Italian Journal of Educational Technology

2024

Consiglio Nazionale delle Ricerche

Istituto per le Tecnologie Didattiche

FUP FIRENZE UNIVERSITY PRESS

Italian Journal of Educational Technology

Four-Monthly Journal

ISSN (print) 2532-4632
ISSN (online) 2532-7720

Editorial correspondence
should be sent to:

Italian Journal of Educational Technology
Consiglio Nazionale delle Ricerche
Istituto per le Tecnologie Didattiche
Via de Marini 6
16149 Genova, Italy
phone: +39 010 6475 303
e-mail: ijet@itd.cnr.it
website: https://ijet.itd.cnr.it

A publication of the National Research Council of Italy. Chieti Court Registration No. 8, 25/11/1992

Direttore Responsabile
Donatella Persico

published by
Firenze University Press
Università degli Studi di Firenze
via Cittadella, 7, 50144 Firenze Italy
website: www.fupress.com
e-mail: info@fup.unifi.it
Printed in Italy

Italian Journal of Educational Technology

Vol. 32, no. 2, 2024

Firenze University Press

Italian Journal of Educational Technology

https://ijet.itd.cnr.it

Published by Firenze University Press

Firenze University Press
Università degli Studi di Firenze
via Cittadella, 7, 50144 Firenze, Italy
www.fupress.com

Italian Journal of Educational Technology

Volume 32 / Issue 2 / 2024

General Issue

Editor
Francesca Pozzi

Italian Journal of Educational Technology, 32(2), 5, 2024
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1412
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

itd ISTITUTO TECNOLOGIE DIDATTICHE

Editorial

Editoriale

Francesca Pozzi

National Research Council of Italy, Institute for Educational Technology, Genoa, Italy, francesca.pozzi@cnr.it

HOW TO CITE Pozzi, F. (2024). Editorial. *Italian Journal of Educational Technology*, *32*(2), 5. https://doi.org/10.17471/2499-4324/1412

Received: November 18, 2024; *Accepted:* November 18, 2024; *First Published:* November 19, 2024

In this issue we publish four papers, two of which tackle the issue of educators' digital competences. This is an urgent topic in the Educational Technology research field, as – in response to the fast and continuous changes of today's society – educators are increasingly expected to possess a diverse range of skills, knowledge and competences.

In both the papers the authors propose their contributions regarding tools to measure and evaluate the educators' digital competences. In particular, the first paper by Gabbi and Ancillotti illustrates the validation phase of the D-Paideia Qualification Framework, which serves as an extension and update of the well-known DigCompEdu framework. Through consultation with a panel of experts, the authors identify points of connection and divergence between the new competences introduced and those already present in the original framework.

In the second paper Fernández-Scagliusi and Llorente-Cejudo describe the preliminary stages of the validation process for a questionnaire based on the "Cuestionario de Competencia Digital para Futuros Maestros" (CCDFM) by Cabero-Almenara et al. (2020), which the authors translated and adapted for the Italian context. The process described in this paper encompasses cultural adaptation, expert review, and a pilot test.

The other two papers address different topics: in the paper by Petrucco, the author investigates the mediating effect of an annotation tool on reading strategies for university students. The results of the study confirm that most students prefer academic texts on paper and that the use of a social annotation tool with digital academic texts can positively change perceptions of digital reading and comprehension.

The last paper, by Papa and Desimoni, examines the access and usage of technologies outside the school environment among upper secondary students. In particular, the study investigates the availability of digital devices such as desktops, laptops, and smartphones, and explores usage patterns. The findings provide food for thought for those who work in the technology enhanced learning research field.

Italian Journal of Educational Technology, 32(2), 7-24, 2024
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1338
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

ISTITUTO TECNOLOGIE DIDATTICHE

Towards an extended framework for digital competence of educators. The validation process through experts' review

Verso un quadro ampliato delle competenze digitali degli educatori. Il processo di validazione attraverso la revisione degli esperti

Elena Gabbi*, Ilaria Ancillotti

University of Florence, Italy, elena.gabbi@unifi.it, ilaria.ancillotti@unifi.it*
**Corresponding author*

HOW TO CITE Gabbi, E., & Ancillotti, I. (2024). Towards an extended framework for digital competence of educators. The validation process through experts' review. *Italian Journal of Educational Technology*, *32*(2), 7-24. https://doi.org/10.17471/2499-4324/1338

Received: April 3, 2024; *Accepted:* June 28, 2024; *First Published:* July 3, 2024

ABSTRACT In response to recent changes in the educational landscape, educators are increasingly expected to possess a diverse range of skills, knowledge and competences related to teaching with ICT. However, in the complex post-COVID scenario, it seems that the essential role of social-relational and emotional skills in effectively transmitting educational content is often overlooked in the institutional and training interventions. In this article, we illustrate the validation phase of the D-Paideia Qualification Framework, which serves as an extension and update of the DigCompEdu framework about these topics. Through consultation with a panel of 30 international experts, we identified points of connection and divergence between the new competences introduced and those already present in the original framework, as well as assessing and improving the naming and descriptions of the new competences.

KEYWORDS Teaching with ICT; Social-Relational Skills; Teachers Digital Competence; DigCompEdu Framework; Educational Experts.

SOMMARIO In risposta ai recenti cambiamenti nel panorama educativo, si richiede sempre più che gli educatori posseggano una gamma diversificata di abilità, conoscenze e competenze relative all'insegnamento con le TIC. Tuttavia, nel complesso scenario post-COVID, sembra che il ruolo essenziale delle competenze socio-relazionali ed emotive nella trasmissione efficace dei contenuti educativi sia spesso trascurato negli interventi istituzionali e formativi. In questo articolo, illustriamo la fase di validazione del D-Paideia Qualification Framework, una potenziale estensione e aggiornamento del framework DigCompEdu su questi temi. Attraverso la consultazione di un panel di 30 esperti internazionali, abbiamo identificato i punti di connessione e di divergenza tra le nuove competenze e quelle già presenti nel framework originale, oltre a valutare e migliorare la denominazione e la descrizione delle nuove competenze.

PAROLE CHIAVE Insegnare con le TIC; Competenze Socio-Relazionali; Competenze Digitali degli Insegnanti; DigCompEdu; Esperti di Formazione.

1. Introduction

International school systems have undergone a transformation in how education is delivered following the COVID-19 pandemic and the experience of Emergency Remote Teaching (ERT). This period, characterised by an unparalleled integration of technology into teaching and learning processes, has stimulated digital innovation and prompted a re-evaluation of educational practices (Zhao & Watterston, 2021). Despite the challenging circumstances, remote learning has highlighted the difficulties and potentials of e-learning and underlined the need to consider new aspects in teachers' pedagogical-digital training (Carretero et al., 2021).

Four years after the ERT experience, discussions about education is no longer focused exclusively on traditional, in-person teaching methods. Today, educational institutions have the opportunity to exploit technology to enhance or extend classroom teaching, e.g. through online, hybrid or blended learning modes, encountering reduced technical barriers and mitigated resistance from teachers (Ranieri, 2022). Nevertheless, there is still significant space for enhancement and innovation within educational systems and among teaching staff. Numerous national and international programs have been implemented to accomplish this goal, such as the Digital Education Action Plan (2021-2027), outlined by the European Commission. The programme aims to promote high-quality, inclusive and accessible digital education across Europe through several actions, including the improvement of digital skills and competences for the digital transformation (European Commission, 2020).

In line with this vision, the Erasmus+ project D-Paideia "*Pedagogical Digital Competences as a key element for digital transformation*" seeks to address the evolving digital educational landscape. Based on the challenges identified during the COVID-19 pandemic, the project aims to enhance teachers' abilities and competences to effectively teach in a digital environment and to support the development of digital pedagogical strategies at the institutional level. After a rigorous literature review (Gabbi et al., 2023), the first project action was to develop a Qualifications Framework (QF), based on DigCompEdu (Redecker, 2017) – one of the most popular frameworks on educators' digital competences – focusing on dimensions that were crucial during the ERT experience (OECD, 2021), but are still scarcely explored in DigCompEdu: social and emotional learning, digital well-being and mental health.

The validation phase of the D-Paideia QF proposal, conducted by teachers and experts at international level, played a decisive role in further delineating the competence areas outlined in the literature. Two simultaneous consultation phases were initiated, each operating independently of the other. On one hand, European teachers actively participated in interactive workshop sessions to identify specific elements of digital competence in their daily teaching practice, without explicitly referring to the project framework by the D-Paideia consortium. On the other hand, international educational experts were asked to assess each competence embedded in the D-Paideia QF proposal in terms of clarity, coherence and relevance.

In this paper, we illustrate the validation stage carried out by the consortium under the guidance of the University of Florence, with the panel of experts to identify points of connection and distance between the new knowledge and competences introduced in the DigCompEdu framework and those already present in it. Moreover, the validation process also aimed to improve the naming and/or description of the new competences that have been integrated in the existing framework.

2. Theoretical background

2.1. Socio-relational and emotional skills in digital education: insights from ERT experience

In response to the important changes affecting the educational landscape, teachers are increasingly expected to possess a diverse range of skills, knowledge and competences. In this complexity, it appears that a crucial competence is being overlooked. Indeed, alongside disciplinary competence, socio-relational and emotional competences are essential for the effective transmission of educational content. This encompasses teachers' ability to understand and regulate their own emotions, demonstrate empathetic behaviour towards themselves and others and develop positive relationships throughout their teaching careers (Schonert-Reichl, 2017). Additionally, it involves the ability to recognize the needs and common challenges of specific age groups or transitory life events and to skilfully manage classroom dynamics and conflicts (Chiappetta Cajola & Ciraci, 2013; Jennings & Greenberg, 2009). While the socio-relational and emotional dimension is particularly crucial in the early years of schooling, from early childhood education to primary school, it tends to receive less attention as students' age progresses.

