The importance of assessing digital skills in secondary schools

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***Abstract*—Digital competence is now an essential prerequisite for lifelong learning, social participation and active citizenship. This paper presents a national assessment model developed to evaluate the digital skills of second-year secondary school students. Based on the European Framework for Citizens' Digital Competences, the model focuses on four main areas: information and data literacy; online communication and collaboration; digital content creation; and safety and responsible use of digital environments.**

The development of the assessment tool involved the creation of an item bank calibrated using established psychometric methodologies, as well as adopting a vertical scale that allows comparisons to be made over time between school cohorts. Proficiency levels were established through structured standard-setting procedures that distinguish three thresholds: basic, intermediate and advanced.

The results show that most students reach at least an intermediate level of proficiency across all domains. They demonstrate particular strength in information management and face greater challenges in digital safety, particularly regarding data protection and the management of online interactions. Furthermore, regional and socioeconomic disparities emerge, reflecting inequalities in learning opportunities and technological access.

Correlational analyses reveal positive and significant associations between digital skills and performance in standardized Italian and Mathematics tests. These correlations, ranging from approximately 0.35 to 0.58, suggest that higher levels of digital proficiency are associated with improved reading comprehension and more effective handling of numerical information. Level distribution confirms this trend: students with advanced digital skills are more frequently found in the advanced levels of subject tests, while those with basic digital skills tend to be concentrated in the lowest performance brackets.

Overall, the results suggest that digital competence is a cross-cutting dimension that supports fundamental learning. These findings provide useful insights for educational planning aimed at reducing regional and social disparities.

***Keywords* — digital competence; assessment; secondary education; information literacy; digital safety; learning outcomes; equity in education**

I. INTRODUCTION

Digital competence is globally recognized as a fundamental pillar for lifelong learning, active citizenship, and social inclusion. In an educational landscape shaped by rapid technological acceleration and the pervasive integration of artificial intelligence, the European Digital Competence Framework for Citizens (DigComp) provides a standardized reference for the skills necessary to navigate information, communicate safely, and create digital content. Modern educational systems are increasingly required to foster complex cognitive abilities, moving beyond basic computer literacy toward critical data evaluation, digital safety, and ethical technological use. In this context, digital competence has evolved into a transversal meta-competence essential for full participation in a digitized democracy and economy.

Despite the emphasis on digital education within national curricula and European strategic frameworks, such as the Digital Education Action Plan (2021-2027), a significant empirical gap remains in systematic, large-scale national assessments capable of objectively measuring these skills in secondary education. This lack of robust measurement tools creates a critical blind spot for educational policy-makers. A major limitation in the existing literature is that current evaluations are often localized, experimental, or heavily dependent on student self-reported data. However, psychometric research consistently demonstrates that perceived digital competence frequently overestimates actual proficiency levels, particularly among digital natives who may possess high fluency in social or entertainment tools but lack the sophisticated cognitive frameworks required for critical problem-solving and safe navigation. Furthermore, assessments routinely overlook how socio-economic and geographical backgrounds impact the evolution from a divide of access (first-level) to a divide of high-level usage and critical understanding (second and third-level divides). Finally, the empirical relationship between psychometrically calibrated digital skills and traditional academic performance in core achievements, such as Reading comprehension and Mathematics, remains under-explored, leaving it unclear whether digital proficiency acts as a cross-cutting learning multiplier.

This study addresses these research and policy gaps by presenting a comprehensive national assessment model tailored for second-year upper secondary school students (Grade 10) in Italy. Utilizing a psychometrically calibrated item bank developed through Item Response Theory (IRT) and Rasch modeling, this approach maps specific task difficulties directly to student abilities. Furthermore, the study implements a vertical scaling design to support longitudinal comparisons across school cohorts. By establishing clear, expert-validated proficiency thresholds (basic, intermediate, and advanced) across four key domains of the DigComp framework, information literacy, communication, content creation, and safety, this research

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provides a nuanced map of actual student capabilities. Lastly, by cross-analyzing these outcomes with standardized national data (INVALSI) for Italian and Mathematics, this paper explores the systemic interplay between digitalization and core learning quality, offering robust empirical evidence to guide targeted policies for educational equity and social mobility.

II. Literature Review

The theoretical and empirical foundation of digital competence assessment has undergone a profound transformation over the last two decades. What was once perceived as a niche technical proficiency has evolved into a complex, multidimensional construct essential for navigating modern society. This section reviews the key developments in the field, organized by core themes, to provide comprehensive context for the present study.

