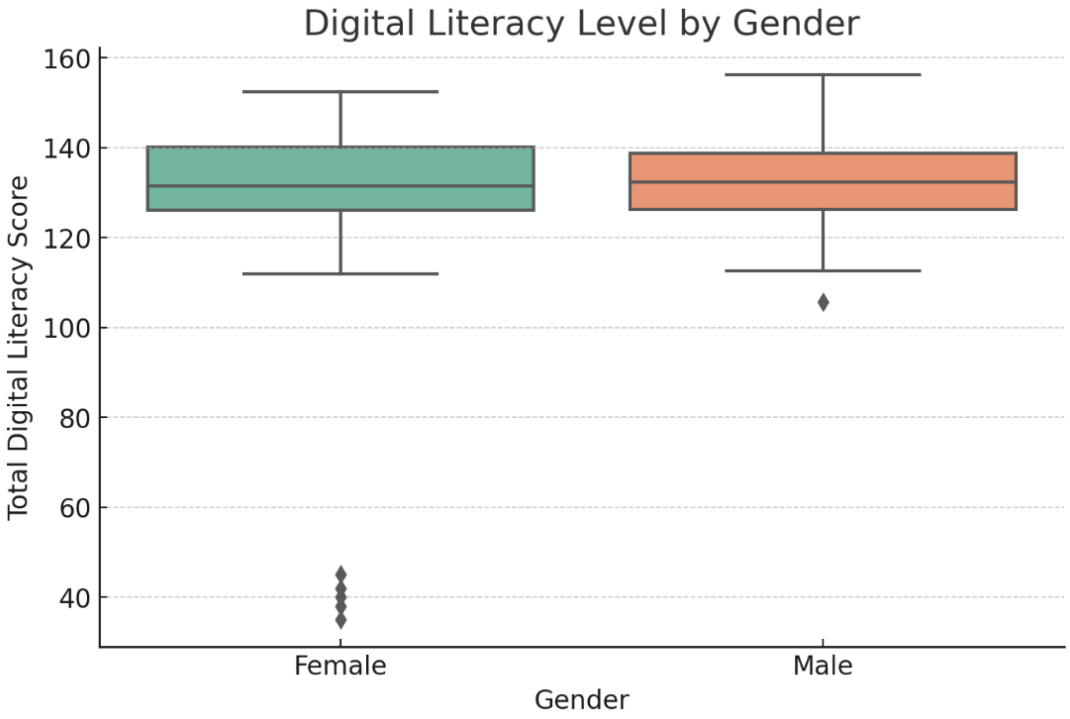

Figure 1.
Digital Literacy Level by Gender.

The results revealed no statistically significant differences in digital literacy levels based on gender (F = 0.0137, p = 0.9069). The mean digital literacy score was 131.18 points for female students and 131.33 points for male students, indicating a negligible and non-significant difference from both a statistical and practical standpoint (Table 2).

This finding suggests that, within the analyzed sample, gender does not constitute a differentiating factor in the development of digital competencies. This aligns with recent studies highlighting how widespread access to information and communication technologies has contributed to narrowing traditional gender-based digital gaps, particularly in formal educational contexts [24, 25].

Table 2.
Differences in Digital Literacy Level by Gender.

Gender	Mean (SD)	F	p-value
Female	131.18 (14.76)	0.0137	0.9069
Male	131.33 (15.17)		

6. Discussion

The findings of this study provide relevant evidence regarding the levels of digital literacy among upper secondary education students, as well as the individual variables that are, or are not, associated with its development. First, a generally high level of digital literacy was identified, which is consistent with recent research documenting the growing acquisition of digital competencies among adolescents and young adults because of their early and frequent exposure to information and communication technologies [22, 26].

The correlational analysis revealed a positive and statistically significant association between overall academic performance and digital literacy levels. This finding aligns with previous studies suggesting that digital competencies can positively influence academic achievement by facilitating access to learning resources, supporting autonomous study organization, and enhancing the efficiency of information search and processing [23, 27].