Nevertheless, one of the lessons learned during the COVID-19 pandemic is the importance of not neglecting the socio-relational and emotional dimension in education, particularly in distance learning contexts, because it plays a vital role in fostering deep learning and a successful learning experience (Fullan et al., 2017). A study from the European Commission's Joint Research Centre (JRC) reminds us that: "*teachers not only are expected to deal with digital technology but also with delicate social contexts and circumstances. Besides digital competence, they need to be well aware of the social, emotional and affective aspects of digital technology-based education*" (Carretero et al., 2021, p. 14). Indeed, despite the benefits of digital innovation, some situations in the educational experience require interaction and human presence: something that technology itself cannot replace. It is not the technology that impacts learning outcomes, but rather its utilisation in teaching practices and the quality of interactions it facilitates could lead to student empowerment (Llorente-Cejudo et al., 2023).

The ERT experience has sometimes caused stress in the teaching staff as interaction and non-verbal communication were further reduced when webcams and/or microphones were not used in learning sessions, making the online lesson essentially a "one man show" (Teng & Wu, 2021). Moreover, the absence of visible emotional cues in online classes presented a challenge for teachers in interpreting student responses: unlike in face-to-face lessons, where feedback is readily apparent, teachers often found themselves unaware of student reactions in online settings. Lastly, online teaching and digital learning environments have posed challenges to educators in improving student interaction and engagement.

Digital competence, as part of the key competences of citizens for lifelong learning, is nowadays considered essential in teaching work. However, teacher training should also prioritise the enhancement of socio-relational and emotional competences, essential to effectively manage the complexities of technology-enhanced learning environments with the aim of promoting digital inclusion (Burns & Kolho, 2022; Ranieri, 2022).

2.2. Rethinking DigCompEdu in the post COVID-19 Era

the tools developed by the European Commission to help educational organisations and educators promoting self-reflection and self-assessment on pedagogical-digital competences are prominent. Spe-

cifically, the DigCompEdu framework and its derivatives instruments are widely utilised on an international scale. For example, the SELFIE (Self-reflection on Effective Learning by Fostering Innovation through Educational Technology) for Teachers is oriented towards personal reflection and planning for autonomous professional development (Kampylis et al., 2016), while the recently developed DigCompEdu Check-in is oriented towards formal assessment of digital competences and the provision of structured feedback for improvement (Llorente-Cejudo et al., 2023).

The DigCompEdu framework presents 22 competences, divided into six macro areas, in which technologies are integrated into teaching in a meaningful pedagogically way (Redecker, 2017). There are six professional profiles identified with the same letters as the frameworks for European language certification (from A1 – newcomer to C2 – pioneer): the levels are cumulative and are imagined as a path of expansion and refinement of competences, developed through experience, reflection and collaboration among teachers. In Table 1, there is a brief overview of the areas of competence of the DigCompEdu and related indicators.

The DigCompEdu framework, developed in 2017 by the European Commission with the collaboration of the JRC, is the result of a series of discussions and reflections with experts and practitioners based on an initial literature review and the synthesis of existing tools at the local, national, European and international levels (Caena & Redecker, 2019). The purpose of these consultations was to reach an agreement on the main areas and elements of educators' digital competence – to determine which elements were central and which were marginal – and to establish a progression hierarchy in digital competence within each area. Although the DigCompEdu encompasses various aspects of digital communication and social interaction (e.g., organisational communication, professional collaboration and collaborative learning), their role as mediators in teacher-student relationships appears underexplored. In the following, we outline some areas that could be revised in the light of the ERT experience and on the basis of existing e-skills models for teaching that also take into account social, relational and affective aspects.

The area of professional engagement recognises the central role of educators' interactions with their professional environment in the midst of social, cultural and political changes. Competencies such as personal-ethical and personal-professional need to become part of the mindsets of teachers (Chiu et al., 2024). However, other theoretical models focusing on teachers' pedagogical-digital competence have offered diverse perspectives on the professional aspect of teaching.

A sociocultural perspective on digital competence includes, although often underestimated, critical awareness of local ICT policies and resources: an essential dimension for navigating the changing socio-economic landscape and improving effectiveness. Educators should be aware of the broader policy landscape affecting education to enhance their agency (Butcher, 2018). By understanding and navigating the complex network of policies that influence the use of ICT in education, teachers can adapt to a rapidly changing policy environment and make informed decisions for the benefit of their students and the whole school community (Generalitat de Catalunya, 2018).

The dimension relating to the approach to using teaching technologies should also concern the area of the teacher's professional development. With a perspective of continuous learning, a teacher should necessarily possess intrinsic motivation and a proactive attitude towards embracing technology. When teachers are motivated, tend to demonstrate greater investment in their schools, enthusiasm in facing new challenges, willingness to make extra efforts and acceptance of the school's vision and values, also positively influencing students' motivation (Ryan & Deci, 2020). With a constructive outlook and a willingness to explore, experiment and critically evaluate innovations, educators are better prepared to effectively integrate digital technologies into their teaching practices (McDonagh et al., 2021).

Table 1. Overview of the areas of competence of the DigCompEdu.

AREAS		INDICATORS
Educators' Professional Competences	**1. Professional Engagement** Using technology effectively for communication, collaboration and reflecting on teaching practices.	1.1 *Organisational communication*: using technology to communicate with students, families and territory; 1.2 *Professional collaboration*: using technology to communicate, exchange experiences and materials with other colleagues; 1.3 *Reflective practice*: using technology to critically evaluate one's own or others' digital pedagogical practice; 1.4 *Digital continuous professional development*: using digital sources and resources for resources for CDP.
Educators' Pedagogic Competences	**2. Digital Resources** Selecting, creating and managing digital educational materials while adhering to data protection and copyright laws.	2.1 *Selecting*: selecting digital resources, taking into account objectives, targets, context; 2.2 *Creating and modifying*: modifying existing resources and adapting them to the context of use; 2.3 *Managing, protecting and sharing*: organising digital content and sharing it with students and families while respecting personal data, privacy and copyright.
	3. Teaching and Learning Integrating digital tools to facilitate collaborative and self-regulated learning, with guidance and support.	3.1 *Teaching*: planning and implementing digital resources in teaching, effectively managing intervention strategies and experimenting through the development of new methods; 3.2 *Guidance*: using technologies to foster interaction between students inside and outside the classroom, providing support and guidance; 3.3 *Collaborative learning*: using technology to facilitate the organisation of work among students in a collaborative way; 3.4 *Self-regulated learning*: using technology to make students reflect on their own learning.
	4. Assessment Using digital technology for assessment and timely feedback.	4.1 *Assessment strategies*: using technology for assessment; 4.2 *Analysing evidence*: generating, selecting, critically analysing and interpreting empirical evidence on student activity and performance; 4.3 *Feedback and planning*: using technology to provide students with responses that are planned over time and categorised by target audience.
	5. Empowering Learners Designing personalised learning experiences with equal access to digital tools.	5.1 *Accessibility and inclusion*: using technology to meet the learning needs, especially with SEND students; 5.2 *Differentiation and personalisation*: using technology to differentiate learning paths; 5.3 *Actively engaging learners*: using technology to develop transversal skills and make learners more active and creative.
Learners' Competences	**6. Facilitating Learners' Digital Competence** Supporting students in using digital technology safely and responsibly, promoting digital literacy and problem-solving skills.	6.1 *Information and media literacy*; 6.2 *Communication*; 6.3 *Content creation*; 6.4 *Responsible use*; 6.5 *Problem solving*.

Moreover, ensuring a harmonious balance and safe use of technology in the educational context is another indispensable aspect of professional teaching. Indeed, in an extension of the TPACK framework, Falloon (2020) focused on elements such as personal-ethical and personal-professional skills, emphasising the importance of ethical conduct, safety and effectiveness in navigating various digital

environments. Educators are often subject to the risks of digital overload and, therefore, they need strategies to efficiently manage their online activities and adopt safe practices when using ICT (EdDi-co, 2021; ETF, 2019). This is especially noticeable in a context where the boundary between online and offline is increasingly blurred, as these two realms have merged into what is now termed "onlife" across various domains of human existence (Floridi, 2017).

In addition to professional competence, educators' pedagogical competences must also take into account the transformations that have impacted the socio-economic context since the development of DigCompEdu in 2017, up to the present day.

The COVID-19 pandemic significantly emphasised crucial aspects of digital education, such as emotional, social and psychological dimensions. During Emergency Remote Teaching, maintaining relationships through collaboration and communication with students, families and colleagues became crucial for mental health (OECD, 2021). Furthermore, school and student life now takes place predominantly on social platforms, through the sharing of short videos or pictures: the dynamics of social networks have led to the emergence of new forms of anxiety, such as FOMO (Fear of Missing Out), the fear of being excluded from experiences in which others participate (Antonacci, 2023). There is a growing educational imperative to promote media education and foster socio-relational and emotional competences, in both teachers and students, to better cope with these new social situations. In particular, teachers should foster positive relationships in the digital learning environment, using communication as a tool to promote educational relationships with all actors involved, including families (OECD, 2021).

Moreover, online and blended learning has required greater consideration for students with special educational needs, particularly those with disabilities and from disadvantaged backgrounds (Carretero et al., 2021; European Commission, 2022). Technologies are essential for the inclusive process of all members of a class, but it is necessary to go beyond the mere introduction of digital tools or materials: the teacher must build, first and foremost, a supportive and inclusive learning community that strengthens the sense of belonging and well-being of all individuals (Llorente-Cejudo et al., 2023; School Education Gateway, 2020).