The Evolution of Digital Competence Frameworks

The conceptualization of digital skills began in the late 1990s with a narrow focus on computer literacy. At that time, research and educational policies were primarily concerned with the functional ability to operate hardware and basic software applications. However, as the internet became ubiquitous, the paradigm shifted toward information literacy, emphasizing the ability to locate and retrieve online data.

A definitive milestone in this evolution was the 2013 publication of the first European Digital Competence Framework (DigComp 1.0) by the Joint Research Centre. This framework was revolutionary because it moved beyond technical skills, defining digital competence as a holistic set of knowledge, skills, and attitudes across five key areas: information, communication, content creation, safety, and problem-solving. This established a common language for European member states. Subsequent updates, notably DigComp 2.1 and 2.2 (2022), integrated increasingly sophisticated dimensions. These included Artificial Intelligence (AI) literacy, remote collaboration protocols, and a focus on the environmental impact of digital technologies.

The evolutionary path has recently reached a new peak with the release of the DigComp 3.0 framework. This latest version further refines the descriptors to account for the rapid acceleration of generative AI and the increasing complexity of digital citizenship in post-pandemic societies. The transition from DigComp 1.0 to 3.0 illustrates a clear trend: digital competence is no longer seen as a separate technical skill but as a transversal prerequisite for all learning domains. It is now fundamentally linked to critical thinking and ethical agency, requiring constant normative and assessment updates to remain relevant in an ever-changing technological landscape.

Trends in Large-Scale Assessment and Psychometrics

In parallel with these theoretical frameworks, the methodologies used to measure digital skills have undergone a radical transformation. Early research in the mid-2000s relied heavily on self-reported surveys (OECD, 2009). However, a significant body of literature soon identified a pervasive overestimation bias. Studies demonstrated that students' perceived skills, often influenced by their frequency of social media use, did not match their actual performance when faced with complex cognitive tasks.

To address these validity issues, international surveys like the IEA International Computer and Information Literacy Study (ICILS), launched in 2013, introduced performance-based tasks. This marked a shift from asking students what they could do to observing what they did in simulated digital environments. From a statistical perspective, the adoption of Item Response Theory (IRT) and Rasch modeling has been instrumental. These methodologies allow for the creation of calibrated item banks, where the difficulty of a task and the ability of a student are mapped onto the same mathematical scale.

Recent national assessments have built upon these advancements to develop vertical scales. Vertical scaling is particularly significant as it enables longitudinal comparisons between different school cohorts over time, allowing researchers to track whether the school system is effectively improving digital proficiency across generations. This psychometric rigor ensures that the assessment is not merely a snapshot but a robust instrument for monitoring educational progress and system-wide effectiveness.

The Digital Divide and Socio-Economic Impact

A consistent and sobering theme in literature is the persistence and evolution of the digital divide. Research in the early 2000s focused almost exclusively on the first-level divide, which concerned physical access to devices and connectivity. However, as hardware became more affordable, scholars like Van Dijk (2012) and Gui et al. (2015) identified a second-level divide related to the quality of usage and the specific skills possessed by users.

More recently, the literature has highlighted a third-level divide: the difference in the actual returns or tangible outcomes individuals gain from their digital use. Even when students have equal access to technology, those from higher socio-economic backgrounds tend to use it for information seeking and content creation, while those from disadvantaged backgrounds use it primarily for entertainment. Longitudinal data from the OECD (2015) and national studies conducted during the COVID-19 pandemic (Ricci, 2021) have demonstrated that students from lower socio-economic backgrounds often lack the safety and critical evaluation skills necessary to turn digital access into academic achievement.

This evidence supports the hypothesis that digital skills are strongly correlated with traditional academic subjects like Mathematics and Reading comprehension. Rather than being a separate domain, digital competence acts as a multiplier for educational inequality. Students with strong linguistic and logical foundations find it easier to navigate complex digital information, whereas those already struggling with traditional literacy find the digital environment adds a further layer of difficulty. This creates a cumulative disadvantage that school systems must address through targeted, evidence-based interventions.

III. Materials and Methods

The methodology of this study is designed to provide a robust, scientifically grounded, and scalable assessment of digital competencies within the Italian secondary education system. Given the complexity of measuring a transversal construct like digital literacy, the research follows a rigorous quantitative approach based on large-scale assessment (LSA) standards, ensuring that the results are both representative of the national population and psychometrically sound. The assessment tool is strictly aligned with the European Digital Competence Framework for Citizens (DigComp 2.2), which serves as the theoretical

and operational backbone of the study. This framework was selected due to its international recognition and its ability to decompose digital competence into observable behaviors. While the full DigComp framework includes five areas, this measurement model focuses on four specific competence domains that are most relevant to the academic and civic development of students in Grade 10:

- Information and Data Literacy: the ability to articulate information needs, locate and retrieve digital data, and judge the relevance and reliability of sources.
- Online Communication and Collaboration: interacting through digital technologies, sharing data while respecting netiquette, and managing one's digital identity.
- Digital Content Creation: the ability to create and edit digital content in different formats and to understand the basics of intellectual property and licensing.
- Safety and Responsible Use: protecting devices, personal data, and privacy in digital environments, as well as understanding the physical and psychological well-being risks associated with technology use.