Conversely, the absence of a significant correlation between age and digital literacy appears congruent with the age homogeneity of the sample, which consisted predominantly of adolescent students aged 17 to 18. While broader studies have identified age as a potentially relevant factor in more diverse populations, research indicates that among adolescents and young adults, age tends to exert a limited effect on digital competence, particularly when technology access and use are widespread [24, 28].

The results concerning digital literacy levels by gender support current trends in the literature, pointing to the progressive narrowing of the gender digital divide in school and urban settings [25, 29]. Whereas gender once represented a significant determinant of access to and appropriation of technology, recent advances in educational policies, digital infrastructure coverage, and the pervasive presence of virtual environments in daily life have contributed to a more equitable landscape.

7. Conclusions and Implications

The results of this study suggest that upper secondary education students participating in the research exhibit high levels of digital literacy, regardless of gender or age. These findings support the hypothesis that daily exposure to digital technologies, along with their progressive integration into both formal and informal educational processes, has significantly contributed to the development of digital competencies within this cohort.

Ultimately, the findings underscore the importance of strengthening technology integration programs in upper secondary education not only as a means of enhancing academic performance but also as a strategic tool for fostering the transversal skills required in the twenty-first century. They further highlight the need to continue monitoring the factors associated with the development of digital skills, incorporating in future research variables such as device accessibility, teacher digital literacy, and intrinsic motivation for educational technology use.

As a recommendation arising from this study, it is proposed that systematic digital competence development programs be incorporated into upper secondary education curricula. These should include key components such as digital critical thinking, ethical information use, and academic platform management. Additionally, it is recommended that institutional indicators be established to assess and monitor the development of these competencies both diagnostically and formatively across all educational levels.

Practical implications of the study include the urgent need for policymakers and educational institutions to ensure basic conditions for digital equity, particularly in vulnerable contexts, by providing connectivity, access to digital devices, and inclusive virtual learning environments. Continuous professional development for educators in digital pedagogy is essential, alongside the creation of high-quality educational content that aligns with current digital demands. These actions will contribute to the formation of a pedagogical culture rooted in technological fluency and inclusivity.

Finally, the importance of promoting applied educational research on digital literacy is emphasized to generate context-sensitive evidence that informs effective and sustainable public policies. In sum, digital literacy should not be regarded as a peripheral set of skills, but rather as a fundamental condition for ensuring inclusion, equity, and quality in education both now and in the future. The institutionalization of digital literacy strategies will not only enhance learning outcomes but also empower new generations to navigate and thrive in an increasingly interconnected, digital world.

References

[1] R. Vuorikari, S. Kluzer, and Y. Punie, *DigComp 2.2: The digital competence framework for citizens – With new examples of knowledge, skills and attitudes*. Luxembourg: Publications Office of the European Union, 2022.

[2] G. B. Gudmundsdottir and O. E. Hatlevik, "Education and digital competence," *European Educational Research Journal*, vol. 19, no. 1, pp. 1–15, 2020.

[3] C. Redecker and Y. Punie, "Digital competence frameworks in Europe," *International Journal of Digital Literacy and Digital Competence*, vol. 11, no. 1, pp. 1–15, 2020.

[4] M. H. Nguyen, M. G. Simkin, and J. S. Fairweather, "Digital literacy dimensions: An integrative framework for education," *Computers in Human Behavior Reports*, vol. 9, p. 100224, 2023.

[5] F. Siddiq and R. Scherer, "Developing digital competence among teachers and students," *Education and Information Technologies*, vol. 27, no. 5, pp. 6503–6522, 2022.

[6] O. McGarr and A. McDonagh, "Digital competence and the curriculum," *Educational Review*, vol. 73, no. 1, pp. 68–84, 2021.

[7] S. Carretero, R. Vuorikari, and Y. Punie, *DigComp 2.2: The digital competence framework for citizens*. Luxembourg: Publications Office of the European Union, 2021.

[8] A. Calvani, A. Fini, and M. Ranieri, "Digital competence assessment: A review of literature and proposals," *British Journal of Educational Technology*, vol. 52, no. 4, pp. 1427–1442, 2021.