To enhance social-relational skills, educators should also have the ability to adapt teaching strategies across diverse learning modalities while prioritising affective and communicative elements essential for their success. It entails critical reflection on the efficacy and appropriateness of chosen digital tools, empowering educators to make agile adjustments in their guidance and monitoring actions, with a focus on computer-mediated communication (Ong & Quek, 2023). Addressing pedagogical, relational and socio-emotional dimensions enhances teaching and learning experiences across various settings to support the continuity of the educational relationship in different modes such as fully online, blended or hybrid (ETF, 2019; Kelentrić, Helland & Arstorp, 2017).

Finally, educators need to understand how to use and share personal and professional information, deal with online identity management and consider the potential impact of digital actions on professional and educational relationships. This aspect emphasises professional interactions within contexts such as online communities, interactions with students and the broader educational community. It entails the teacher's responsibility to uphold ethical boundaries within their digital identity, to maintain a balance between their digital and professional personalities and to preserve online privacy and safety (ETF, 2019; Falloon, 2020).

2.3. The innovation proposed by the D-Paideia QF

Due to its prominence and significance, the DigCompEdu Framework served as the foundational basis for developing the D-Paideia QF, which was refined through an iterative process, consistently with the process followed to develop the original model. Initially, based on extensive desk research, theoretical references (e.g., Butcher, 2018; Falloon, 2020), operational models (e.g., ETF, 2019; McDonagh et al., 2021) and institutional surveys on teachers' digital competence in Europe before and after COVID-19 (e.g., OECD, 2021; School Education Gateway, 2020) were identified and selected (Gabbi et al., 2023). This review helped identify existing competencies and highlight gaps, particularly in addressing socio-relational and emotional skills and digital wellbeing issues. The basic elements of the selected resources were then mapped to form the new set of competences to be added to DigCompEdu and grouped to form the competence areas of the D-Paideia QF. Special attention was given to ensuring that each competency was comprehensive, actionable and reflective of the latest developments in digital education and policy. Specifically, the proposed enhancements concerned the integration of three new elements in the Professional engagement dimension, the introduction of a new area in teachers' pedagogical competences named "Social skills and communication" and, finally, the alignment of students' competences with the latest version of the DigComp2.2 (i.e. "Responsible use" has been replaced by "Safety").

Table 2. The D-Paideia QF new dimensions and their description.

DIGCOMPEDU AREA	NEW COMPETENCES
1. Professional engagement (in *Educators' professional competences*)	*1.5 Awareness on local and global policy* To organise and manage the school environment and educational resources in a responsible and sustainable way. To be aware of implications of national and international policies in relation to teaching with technology. *1.6 Motivation for adopting digital technologies* To be open to exploring and experimenting with new digital technologies. To critically evaluate currently used digital practices and make informed decisions about their educational merits and limits. *1.7 Balance and safety 'onlife'* To promote a sustainable, safe and ethical way of accessing and using digital resources for teachers and learners. To be prepared and to educate the students about the implications and effects of their digital actions and behaviours on other users.
7. Social skills and communication (in *Educators' pedagogic competences*)	*7.1 Managing educational relationships with ICT* To interact effectively, efficiently and ethically with colleagues, students and families, as well as to facilitate the acquisition of skills in students. To manage the relational dynamics of the online classroom, especially for students with disabilities and those with low socio-economic backgrounds. *7.2 Diverse and flexible teaching strategies* To design, manage and evaluate face-to-face, blended and fully online learning strategies. To consider the communication needs and relational management involving dynamics and strategies peculiar to each modality, when selecting and using resources, digital tools and online learning platforms to ensure students' learning inside and outside the classroom. *7.3 Digital reputation and identity management* To distinguish and manage the consequences of digital identity in terms of social interactions and educational relationships. To participate in virtual educational environments and showcase the digital identity to provide and share professional and educational resources.

Alongside elements concerning attitudes towards learning technologies and attention to the balance between online life and work, attention to the regulatory environment, which emphasises certain aspects of digital skills, also emerges. Being aware of policies that affect students' lives enables educators to empathize with their challenges and provide appropriate support. For example, policies related to inclusive education, mental health and digital safety require educators to address students' emotional and social needs sensitively and effectively. Competencies in the new area of communication in social and educational relationships include aspects related to enhancing positive connections within the school community, understanding the impact of technologies on the design of teaching and support activities and maintaining attention to the ethical and professional boundaries related to digital exposure.

The defined competences and areas were then subjected to consultations with stakeholders, respectively teachers and educational experts (Ranieri et al., 2023). The present contribution focuses on the expert review, aiming to assess the significance attributed to the highlighted aspects by practitioners and validate it.

3. Methodology

3.1. Aim and context of the study

The D-Paideia QF, formulated in light of the educational and skill requirements of the COVID-19 pandemic and the evolving social needs, seeks to incorporate innovative components in the definition of teacher digital competence. Expert consultations aim to receive precious insights to review and consolidate the framework, so that it becomes valuable and shareable, through the collaborative exchange of experiences and expertise of educational specialists.

The primary goal of the research is to validate the D-Paideia QF, an updated version of the DigCompEdu framework (described in Par. 2.3), achieving two main purposes: (a) to develop a conceptual QF outlining various facets of teachers' digital competences in the post-COVID era concerning relational, emotional and affective skills, and (b) to identify potential gaps or overlaps among specific dimensions constituting teachers' digital competences.

The non-probabilistic sampling method employed is the expert sampling technique, which consists of the intentional selection of participants based on their specific qualities and "*involves identification and selection of individuals or groups of individuals that are proficient and well-informed with a phenomenon of interest*" (Etikan, Musa & Alkassim, 2016, p. 2). The concept behind purposive sampling is to focus on individuals with specific characteristics who can provide more meaningful assistance in the relevant research. The target group comprises experts identified by the partners of the international project[1] who have established experience in educational technology and the professional development of teachers in the context of teaching in digital environments. Individuals with expertise from academia and research institutes (researchers, professors, doctoral students), school administrators, teachers' trainers and decision-makers can be nominated for the selection. In the recruitment process, 47 professionals were initially contacted by the research group, directly through invitations over emails.

3.2. Research methods and analysis tools

The research study adopted a mixed-methods approach that combines quantitative and qualitative data collection and analysis methods to provide a holistic understanding of experts' perspectives

[1] The D-Paideia consortium consists of 6 organizations from Italy, Greece, Belgium, Spain and Bulgaria.

(Creswell & Plano Clark, 2011). The online consultation with educational experts involved the participation of 30 individuals in the period from September to October 2023. The consultation phase was conducted through a semi-structured questionnaire administered online focused on the D-Paideia QF. The questionnaire was developed by three researchers and underwent evaluation by all members of the European project partnership. The survey with 18 questions on a Likert scale (1-7) was implemented on Qualtrics. A definition was provided for each of the six proposed additions to DigCompEdu. In connection with this, the degree of agreement on the following statements was asked:

1) The definition is clear and understandable
2) The competence is consistent with the background of the QF and DigCompEdu
3) The addition of this specific competence to DigCompEdu is relevant.

The questionnaire was enriched with an open-ended question to collect any insightful suggestions on the framework ("*Do you have any further comments on the D-PAIDEIA Qualifications Framework?*").

Before completing the online survey, experts were informed about the questionnaire's context to clarify the approach and ensure a common understanding of the questions. This was achieved by explaining the purpose of the expert consultation through email and presenting the broader context of the D-Paideia QF development.

During the data analysis phase, various techniques were employed: data from the consultations underwent analysis using SPSS v.28, involving descriptive statistics and frequencies, while qualitative data from the open-ended question were subjected to content analysis (Mayring, 2014). The analysis categories applied to the textual corpus were: a) definitions of teachers' digital competences concerning relational, emotional and affective skills, and b) potential overlaps with the existing dimensions of DigCompEdu.

4. Results

4.1. Participants

The final sample of experts in the consultations consisted of 30 participants. The average age was 47.67 years (SD = 10.76), with a minimum age of 27 years and a maximum age of 65 years. The experts had professional experience in teaching, with an average of 20.40 years (SD = 10.36). Regarding gender, the majority of experts were female and, from a nationality perspective, experts were from various parts of the world, mostly from European countries involved in the project partnership (Table 3).

The largest nationality group among participants was Italian, followed by Spain, Greece and Bulgaria, while other represented countries included Belgium, Croatia, Brazil and more. In terms of profession, experts had a wide range of professional backgrounds, with a prevalence from the field of research and academia. The most represented category was Researcher, followed by Teacher. Other professions included Educator, Computer Engineer, Educational Developer, PhD in Education Technology, Scientific Officer, Teacher Trainer and Advocacy regarding education policies. In summary, the sample of experts in the consultations was diverse in terms of age, gender, nationality and profession, bringing a variety of perspectives and experiences to the discussions on the D-Paideia QF.

4.2. Evaluation of the proposed competences

To provide an overview of the most relevant aspects for the experts about the proposed additions to DigCompEdu, the data are now shown. Table 4 provides an overview of the 30 expert opinions regard-

Table 3. Sample demographics.

Characteristics of the experts	Frequency	%
Gender		
Female	22	*73.3*
Male	8	*26.7*
Nationality		
Italy	7	*23.3*
Spain	6	*20.0*
Greece	4	*13.3*
Bulgaria	3	*10.0*
Other	10	*33.3*
Profession		
Researcher	9	*30.0*
Teacher	6	*20.0*
Lecturer	3	*10.0*
Full/Associate Professor	3	*6.7*
Headteacher	2	*6.7*
Other	7	*23.3*

ing the clarity of various competences and their definitions. In addition to the average, the degree of agreement is represented in the different items, showing the percentages of experts who responded with high or moderate agreement. This percentage was obtained by grouping the 7-point Likert scale scores into a general agreement category (for scores of 5 "Slightly Agree" or 6 "Agree" or 7 "Strongly Agree").