The study was conducted on a nationally representative sample of students in their second year of upper secondary school (Grade 10). To ensure the highest degree of representativeness, a stratified probabilistic sampling design was employed. The stratification variables included geographical macro-area (North-West, North-East, Centre, South, and South and Islands), school type (Licei, Technical Institutes, and Vocational Institutes), and the socio-economic status of the school's catchment area. This design allowed for the generalization of findings to the entire national population while maintaining a low margin of error.

The data collection was integrated into the national testing windows managed by the National Institute for the Evaluation of the Education System (INVALSI). This integration ensured high participation rates and the standardization of administration conditions, as tests were delivered via a secure Computer-Based Testing (CBT) platform. The development of the assessment instrument followed a rigorous four-stage psychometric workflow, moving from item generation to the definition of proficiency thresholds.

- Item Bank Construction: a dedicated bank of items was developed by a multidisciplinary team of subject matter experts and psychometricians. Each item was designed to map not only to a specific DigComp domain but also to a specific cognitive level, ranging from simple recall and functional use to higher-order critical evaluation and problem-solving. The assessment utilized a consistent item format consisting of single-choice multiple-choice questions (MCQs), where only one correct option was provided among the distractors, ensuring a standardized measurement of students' knowledge across all digital domains.

To ensure scientific transparency and support the interpretability of the study, Table 1 presents three illustrative sample items from the INVALSI digital competence assessment bank, mapping different DigComp areas, proficiency levels, and cognitive targets.

Table 1. Illustrative Sample Items from the Digital Competence Bank

DigComp Area & Competence	Level & Target	Sample Item	Objective
Area 4: Safety 4.1 Protecting devices	Basic Skill	A friend has asked you for advice on how to create a password. Which of the following is the most secure example to show them?	Identify secure authentication measures to prevent unauthorized data access.
Area 2: Communication 2.2 Sharing through technologies	Basic Skill	You received a photo in a messaging app showing a "1" in a dotted circle next to it. What does this mean?	Understand interface features for temporary media sharing.
Area 1: Information literacy 1.1 Browsing and filtering data	Advanced Knowledge	You notice that search engine results are influenced by your previous searches. Which of the following actions is the most effective way to obtain less personalized results?	Recognize algorithmic filtering and apply privacy-preserving strategies.

- Calibration: following a pilot phase to eliminate ambiguous or poorly performing items, the final item bank was calibrated using Item Response Theory (IRT). Specifically, the Rasch model was applied. This model allows for the placement of both person ability and item difficulty on the same logit scale. By ensuring that the data met the requirements of the Rasch model (unidimensionality and local independence), it was guaranteed that the test measured a single underlying latent trait for each domain. This provides a more accurate measure of proficiency than simple raw scores, as it accounts for the specific difficulty of the tasks successfully completed by each student.
- Vertical Scaling: a vertical scaling procedure was implemented to establish a common metric across different test forms and, potentially, different school levels. The assessment framework has been designed to support future longitudinal comparisons through the planned use of 'anchor items' (items common to different versions of the test) starting from the 2026 cycle. This design is critical for long-term educational monitoring, as it will enable the tracking of proficiency growth across different school cohorts over time. Consequently, the 2025 results serve as the calibrated baseline, ensuring that current data can be scientifically compared with future assessment cycles as the vertical scale is fully implemented.
- Standard Setting: to make the quantitative results interpretable for educators and policy-makers, a structured standard-setting procedure was conducted. Using the Bookmark Method, a panel of experts analyzed the calibrated item bank to identify the points on the scale that represent meaningful shifts in competence. Three distinct proficiency thresholds were established:

* Basic: the student can perform simple digital tasks with explicit guidance, recognizing common tools and following basic safety instructions.
* Intermediate: the student demonstrates independent management of digital tasks, can solve routine problems, and understands how to search for and verify information.
* Advanced: the student demonstrates critical, creative, and autonomous use of digital tools. They can navigate complex, ambiguous digital scenarios and apply advanced safety and content-creation protocols.