[9] P. Reddy, B. Sharma, and K. Chaudhary, "Digital competence in higher education: A systematic review and research trends," *Computers & Education*, vol. 185, p. 104521, 2022.
[10] X. Chen and K. Zhang, "Gender differences in digital competence among high school students: A latent profile approach," *Computers & Education*, vol. 174, p. 104309, 2021.
[11] A. García-Holgado, F. J. García-Peñalvo, and A. Vázquez-Ingelmo, "Accessibility and digital literacy in blended learning models," *Education Sciences*, vol. 10, no. 6, p. 161, 2020.
[12] O. E. Hatlevik and K. A. Christophersen, "Digital competence at the beginning of upper secondary school: Identifying factors explaining digital inclusion," *Computers & Education*, vol. 113, p. 103956, 2021.
[13] OECD, *21st-Century readers: Developing literacy skills in a digital world*. Paris: OECD Publishing, 2021.
[14] M. Ragnedda and B. Mutsvairo, "Digital inequalities in developing countries," *Information, Communication & Society*, vol. 25, no. 2, pp. 190–206, 2022.
[15] R. Flores, J. Medina, and M. Chávez, "Infrastructure and digital education policy in Mexico," *Journal of Educational Technology Policy and Administration*, vol. 6, no. 3, pp. 89–104, 2022.
[16] M. Ruiz and L. Sánchez, "Digital inclusion strategies in Mexican education," *International Journal of Educational Technology in Higher Education*, vol. 18, no. 1, p. Article 3, 2021.
[17] T. Correa and D. Contreras, "Digital divide and education in Latin America," *Information, Communication & Society*, vol. 25, no. 12, pp. 1765–1782, 2022.
[18] N. Villaseñor and J. Arreola, "Digital skills and education equity in Mexico," *Revista Electrónica de Investigación Educativa*, vol. 23, p. e34, 2021.
[19] R. Hernández-Sampieri, C. Fernández-Collado, and P. Baptista-Lucio, *Research methodology*, 7th ed. Mexico City: McGraw-Hill, 2022.
[20] L. Cohen, L. Manion, and K. Morrison, *Research methods in education*, 8th ed. London: Routledge, 2018.
[21] World Medical Association (WMA), "Declaration of Helsinki: Ethical principles for medical research involving human subjects," 2013. https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/
[22] Z. Zainuddin, C. J. Perera, and S. H. Halili, "Flipped classroom research trends during 2010–2019: A descriptive and bibliometric analysis," *The International Review of Research in Open and Distributed Learning*, vol. 21, no. 1, pp. 43–72, 2020.
[23] M. Bond, "Facilitating student engagement through the flipped learning approach in K-12: A systematic review," *Computers & Education*, vol. 173, p. 104271, 2021.
[24] M. Karaca, M. Şahin, and D. Yıldız, "Exploring faculty and student experiences with flipped learning in medical education," *Medical Science Educator*, vol. 32, pp. 783–790, 2022.
[25] A. Santos, A. Gutiérrez, and R. Molina, "Flipped classroom and development of clinical skills in medical students," *Educación Médica*, vol. 22, no. 1, pp. 44–51, 2021.
[26] C. K. Lo and K. F. Hew, "A critical review of flipped classroom challenges in K-12 education," *Educational Research Review*, vol. 30, p. 100298, 2020.
[27] B. Tang, A. Corell, and F. García, "Evaluation of the flipped classroom in medical sciences: A systematic review," *Educación Médica*, vol. 22, no. 6, pp. 101–109, 2021.
[28] F. J. García-Peñalvo, A. Corell, V. Abella-García, and M. Grande, "Online assessment in higher education in the time of COVID-19," *Education in the Knowledge Society*, vol. 21, p. 26, 2020. https://doi.org/10.14201/eks.23086
[29] C. Cameron and J. Rennie, "Flipped learning in medical education: A critical narrative review," *Medical Education*, vol. 54, no. 6, pp. 558–567, 2020.