The data presented in the table above indicate that experts generally found the definitions of the assessed competences to be clear and understandable. In the Professional engagement area, the dimension concerning local and global policy awareness received favourable agreement. However, the dimensions of Motivation for adopting digital technologies and Balance and safety 'onlife' were rated more positively in terms of clarity. The new area of Social skills and communication includes the competence of Managing educational relationships with ICT, which is perceived as less clear compared to others. On the other hand, the competences of knowing how to adopt Diverse and flexible teaching strategies and Digital reputation and identity management achieved a high degree of agreement in terms of definition.

Table 4. Clarity of the new dimensions and their definition: answers from the experts (n = 30).

	M	SD	%
Professional engagement			
1.5 Awareness on local and global policy	5,70	1,53	*86,7*
1.6 Motivation for adopting digital technologies	5,93	1,48	*83,3*
1.7 Balance and safety 'onlife'	5,83	1,42	*83,3*
Social skills and communication			
7.1 Managing educational relationships with ICT	5,60	1,43	*86,7*
7.2 Diverse and flexible teaching strategies	5,80	1,35	*90,0*
7.3 Digital reputation and identity management	5,63	1,43	*90,0*

Table 5. Coherence and relevance: answers from the experts (n = 30).

	The competence is consistent with the background of the QF and DigCompEdu			The addition of this competence to DigCompEdu is relevant		
	M	*SD*	*%*	*M*	*SD*	*%*
Professional engagement						
1.5	5,60	1,43	*83,3*	5,53	1,68	*80,0*
1.6	5,63	1,75	*83,3*	5,80	1,83	*80,0*
1.7	6,03	1,50	*90,0*	5,83	1,74	*80,0*
Social skills and communication						
7.1	5,63	1,45	*86,7*	5,57	1,70	*80,0*
7.2	5,77	1,57	*90,0*	5,87	1,85	*83,3*
7.3	5,57	1,52	*86,7*	5,37	1,63	*80,0*

Subsequently, a comprehensive analysis of the experts' opinions was conducted, focusing on the coherence of competences with the QF and the DigCompEdu model, as well as their perceived relevance for integration into the European educational model (Table 5).

Overall, the experts found these competences to be consistent with the background of the QF and the DigCompEdu model and relevant for inclusion in the European model. The standard deviations reflect some variability in expert opinions, but the general trend is positive. Specifically, the competence Balance and safety 'onlife' received the highest mean score, suggesting a strong alignment with the QF background and the DigCompEdu model. Instead, awareness on local and global policy had the lowest mean score but still maintained an acceptable level of consistency. Besides assessing clarity and coherence about the theoretical and empirical background, the most crucial aspect is the relevance of updating the DigCompEdu in the proposed direction, thereby emphasising those dimensions of professional engagement and social-relational skills that can transform teaching practice through digital. In this case, the experts showed a more moderate acceptance, although the trend of general agreement remains positive. The dimensions of motivation, health and flexible strategies met with greater support for inclusion in the framework.

4.3. Content analysis of expert feedback

In addition to the quantitative data, the experts also commented on the overall proposal. Content analysis was conducted on the text of the responses to the open-ended question by identifying the data related to the two analytical categories: a) the suggestions regarding the definitions of teachers' digital competences related to relational, emotional and affective competences and b) the potential overlaps with the existing DigCompEdu dimensions.

In general, the answers to the open question refer to the structure of the proposed update and the content of the individual dimensions, the wording of the definitions and further elements for the review of the model (e.g., "*I think that the most important to include are 1.6, 1.7 and 7.2, because they focus on topics that are very relevant nowadays"; "In my view, the competence "Managing educational relationships with ICT (7.1)" is too broad as it overlaps with other competences of the framework").* Table 6 summarises the discussion elements that emerged for each dimension, after analysing the content of 16 replies including detailed opinions on the new competences.

Table 6. Experts' comments for each additional dimension).

New dimensions	Specific suggestions in the description of competences	Overlaps with the dimensions of DigCompEdu
Professional engagement Area		
1.5	Awareness of policies refers more to local or regional authorities than teachers Suggestion to include awareness of political and corporate interests	Proposed a separate dimension (self-awareness about tech impact on teachers)
1.6	Distinction between attitude and competence discussed Suggestion to change the title and definition for clarity	Proposed moving the competence to area 2 (Digital resources)
1.7	Proposed a revised title and definition for clarity	Concerns raised about the distinction or connection with competence 6.4 (Responsible use)
Social skills and communication Area		
7.1	A request for more clarity regarding the situations and contexts covered, especially for vulnerable groups	Concerns about the broadness and overlap with other competences: 5.2 (Differentiation & personalisation), 5.3 (Actively engage students), 1.1 (Organisational communication) and 6.2 (Communication)
7.2	Proposed a revised title and definition for clarity	Proposed moving competence to area 3 (Teaching and learning). Concerns about the overlap with other competences: 1.1 (Organisational communication), 1.2 (Professional collaboration) and 3.1 (Teaching)
7.3	Suggestion to change the definition to adequately cover the digital reputation aspect	The suggestion that the competence should be included in category 1.1 (Organisational communication) Concerns about the overlap with other competences: 2.3 (Managing, protecting, sharing)

In the Professional engagement area, the suggestion to broaden the awareness of policies beyond local or regional authorities to include "*political and corporate interests*" may enhance the competence in understanding the wider context of educational technology implementation and its implications, "*having the best interests of learners in mind*". The comments about Motivation for adopting digital technologies highlights the need to clarify the "*intrinsic and extrinsic aspects*" and to clearly distinguish between motivation, attitude and competence ("*motivation is a difficult concept or variable that should be better defined*"). Although motivation "*is a different construct than a competence*", it holds the potential to impact skills by influencing an individual's willingness to engage in learning or perform tasks. Indeed, this proposed competence was deemed "*very important, as we do not need digital technology for its own sake, but only when it benefits the learning experience*". In addition, suggestions were made by experts to revise the title and the definition of Balance and safety 'onlife' to better reflect the intended meaning, considering specifically health issues for teachers and the "*promotion of a sustainable, safe and ethical use of educational resources*". Regarding the Social skills and communication area, there is a request for more transparency regarding the situations and contexts covered in Managing educational relationships with ICT ("*I consider that it should be another concept to manage the relational dynamics of the online classroom, for students with disabilities and those with socio-economic backgrounds, because it is not clear what situations contemplates and/or how it should be addressed in*

the contexts of vulnerable groups"). Moreover, on Diverse and flexible teaching strategies, suggestions were made to include the teacher's ability to "*resolve problems and unforeseen events that may arise*" and to use both "*analogue and digital tools and learning platforms*" to ensure student learning inside and outside the classroom. Lastly, there is a recommendation to refine the definition of Digital reputation and identity management to "*address the relation and distinction between digital and "real-life" identity [...], as well as to lead by example when participating in virtual educational environments*". This emphasizes the importance of ethical boundaries on digital identity for teachers, finding a balance between digital and professional identity and ensuring online privacy and security.

In relation to the Professional engagement new dimensions, more suggestions were offered about the description but few connections to the existing dimensions in DigCompEdu are observed, while the new area of Social skills and communication is affected by numerous comments to this effect. The connections with the pedagogical aspects of integrating technology into teaching were particularly emphasized, focusing on teachers' abilities to effectively manage and orchestrate the use of digital tools in educational settings. Nevertheless, potential overlaps are not consistently indicated by the experts, who emphasise the relationships between the competences in very different directions. For instance, regarding the dimension of Managing educational relationships with ICT, one expert underscored its overlap with competences related to empowering learners in the classroom, such as differentiation and personalization of the teaching activities and methods to actively engage students. Another expert highlighted its connection with teachers' professional development abilities, specifically organizational communication with families and colleagues, while yet another expert pointed out its relevance to facilitating student competences, particularly fostering digital communication and collaboration skills. Apart from these comments, there was only one opinion against the introduction of the new area ("*Generate a new area isn`t necessary, just rephrase each framework's skill to clarify the motivation for digital skills, digital track, digital relationships and diversify technologies*"). The introduction of this area, however, is intended to emphasise the role of socio-affective components in the management of the teaching-learning process and the idea encountered no further criticism.

While nine experts opted not to provide additional suggestions, some comments did not align with the predefined coding categories used in the content analysis. Nonetheless, a concise summary of the key points is provided. Besides comments generically positive and approving (e.g., "*Overall, I find the additions relevant and appropriate*"; "*I strongly agree with the proposed competences*"), there were two other opinions on more formal aspects, not focused directly on competences: two experts point out issues related "*to the way labels are formulated*", emphasising a lack of uniformity and concerns about sentence length and readability. In two other cases, the experts suggested changes outside the field under investigation: self-regulated learning should be classified under learners' competences rather than in the area of teachers' pedagogical skills and awareness of the impact of ed-tech corporations on the own professional self should be added in the original DigCompEdu. This criticism seems to apply to the original structure of the framework, rather than the adaptations the D-Paideia project proposes.

In conclusion, it can be observed that the experts endorsed the structure and main contents of the proposed D-Paideia QF to increase the effectiveness and dissemination of discussion on these issues ("*The adaptation of the DigCompEdu Framework makes it more significant in the contemporary socio-technological context*"). Overall, the experts found connections between the existing dimensions and the new competences, however, no clearly defined overlaps with the original dimensions were identified. Specifically, they directed their attention to asking for a more precise correspondence between category and definition and carefully justifying the possible links with the other dimensions of DigCompEdu.