Statistical Analysis

The relationship between digital competence and traditional academic performance was analyzed using a

multi-step statistical approach. First, Pearson correlation coefficients were calculated to explore the strength of the association between digital scores and INVALSI scores in Reading comprehension and Mathematics. Second, multivariate regression models were employed to determine the extent to which digital competence predicts academic success while controlling background variables such as gender, geographical area, and the ESCS index (Economic, Social, and Cultural Status). This allowed us to isolate the specific impact of digital skills on learning outcomes.

Ethical Approval and Informed Consent

The study was conducted in strict accordance with the ethical standards of the National Institute for the Evaluation of the Education System (INVALSI). The procedures were reviewed and approved by the Internal Data Protection Office in compliance with the European General Data Protection Regulation (GDPR). To protect participant privacy, all data was processed in a strictly anonymized and aggregated form. Students and their families were informed of the study's purposes, and participation was managed through the standard institutional protocols for national assessments, ensuring that no individual student could be identified from the research outputs.

IV. Results and Discussion

The national assessment of digital competencies among second-year secondary school students provides a detailed overview of the current digital proficiency in the Italian education system. The integration of psychometric calibration and standardized testing allows for a robust interpretation of the relationship between digital skills and traditional academic outcomes.

The distribution of students across proficiency levels indicates that the majority of the population reaches a sufficient level of digital competence, as shown in Table 2.

Table 2. Students by proficiency level in Digital Competence areas (Grade10). Percentage distribution. Source: INVALSI 2025

Proficiency Level	Information and Data Literacy	Communication and Collaboration	Digital Content Creation	Safety
Basic	10.9%	9.3%	16.0%	15.0%
Intermediate	38.1%	33.8%	40.8%	42.8%
Advanced	51.1%	56.9%	43.2%	42.2%
TOTAL	100.0%	100.0%	100.0%	100.0%
At least Intermediate	89.1%	90.7%	84.0%	85.0%

The results confirm that digital competence is not an isolated skill set but is deeply intertwined with general cognitive abilities and academic achievement. The observed correlation coefficients (ranging from 0.35 to 0.58) suggest that students with high linguistic and logical-mathematical skills are better equipped to navigate digital environments effectively.

Regional and Socio-Economic Disparities

A critical finding of this study is the persistence of geographical disparities. Students in Northern regions generally achieve higher scores compared to their peers in Southern regions (Fig. 1). These results align with previous research on the second-level digital divide, which emphasize that access to hardware is insufficient without the corresponding pedagogical support.

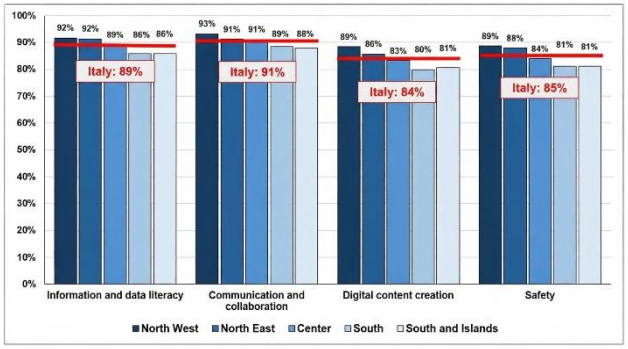


Fig. 1. Students reaching at least the Intermediate level in Digital Competence domains (Grade 10), by geographical macro-area. Percentage values. Source: INVALSI 2025

Generally, the North-West and North-East regions show a higher share of students reaching at least the intermediate level (with the exception of the North-East in the Communication and Collaboration domain); conversely, the lowest percentages are observed in the South and the South and Islands. In the Centre, the percentage is very close to the overall national average for Italy.

The Safety Domain Challenge:

Among the four areas analyzed, Safety and responsible use (Safety) showed the lowest average scores. This suggests that while students are proficient in Online communication, they often lack the necessary critical awareness to identify digital risks or protect their personal data. On average, girls achieve lower scores than boys, particularly in the Safety area.

Our findings support the hypothesis that socio-economic background continues to play a significant role in determining digital proficiency. Following the trends identified by Ricci [20], the data suggest that the school system must transition from teaching technical usage to fostering critical evaluation. The significance of addressing these gaps lies in the potential to use digital education as a tool for social mobility, reducing the impact of the original socio-economic status on final learning outcomes.

Considering the family background index (Fig. 2), the share of male and female students achieving at least an intermediate level is significantly lower in the low-ESCS group across all measured areas, while it is higher in the high-ESCS group. In contrast, the differences between the two intermediate groups are minimal.