5. Discussion

This contribution illustrates the main results of the stage of expert consultation to validate a framework aimed at updating DigCompEdu concerning the relational, social and affective competences elicited by teaching-learning processes involving technologies. The study explores through a mixed-method approach the alignment between the proposed competences and the existing framework. The feedback from 30 educational experts on the D-Paideia QF showed no relevant differences in evaluating the six proposed competences and indicated that they mostly possessed clear and understandable definitions, aligned with the literature review and the DigCompEdu and were deemed relevant for incorporation into the European framework. The open-ended responses primarily revolved around the structure and content of the proposed update, the distinction between what already exists in DigCompEdu and the definitions' wording, indicating a favourable acceptance of the theoretical framework that guided the selection and definition of the various competences. Although experts have pointed out various connections between the competences, although in different ways, it should be noted that the dimensions of DigCompEdu are structurally interconnected (Redecker, 2017) and that the extension should reflect this feature of the framework without this leading to overlapping content.

The topics addressed in the study were considered important and relevant for future implementations, particularly after the ERT experience and the consequences of the COVID-19 period (Carretero et al., 2021). The theme of awareness regarding policies is linked to the need to understand and comply with institutional regulations related to the use of digital technologies in education, as well as to effectively manage the resources and digital strategies within one's working environment. Recognizing and managing ICT practices in the classroom in accordance with institutional and national policies ensures consistent and effective implementation of teaching activities (Butcher, 2018). The teacher's role is crucial as they are at the forefront of implementing digital transformation within schools. On one hand, the ability to organize and manage the school environment and educational resources responsibly and sustainably is essential for creating an effective and stimulating learning environment for students. On the other hand, teachers' digital competence not only impacts the effective adoption of digital technologies in the classroom but can also drive innovation and change in the local educational context (Generalitat de Catalunya, 2018). Furthermore, having awareness and motivation to critically intervene in education reform policies is crucial to contribute to improving the overall education system and adapting it to the current and future needs of students and teachers, facilitating informed participation of all stakeholders. In a context where the risk of platformisation – the increasing dependence on digital platforms – is growing, the importance of adopting a critical and reflective approach has also emerged (Kerssens & van Dijck, 2022). Self-awareness regarding technological impact and different economic interests can play a significant role in supporting European and national policies for sustainable and independent development.

Attitude and motivation towards the use of educational technologies are crucial elements in the effective adoption of technologies, both for exploring new methods and tools and for assessing the appropriateness of current practices. Therefore, digital competence cannot be understood solely based on technical knowledge and skills, as attitude is also considered an essential element in its definition (European Commission, 2019). Openness to new digital technologies, along with self-efficacy, may serve as predictors of teachers' technology use (McDonagh et al., 2021). This suggests that a positive attitude and belief in one's ability to effectively use technologies could significantly influence the degree of technology adoption by teachers.

Another element confirmed by expert opinion concerns the theme of digital health and well-being. Consistent with other models, being able to identify and address risks related to excessive use of digital devices involves understanding how such technologies can impact the physical and mental well-being of educators (EdDiCo, 2021). For instance, they should be able to manage stress resulting from the intensive use of digital technologies, maintain a balance between work and digital life and adopt strategies to prevent visual fatigue or other health issues related to prolonged screen time. Moreover, it is important to consider the risks of overexposure and the right to disconnect, to manage stress stemming from the high use of digital technologies and to maintain a balance between work and private life (Murphy et al., 2021).

The area of social skills and communication emphasizing the importance of social-relational and emotional dynamics within educational relationships and their impact on student learning experience, received a good evaluation from the experts. It highlights the central role of educators in cultivating positive digital learning environments, with a focus on fostering communication to nurture educational relationships among stakeholders and prioritizing inclusion and well-being (OECD, 2021; School Education Gateway, 2020). It also accentuates educators' adaptability in facilitating diverse learning modalities, prioritizing affective and communicative elements to ensure successful outcomes, thereby enhancing teaching and learning experiences in diverse settings, such as face-to-face, blended and online learning (ETF, 2019). Finally, it focuses on understanding and managing personal and professional information in the digital environment, emphasizing ethical behaviour, maintaining a harmonious balance between digital and professional identities and safeguarding privacy and security (Falloon, 2020). This competency construct aims to empower educators to effectively navigate the complexities of digital learning environments while promoting the well-being and success of students and educational communities.

Lastly, from a methodological standpoint, engaging experts – most of them peers from the scientific and academic community – enables the verification and validation of a framework with the assistance of professionals possessing informed perspectives and skills honed in the field. Indeed, familiarity with the original framework and expertise in digital competences for teaching were essential prerequisites for obtaining valuable insights and relevant suggestions. Although the results of the study are not generalizable, in purposive sampling subjects are selected according to the goal of the study, with the expectation that each participant provides unique and valuable information (Etikan et al., 2016). This approach is also aligned with the development procedure of most European institutional frameworks, such as DigCompEdu, which have included numerous stages of consultation with several stakeholders (Caena & Redecker, 2019).

Despite the promising results, this study has certain limitations that should be acknowledged, in addition to the aforementioned lack of representativeness of the experts' sample. The potential integration of several aspects to teachers' digital competence – only focusing on the socio-relational and emotional dimensions of digital teaching and learning – can't be exhaustive. Additionally, while the proposed new competences were thoroughly examined, the study did not include an evolution of these competences along the same six-stage progression model (from newcomer to pioneer) as utilized in the DigCompEdu framework. Incorporating this progression model at a more advanced stage of the project will be a priority, addressing this gap in future research developments.

6. Conclusions

The integration of the new dimensions into the DigCompEdu framework emphasises the commitment to improving the professional skills of educators in digital education in light of the societal

changes that have taken place since the advent of the COVID-19 pandemic and the experience of ERT. The D-Paideia QF aims to equip teachers with the necessary skills, knowledge and mindset to teach effectively in digital learning environments, while also recognizing the indispensable socio-relational and emotional dimensions of teaching and learning experience. The attitudinal and critical awareness dimensions of technology use can support teachers to design and implement interventions with the students' interests and well-being in mind. Furthermore, social-relational and communication skills play a crucial role in technology-mediated communication, particularly in environments where non-verbal contextual cues are absent and disparities can lead to unequal learning opportunities.

Concluding, the overall acceptance by educational experts was uniform across the framework, with minimal discrepancies noted between the six added dimensions. The current study is part of a strategy that aims to harness the experience and knowledge of academic research to develop targeted practical interventions in the field of digital education, through in-depth analysis of existing literature and empirical data collection and analysis. In the end, the reflection on DigCompEdu's update has been enriched with insights from academic literature and practical experience, consolidating its value and relevance as a resource for educators in the digital age. The results of the study, in addition to refining the D-Paideia QF, will be used to inform the curriculum design for professional development of teachers, providing them with the necessary social and relational skills to adapt to the changing digital educational environment. Concurrently, it will be necessary to conduct an analysis of existing self-evaluation tools – such as the SELFIE for teachers and DigCompEdu Check-in – in order to validate a new instrument that accurately reflects the assessment of the newly proposed competences. This integration will demonstrate how the instrument can be embedded into educators' self-evaluation practices, thus facilitating the adoption of the revised competences. With this integrated approach bridging academic research and field practice, the endeavour is to foster high-quality learning and facilitate the ongoing enhancement of digital education.

7. Author contributions

This contribution can be attributed for paragraphs 2.3, 3, 4 and 6 to Elena Gabbi, for paragraphs 1, 2.1 and 2.2 to Ilaria Ancillotti, while paragraph 5 was jointly authored by the authors.

8. Funding

The study was conducted within the Erasmus+ project D-Paideia "Pedagogical Digital Competences as a key element for the digital transformation" (2023-2025). The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

9. Acknowledgements

The authors would like to extend our heartfelt gratitude to Prof. Maria Ranieri for her leadership in directing the research efforts of the University of Florence team within the Erasmus+ project D-Paideia.

10. References

Antonacci, F. (2023). Immaginari di scuola in TikTok. *Paideutika*, *38*, 11–26. https://doi.org/10.57609/paideutika.vi38.5642

Burns, M., & Kolho, A. (2022). *Digital and social-emotional competences needed in the teaching profession*. HAMK Unlimited. https://unlimited.hamk.fi/ammatillinen-osaaminen-ja-opetus/digital-and-social-emotional-competences-needed-in-the-teaching-profession/

Butcher, N. (2018). *UNESCO ICT Skills Framework*. UNESCO.

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (DigCompEdu). *European Journal of Education*, *54*(3), 356-369.

Carretero Gomez, S., Napierala, J., Bessios, A., Mägi, E., Pugacewicz, A., Ranieri, M., Triquet, K., Lombaerts, K., Robledo Bottcher, N., Montanari, M., & Gonzalez Vazquez, I. (2021). *What did we learn from schooling practices during the COVID-19 lockdown* (EUR 30559 EN). Publications Office of the European Union. https://doi.org/10.2760/135208

Chiappetta Cajola, L., & Ciraci, A. M. (2013). *Didattica inclusiva: Quali competenze per gli insegnanti*?. Armando Editore.

Chiu, T. K. F., Falloon, G., Song, Y., Wong, V. W. L., Zhao, L., & Ismailov, M. (2024). A self-determination theory approach to teacher digital competence development. *Computers & Education*, *214*. https://doi.org/10.1016/j.compedu.2024.105017

Creswell, J. W., & Plano Clark, V. (2011). *Mixed methods research*. SAGE Publications.

EdDiCo (2021). *Learning maturity model for digital education competence*. EdDiCo project platform. https://eddico.eu/wp-content/uploads/sites/24/2022/01/content/learning-maturity-model-for-digital-education-competence.html#/

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1-4.

ETF. (2019). *Digital teaching professional framework*. Education and Training Foundation. https://www.et-foundation.co.uk/

European Commission. (2019). *Key competences for lifelong learning*. Directorate-General for Education, Youth, Sport and Culture. Publications Office. https://data.europa.eu/doi/10.2766/569540

European Commission. (2020). *Digital Education Action Plan 2021-2027: Resetting education and training for the digital age*. Publications Office. https://education.ec.europa.eu/focus-topics/digital-education/action-plan

European Commission. (2022). *Education and training monitor: comparative report*. Directorate-General for Education, Youth, Sport and Culture. Publications Office. https://data.europa.eu/doi/10.2766/117416

Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development*, *68*, 2449-2472. https://doi.org/10.1007/s11423-020-09767-4

Floridi, L. (2017). *La quarta rivoluzione: come l'infosfera sta trasformando il mondo*. Raffaello Cortina Editore.

Fullan, M., Hill, P., & Rincón-Gallardo, S. (2017). Deep learning: shaking the foundation. new pedagogies for deep learning: A global partnership. http://npdl.global/wp-content/uploads/2017/03/npdl-case_study_3.pdf

Gabbi, E., Ancillotti, I., & Ranieri, M. (2023). La competenza digitale degli educatori: Teorie, modelli, prospettive di sviluppo. *Media Education – Studi, ricerche e buone pratiche*, *14*(2). https://doi.org/10.36253/me-14742

Generalitat de Catalunya. (2018). Teachers' digital competence in Catalonia. Departament d'Ensenyament. https://repositori.educacio.gencat.cat/bitstream/handle/20.500.12694/229/teachers_digital_competence_in_catalonia_2018.pdf

Jennings, P. A., & Greenberg, M. T. (2009). The prosocial classroom: Teacher social and emotional competence in relation to student and classroom outcomes. *Review of Educational Research*, *79*(1), 491-525. https://doi.org/10.3102/0034654308325693

Kampylis, P., Devine, J., Punie, Y., & Newman, T. (2016). Supporting schools to go digital: from conceptual model towards the design of a self-assessment tool for digital-age learning. In L. G. Chova, A. L. Martínez, I. Candel Torres (Eds.), *ICERI Proceedings* (pp. 816-825), IATED Digital Library.

Kerssens, N., & van Dijck, J. (2022). Governed by edtech? Valuing pedagogical autonomy in a platform society. *Harvard Educational Review*, *92*(2), 284-303.

Kelentrić, M., Helland, K., & Arstorp, A. T. (2017). *Professional digital competence framework for teachers*. The Norwegian Centre for ICT in education.

Llorente-Cejudo, C., Barragán-Sánchez, R., Puig-Gutiérrez, M., & Romero-Tena, R. (2023). Social inclusion as a perspective for the validation of the "DigCompEdu Check-In" questionnaire for teaching digital competence. *Education and Information Technologies*, *28*, 9437-9458. https://doi.org/10.1007/s10639-022-11273-4

Mayring, P. (2014). *Qualitative content analysis: theoretical foundation, basic procedures and software solution*. Klagenfurt.

McDonagh, A., Camilleri, P., Engen, B. K., & McGarr, O. (2021). Introducing the PEAT model to frame professional digital competence in teacher education. *Nordic Journal of Comparative and International Education*, *5*(4), 5–17. https://doi.org/10.7577/njcie.4226

Murphy, C., Marcus-Quinn, A., & Hourigan, T. (2021). Exploring the ripple effect of 'always on' digital work culture in secondary education settings. In *Handbook for Online Learning Contexts: Digital, Mobile and Open: Policy and Practice* (pp. 339-353). Springer International Publishing.

OECD. (2021). *Supporting young people's mental health through the COVID-19 crisis. Tackling coronavirus (COVID-19)*. Browse OECD contributions. https://read.oecd-ilibrary.org/view/?ref=1094_1094452-vvnq8dqm9u&title=Supporting-young-people-s-mental-health-through-the-COVID-19-crisis

Ong, S. G. T., & Quek, G. C. L. (2023). Enhancing teacher–student interactions and student online engagement in an online learning environment. *Learning Environments Research*, *26*(3), 681-707. https://doi.org/10.1007/s10984-022-09447-5

Ranieri, M. (2022). *Competenze digitali per insegnare: Modelli e proposte operative*. Carocci Editore.

Ranieri, M., Gabbi, E., Ancillotti, I. (2023). *D-Paideia qualifications framework consultation report*. [Unpublished internal D-Paideia project report].

Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu*. Publications Office of the European Union.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology*, *61*. https://doi.org/10.1016/j.cedpsych.2020.101860

School Education Gateway. (2020, 08 June). *Survey on online and distance learning – Results*. European School Education Platform. https://school-education.ec.europa.eu/en/insights/viewpoints/survey-online-and-distance-learning-results

Schonert-Reichl, K. A. (2017). Social and Emotional Learning and Teachers. *The Future of Children*, *27*(1), 137–155. http://www.jstor.org/stable/44219025

Teng, M. F., & Wu, J. G. (2021). Tea or tears: Online teaching during the COVID-19 pandemic. *Journal of Education for Teaching*, *47*(2), 290-292. https://doi.org/10.1080/02607476.2021.1886834

Zhao, Y., & Watterston, J. (2021). The changes we need: Education post COVID-19. *Journal Of Educational Change*, *22*(1), 3-12. https://doi.org/10.1007/s10833-021-09417-3

Italian Journal of Educational Technology, 32(2), 25-33, 2024
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1354
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

ITD ISTITUTO TECNOLOGIE DIDATTICHE

Questionnaire for assessing the digital competence of future teachers

Questionario per la valutazione delle competenze digitali dei futuri insegnanti

Maria Victoria Fernández-Scagliusi*, Maria del Carmen Llorente-Cejudo

University of Seville, Spain, maria.fernandez25@unibo.it, karen@us.es*
**Corresponding author*

HOW TO CITE Fernández-Scagliusi, M.-V., & Llorente-Cejudo, M.-D.-C. (2024). Questionnaire for assessing the digital competence of future teachers. *Italian Journal of Educational Technology*, *32*(2), 25-33. https://doi.org/10.17471/2499-4324/1354

Received: July 1, 2024; *Accepted:* October 29, 2024; *First Published:* November 14, 2024

ABSTRACT This study presents the preliminary stages of a validation process for a questionnaire developed to assess the digital competencies of future teachers at the University of Bologna, focusing on students in the Pedagogy, Primary Education, and Early Childhood Education programs at the Giovanni Maria Bertin Faculty. Given the increasing importance of technology in various fields, measuring digital competencies is essential for future educators. The questionnaire, based on the "*Cuestionario de Competencia Digital para Futuros Maestros*" (CCDFM) by Cabero-Almenara et al. (2020), was adapted to Italian. The preliminary validation process described in this paper encompassed cultural adaptation, expert review, and a pilot test. To ensure data reliability, analytical techniques like Cronbach's alpha, KMO, and Bartlett's tests were used. Factor analysis and rotation were conducted to examine item structures, alongside factor loading tests. In a context where technology integration in education is essential, this tool promises to enhance teacher preparation and refine digital competency assessment methods. The results underscore its relevance for education professionals and researchers, confirming its potential to improve teacher training practices and broader research on digital competencies.

KEYWORDS Digital Competencies; Future Teachers; Questionnaire; Teacher Education; Technology Integration.

SOMMARIO Questo studio presenta le fasi preliminari di un processo di validazione di un questionario sviluppato per valutare le competenze digitali dei futuri insegnanti all'Università di Bologna, focalizzato sugli studenti di Pedagogia, Educazione Primaria ed Educazione della Prima Infanzia della Facoltà Giovanni Maria Bertin. Data l'importanza crescente della tecnologia, misurare le competenze digitali è essenziale per i futuri educatori. Il questionario, basato sul "*Cuestionario de Competencia Digital para Futuros Maestros*" (CCDFM) di Cabero-Almenara et al. (2020), è stato adattato in italiano. Il processo di validazione preliminare descritto nel paper ha compreso l'adattamento culturale, la revisione da parte di esperti e un test pilota. Per garantire l'affidabilità dei dati, sono state utilizzate tecniche come il coefficiente alfa di Cronbach, il KMO e i test di sfericità di Bartlett. L'analisi fattoriale e la rotazione sono state condotte per esaminare la struttura degli item. In un contesto dove l'integrazione tecnologica è essenziale, questo strumento può migliorare la preparazione degli insegnanti e la valutazione delle competenze digitali. I risultati evidenziano la sua rilevanza per l'istruzione e la ricerca, confermando il suo potenziale per migliorare la formazione degli insegnanti e la ricerca sulle competenze digitali.

PAROLE CHIAVE Competenze Digitali; Futuri Insegnanti; Questionario; Formazione degli Insegnanti; Integrazione Tecnologica.

1. Introduction

With the constant integration of technology into daily and professional life, the assessment of digital skills has become increasingly important. National digital competence standards have been introduced to facilitate educational transformation in the digital age (Ministerio de Asuntos Económicos y Transformación Digital, 2021). These standards aim to integrate information and communication technologies into curricula, promoting the development of students' digital skills (Redecker, 2017; Carretero et al., 2017). However, previous studies reveal that aspects such as technological competence, information retrieval skills, and ethical understanding are still insufficiently developed among students (Calvani, 2013; Tammaro et al., 2020). The presence of these gaps highlights the need for comprehensive and reliable tools to effectively measure and assess digital competence (Hernández González, 2021).

Digital skills range from the basic use of technological tools to the ability to adapt to and take advantage of new technologies in different situations. To accurately assess these skills, it is essential to have reliable measurement tools. In this article, we present the validation of a questionnaire designed specifically to assess the digital competencies of future teachers at the University of Bologna, aimed specifically at students in the degree programs in Pedagogy, Primary Education Sciences, and Educator in Children's Services of the Giovanni Maria Bertin Faculty.

The official recognition of digital competence as a prerequisite for operating in the knowledge society, along with the publication of frameworks for its development, underscores the importance of this concept and raises relevant questions regarding assessment criteria and practices. As Tammaro et al. (2020) state, since digital competence is not limited to a single component, it is clear that its assessment cannot be based on a single type of evidence, but requires the adoption of flexible and integrated approaches.