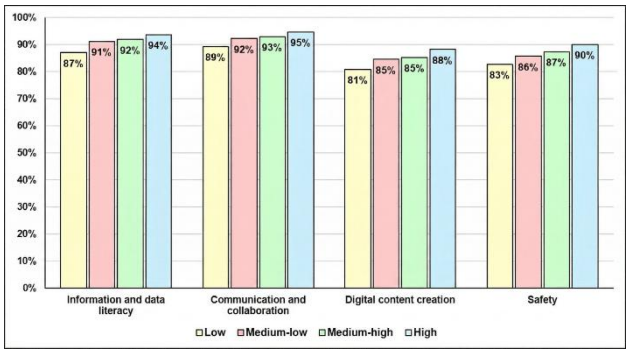


Fig. 2. Students reaching at least the Intermediate level in Digital Competence domains (Grade 10), by ESCS index quartile. Percentage values. Source: INVALSI 2025

Table 3 presents the share of students at each proficiency level across all defined areas, with a distinction between ESCS index quartiles[1].

Table 3. Students by proficiency level in Digital Competence domains (Grade 10), by ESCS index quartile. Percentage distribution. Source: INVALSI 2025

	Low	Medium low	Medium high	High
Information and Data Literacy				
Basic	17,2%	14,3%	12,7%	9,9%
Intermediate	44,3%	42,7%	41,8%	39,3%
Advanced	38,4%	42,9%	45,6%	50,8%
Communication and Collaboration				
Basic	19,1%	15,4%	14,8%	11,8%
Intermediate	42,7%	41,5%	40,5%	37,2%
Advanced	38,2%	43,1%	44,7%	51,0%
Digital Content Creation				
Basic	10,7%	7,7%	7,1%	5,4%
Intermediate	38,2%	35,3%	35,1%	30,4%
Advanced	51,1%	57,0%	57,8%	64,2%
Safety				
Basic	12,9%	8,8%	8,2%	6,3%
Intermediate	42,8%	40,8%	40,3%	37,0%
Advanced	44,2%	50,4%	51,5%	56,7%

V. Conclusion

In conclusion, the assessment model developed and implemented in this study provides a reliable, scalable, and scientifically grounded framework for monitoring digital skills at a national level. By strictly aligning the evaluation instruments with the European Digital Competence Framework for Citizens (DigComp 2.2) and the nascent DigComp 3.0, and by employing advanced psychometric techniques, such as Rasch model calibration and the implementation of a vertical scale, this research offers a robust tool for measuring the digital proficiency of secondary school students. The findings demonstrate that while most of the student population in Grade 10 reaches at least an intermediate level of proficiency, a significant and concerning portion of the population still lacks the advanced cognitive and technical competencies necessary for full, critical, and autonomous digital citizenship in the 21st century.

One of the most compelling findings of this research is the evidence of a significant and positive correlation between digital competencies and traditional academic achievements, specifically in Mathematics and Reading comprehension. This link reinforces the argument that digital literacy should no longer be treated as an isolated or purely technical subject. Instead, it must be recognized as a transversal skill that both enhances and is enhanced by core academic learning and logical-linguistic abilities. Consequently, there is an urgent need for integrated, cross-curricular digital policies that embed technology and data literacy within the broader educational experience rather than relegating them to specialized laboratory hours.

Furthermore, the persistent regional disparities and the clear impact of the socio-economic background (ESCS index) highlighted in this study suggest that the digital divide has evolved from a matter of physical access to a divide in high-level usage and critical understanding. The fact that students from lower socio-economic quartiles consistently underperform in areas like Safety and Digital Content Creation indicates that targeted institutional interventions are required. Without specific support, digital education risks becoming a factor of exclusion rather than a bridge to social equity and mobility.

Looking ahead, educational planning and curriculum design must focus specifically on these weaker domains. Safety and Digital Content Creation represent the most significant gaps in current student performance and are critical for ensuring that future workers can navigate the complexities of the modern labor market and the challenges of generative artificial intelligence. Subsequent research should continue to monitor these trends longitudinally. Expanding this assessment model to other school grades will be essential to evaluate the long-term impact of digital policies on student outcomes and to ensure the overall digital readiness of the nation's future workforce.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Paola Giangiacomo and Patrizia Falzetti conducted the research and analyzed the data; Paola Giangiacomo, Patrizia Falzetti and Barbara Baldazzi wrote the paper and approved the final version.

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[1] The term 'quartiles' refers to the percentiles that divide an ordered distribution of measures into four equal parts: the first quartile, or lower quartile, corresponds to the score below which 25% of the scores in an ascending distribution are located; the second quartile, or median, is the score below which 50% of the measures fall, and so forth.

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