The need to incorporate 21st century skills into training plans is crucial to assessing the growth of digital literacy among trainers. Collaboration, communication, digital literacy, citizenship, problem solving, critical thinking, creativity and productivity are some of these qualities. Teacher training in the use of technology for teaching is an established theme in the academic literature, as highlighted by Calvani (2013). Explicit references to digital skills in the Italian educational context are also found in the Ministry of Education's National Digital School Plan, introduced in 2015. However, it was not until 2017 that a European framework was consolidated with the "European Framework for Educators' Digital Competence: DigCompEdu" (Redecker, 2017).

In the context of teacher training on the use of technology for teaching, it is important to highlight the relevance of the "European Framework for Educators' Digital Competence: DigCompEdu" (DigCompEdu) as a key tool. This framework provides a solid conceptual basis for defining the digital competencies needed for educators, offering practical guidance on activities that can be implemented to improve these competencies (Ranieri, 2022). In the Italian context, the DigCompEdu framework is widely recognized and used, as indicated in the Ministry of Education's "Guidelines for Integrated Digital Didactics (DDI)" and the "Formare al Futuro Program", aimed at training school personnel, including teachers, administrative and management staff.

It is essential to investigate how teachers acquire and improve their teaching technology skills. This makes it possible to check whether government teaching proposals are actually being adopted by teachers in terms of technology use and to identify and promote the training activities that teachers are implementing in their daily work. Teachers will be better prepared to use technology to improve student learning and engagement if these skills are integrated into teacher training programs,

2. Method

The questionnaire used in this study is an adaptation of the "Cuestionario de Competencia Digital para Futuros Maestros" (CCDFM) by Cabero-Almenara et al. (2020). While the original version has been validated in Spanish, this paper presents the first steps in adapting and testing the questionnaire in the Italian context. These preliminary results are intended to guide the full validation process.

Following ISTE standards (Crompton, 2017) and the DigComp project (Carretero et al., 2017), key dimensions were selected to be assessed, just as in the original questionnaire. The items in the questionnaire were updated to reflect these dimensions, and an 11-point Likert scale (0-10) was used to rate each item.

The questionnaire had multiple objectives, including assessing the digital competence of undergraduate students of Pedagogy, Primary Education and Early Childhood Education, and analyzing the reliability and validity of the original questionnaire in its version adapted to Italian. The study consisted of three preliminary phases: translation and cultural adaptation, expert review, and a pilot study to assess the comprehensibility of the questionnaire. These phases represent the initial steps of a broader validation process. The psychometric properties of the instrument will be further examined in future research with a larger sample. Content validity and reliability analyses, such as calculation of Cronbach's alpha coefficient, were conducted. Non-probability convenience sampling was used for participant selection (Hernández González, 2021).

2.1. Validation and data collection

Given the small sample size (N=15), the focus of the data analysis was exploratory rather than confirmatory. Descriptive statistics were used to examine the distribution of responses for each item, and a correlation matrix was constructed to explore the relationships between items. These exploratory analyses provided preliminary insights into the internal consistency of the questionnaire and helped assess whether the items behaved as expected based on the original version of the instrument. While the sample size is insufficient to draw definitive conclusions about the questionnaire's psychometric properties, these initial analyses will guide the next steps in the validation process, which will include confirmatory factor analysis (CFA) with a larger sample.

This preliminary validation followed rigorous cross-cultural adaptation protocols, relying on established guidelines (Parra-González et al., 2021), while data collection was carried out through carefully planned sampling to ensure the representativeness of the sample. In addition, advanced methods were used for data validation, ensuring that the data collected are accurate and reliable. These steps are essential to ensure that the results obtained are reliable and accurately reflect the realities and perceptions of the study participants.

Six Italian academic experts participated in the review and preliminary validation of the questionnaire, ensuring that the instrument accurately reflected the dimensions of interest. Following the approach of Martínez Ramírez (2019), the understanding of the questionnaire was tested directly with the target population by consulting university students.

The collected data were subjected to statistical analysis, including Cronbach's alpha coefficient calculation and factor analysis, to examine the internal consistency of the items and the underlying structure of the digital competencies assessed. The results indicated that the developed questionnaire is a valid and reliable tool for assessing the digital competencies of future faculty members at the University of Bologna.

2.1.1. Translation and cultural adaptation

The translation of the original questionnaire, "Cuestionario de Competencia Digital para Futuros Maestros" (CCDFM), was conducted by professional translators who are native Italian speakers. The translation process aimed to remain faithful to the original Spanish version while adjusting the language to fit the Italian educational context.

During this phase, three additional questions were included to clarify certain concepts for Italian students, bringing the total number of items to 23. This cultural adaptation was an essential step in preparing the questionnaire for future validation, as it ensured that the items were comprehensible and relevant for the target population.

In addition, an "other" option was included in the "Gender" field of the "Sociodemographic Data" section to ensure greater inclusiveness. All questions in the questionnaire were made mandatory to ensure comprehensive data collection and worded to minimize ambiguity and maximize the accuracy of responses.

An optional question asking for participants' email addresses was also included, offering them the opportunity to participate in a focus group to further explore the research topic.

2.1.2. Pilot study

The final phase of this preliminary study was a pilot test designed to assess the comprehensibility of the adapted questionnaire. The pilot study was conducted with 15 students enrolled in the "Master's Degree in Teaching and Communication of Natural Sciences" at the University of Bologna. While the sample size is small, this pilot study provided valuable insights into the clarity of the items and the appropriateness of the cultural adaptations. The students were invited via email to participate in the study, and they completed the questionnaire online using Microsoft Forms. Data collection took place over a period of two weeks, and the average time to complete the questionnaire was approximately 15 minutes.

Given the limited sample size, the pilot study is not intended to serve as a full validation of the questionnaire. Instead, it represents an exploratory stage, allowing us to identify potential issues with the questionnaire's structure and content that can be addressed before conducting a more extensive validation with a larger sample. Ethical considerations were followed throughout, and informed consent was obtained from all participants.

2.2. Exploratory analysis and preliminary reliability of the questionnaire

The data analysis was conducted using SPSS Statistics version 29, focusing on exploratory and descriptive methods. Statistical analyses were performed at a significance level of $p < 0.05$. The objective was to validate the structure of the questionnaire. To this end, the final version of the instrument included two sections: the first with 6 identification questions and the second with 23 Likert-type questions, with eleven response options based on different levels of commitment to technologies, where 0 meant minimum and 10 maximum.

The reliability of a measurement refers to the consistency and stability of the results obtained. It ensures that a measurement instrument is consistent in its parts. If the elements of a scale measure the same concept consistently, the scale is said to have good internal reliability (Vaske et al., 2017). To determine the reliability of a measure, the widely accepted Cronbach's alpha coefficient is used, especially with Likert-type scales. Although there is no hard-and-fast rule, most experts consider a coeffi-

Table 1. Cronbach's Alpha coefficients for size and total.

Size	1	2	3	4	5	Total dimensions
Cronbach's alpha	,862	,886	,845	,847	,873	,937
Cronbach's alpha based on standardized elements	,865	,896	,849	,849	,871	,941
No. of elements	7	3	4	3	6	23

cient of at least 0.70 to be acceptable (Streiner & Norman, 1995). For exploratory or pilot research, a reliability of 0.60 or higher is suggested, as a lower value indicates poor reliability.

Considering the structure of the instrument, divided into five blocks to measure different dimensions, Cronbach's α coefficient was calculated for each of them. The reliability of the questionnaire was assessed both globally and by single dimension, resulting in a high Cronbach's alpha score of 0.937. This score, above the threshold of 0.9, indicates high internal consistency of the instrument, suggesting that it is valid for measuring target variables, as confirmed by the research of O'Dwyer and Bernauer (2014). In addition, the reliability indices for each dimension-technology literacy (.862), communication and collaboration (.886), information search and processing (.845), digital citizenship (.847), and creativity and innovation (.873)-further underscore the instrument's robustness and ability to provide reliable perspectives. In general, the questionnaire's verification process ensures the integrity and validity of the data collected, allowing for meaningful research results.

A detailed analysis revealed that eliminating individual items did not substantially affect the value of Cronbach's alpha coefficient in any of the dimensions studied. Therefore, all items were retained in the final questionnaire. This result indicates that each item contributes meaningfully to the measurement of digital competence within its respective dimension, supporting the decision to maintain all items for a comprehensive assessment.

To ensure the validity of the questionnaire, this study was grounded in previous research and key projects in the field of digital skills, particularly the ISTE standards and the DigComp project. While the original five dimensions of the questionnaire were preserved in the Italian adaptation, the number of items was increased to 23, including modifications and new items aimed at providing a more thorough evaluation of digital competencies.

Given the small sample size, the analysis focused on exploratory methods. Descriptive statistics and correlations between items were examined to assess the internal consistency of the questionnaire. The correlation matrix revealed significant relationships between several items, particularly within the "Technological Literacy" dimension, indicating a consistent response pattern and supporting the internal validity of the scale. This consistency is further corroborated by Cronbach's alpha values, which demonstrate satisfactory reliability across all dimensions.

More advanced tests such as the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity are typically used to assess the suitability of data for factor analysis, as can be seen in Table 2. However, due to the small sample size (N=15), the results of these tests should be interpreted with caution. While the KMO test results indicate a level of adequacy (ranging from 0.716 to 0.756), and Bartlett's test results show significant differences between the items, these findings are preliminary and should be confirmed with a larger, more representative sample.

The Total Correlation Matrix (Table 3) allowed us to examine the internal consistency and structure of the questionnaire items, revealing moderate to strong correlations within each dimension. In

Table 2. KMO (Kaiser-Meyer-Olkin) test and Bartlett's sphericity test.

Size		1	2	3	4	5
Kaiser-Meyer-Olkin Measure of sampling adequacy.		,716	,720	,730	,724	,756
Bartlett's test of sphericity	Ca. Chi-square	46,374	23,973	22,928	15,873	43,835
	Gl	21	3	6	3	15
	Geographic information system	,001	,000	,001	,001	,000

Table 3. Total Correlation Matrix.

Item	Size 1	Size 2	Size 3	Size 4	Size 5
A.1	1.0				
A.2	0.74				
A.3	0.68				
A.4	0.71				
A.5	0.67				
A.6	0.72				
A.7	0.69				
B.1		1.0			
B.2		0.81			
B.3		0.78			
C.1			1.0		
C.2			0.79		
C.3			0.76		
C.4			0.78		
D.1				1.0	
D.2				0.72	
D.3				0.75	
E.1					1.0
E.2					0.72
E.3					0.75
E.4					1.0
E.5					0.72
E.6					0.75

particular, Dimension 1 (Technological Literacy) showed correlations ranging from 0.67 to 0.74, indicating a consistent relationship between the items and the construct being measured. The highest correlation was observed between A1 and A2 (0.74), suggesting these items are closely related in assessing technological literacy. Similarly, Dimension 2 (Communication and Collaboration) exhibited correlations between 0.78 and 0.81, confirming the internal consistency of the items within this dimension. The strongest correlation was between B1 and B2 (0.81), further supporting the idea that these items measure similar aspects of communication and collaboration.

For Dimension 3 (Information Search and Processing), the items showed correlations ranging from 0.76 to 0.79, with a particularly strong relationship between C1 and C2 (0.79), indicating reliable measurement of information processing skills. In Dimension 4 (Digital Citizenship), the correlations

ranged from 0.72 to 0.75, with the highest value between D1 and D3 (0.75), suggesting consistency in the measurement of digital citizenship.

Finally, Dimension 5 (Creativity and Innovation) demonstrated correlations ranging from 0.72 to 0.75, with the strongest correlation between E1 and E3 (0.75), reflecting good internal consistency within this dimension.

Overall, these correlation patterns suggest that the questionnaire items are aligned with their respective constructs and demonstrate internal consistency.

3. Results

The reliability analysis of the questionnaire, as measured by Cronbach's alpha coefficient, revealed an excellent level of internal consistency, with a value of 0.937 for the whole instrument. This result far exceeds the benchmark of 0.9, indicating high reliability of the questionnaire as a whole. Analysis by dimension further confirmed the reliability of the instrument, with Cronbach's alpha values above 0.84 for all five dimensions: technological literacy (0.862), communication and collaboration (0.886), information search and processing (0.845), digital citizenship (0.847) and creativity and innovation (0.873).

The adequacy of the sample and the validity of the questionnaire were further supported by the results of Kaiser-Meyer-Olkin (KMO) sample adequacy analyses and Bartlett's sphericity tests. The KMO values, ranging from 0.716 to 0.756 for all dimensions, indicated the suitability of the sample for factor analysis. Bartlett's sphericity tests confirmed the presence of significant differences between items in each dimension, supporting the hypothesis of a multidimensional and diverse factorial structure.

Further exploratory analysis was conducted using correlation matrix to assess the relationships between items within each dimension. The results revealed moderate to strong correlations between items, particularly within the Technological Literacy and Communication and Collaboration dimensions, where correlations ranged from 0.67 to 0.74 and 0.78 to 0.81, respectively. These findings suggest that the items in these dimensions are well-aligned with their respective constructs.

These results confirm the reliability and validity of the "Cuestionario de Competencia Digital para Futuros Maestros" (CCDFM) in its Italian version, highlighting its ability to effectively measure the different dimensions of digital competence in future teachers[1].

4. Conclusions

Having valid and reliable indicators of prospective teachers' abilities is essential to ensure the effectiveness of training. This study represents an important preliminary step towards the validation of the "Cuestionario de Competencia Digital para Futuros Maestros" (CCDFM) in its Italian version at the University of Bologna. The questionnaire offers an accurate means of assessing the level of digital competence of prospective teachers, allowing them to identify their strengths and areas in which to improve (Hatlevik et al., 2018).

First, the questionnaire provides a valuable foundation for creating a database on the digital skills of students at the University of Bologna. This information provides a clear perspective on the issues on which education should focus (Instefjord & Munthe, 2017). By having accurate information on digital skills, the university can adapt its curriculum and teaching methodologies to more effectively integrate

[1] The questionnaire can be accessed at this link: https://n9.cl/kbe2m

technology into the teaching-learning process. Education and training programs can be created specifically for areas where digital skills need to be strengthened, thus ensuring that training is up-to-date and in line with the needs of today's environment (Napal Fraile et al., 2018).

In addition, the comparison of these findings with previous research provides a unique opportunity to identify possible variations and similarities in the digital competencies of educational science students in different university settings. This comparative approach enriches the overall understanding of training needs in digital skills and contributes to the development of effective strategies for preparing teachers in the digital age (Garzón-Artacho et al., 2021).

The wide use and usefulness of this digital skills questionnaire in various educational situations could lead to its translation into many languages, enabling researchers and educators to gain useful information about skill levels and encouraging cross-cultural comparisons. This is especially important in a highly connected world where teachers must interact with diverse groups of students from various countries.

In this sense, the questionnaire could guide teacher education efforts by offering a resource for improving digital skills in various academic areas (Riquelme-Plaza et al., 2022). Additionally, it aligns with the broader educational goal of fostering the comprehensive development of individuals, with digital inclusion being a key factor in creating a more just and equitable society (Méndez et al., 2023). The role of digital competencies in both formal education and lifelong learning has been widely emphasized in the literature (Tsankov & Damyanov, 2019).

Finally, the application of the questionnaire in different contexts not only offers benefits at the individual level, but also provides data and perspectives for the development of policies and strategies related to digital competencies at the institutional level. The data acquired can be used to detect large-scale trends and needs, helping to establish public policies that promote the development and strengthening of digital skills in society. In addition, it is suggested that other analysis techniques, such as structural equation modeling, be explored to complement the current statistical approach and provide further evaluation of the validity of the proposed theoretical model.

In conclusion, the validation of the questionnaire is an important step forward in promoting the effective use of technology in education. This tool not only ensures reliability for application in other Italian universities, but also provides researchers and practitioners with an accurate means of assessing and improving teachers' digital skills, helping to create a more innovative educational environment prepared to meet the challenges of the 21st century (Chaw & Tang, 2022).

5. References

Cabero-Almenara, J., Barroso-Osuna, J., Gutiérrez-Castillo, J. J., & Palacios-Rodríguez, A. (2020). Validación del cuestionario de competencia digital para futuros maestros mediante ecuaciones estructurales. *Bordón. Revista De Pedagogía, 72*(2), 45-63. https://doi.org/10.13042/Bordon.2020.73436

Calvani, A. (2013). ICT in schools: Ten recommendations for policy makers. *Form@re-Open Journal for Networked Education, 13*(4), 30-46.

Carretero, S., Vuorikari, R., & Punie, Y. (2017). *DigComp 2.1: The digital competence framework for citizens with eight proficiency levels and examples of use*. Publications Office of the European Union. https://doi.org/10.2760/38842

Chaw, L. Y., & Tang, C. M. (2022, October). The relative importance of digital competencies for predicting student learning performance: An importance-performance map analysis. In *21st European Conference on e-Learning ECEL 2022* (p. 61).

Crompton, H. (2017). *ISTE standards for educators: A guide for teachers and other professionals*. International Society for Technology in Education.

Garzón-Artacho, E., Sola-Martínez, T., Romero-Rodríguez, J. M., & Gómez-García, G. (2021). Teachers' perceptions of digital competence at the lifelong learning stage. *Heliyon, 7*(7),.https://doi.org/10.1016/j.heliyon.2021.e07513

Hatlevik, O. E., Throndsen, I., Loi, M., & Gudmundsdottir, G. B. (2018). Students' ICT self-efficacy and computer and information literacy: Determinants and relationships. *Computers & Education, 118*, 107-119. https://doi.org/10.1016/j.compedu.2017.11.011

Hernández González, O. (2021). Aproximación a los distintos tipos de muestreo no probabilístico que existen. *Revista Cubana de Medicina General Integral, 37*(3). http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-21252021000300002

Instefjord, E. J., & Munthe, E. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and Teacher Education, 67*, 37-45.

Martínez Ramírez, J. L. (2019). El proceso de elaboración y validación de un instrumento de medición documental. *Acción y Reflexión Educativa, 44(2019),* 50-63. https://revistas.up.ac.pa/index.php/accion_reflexion_educativa/article/view/673

Méndez, V. G., Suelves, D. M., Méndez, C. G., & Ramon-Llin, J. A. (2023). Future teachers facing the use of technology for inclusion: A view from the digital competence. *Education and Information Technologies, 28*, 9305-9323. https://doi.org/10.1007/s10639-023-11649-w

Ministerio de Asuntos Económicos y Transformación Digital. (2021). *Plan Nacional de Competencias Digitales*.

Napal Fraile, M., Peñalva-Vélez, A., & Mendióroz Lacambra, A. M. (2018). Development of digital competence in secondary education teachers' training. *Education Sciences, 8*(3), 104.

O'Dwyer, L. M., & Bernauer, J. A. (2014). *Quantitative research for the qualitative researcher*. SAGE Publications. https://doi.org/10.4135/9781452270114

Parra-González, M. E., López-Belmonte, J., Segura-Robles, A., & Moreno-Guerrero, A. J. (2021). Gamification and flipped learning and their influence on aspects related to the teaching-learning process. *Heliyon, 7*(2), e06254. https://doi.org/10.1016/j.heliyon.2021.e06254

Ranieri, M. (2022). Teachers' digital competencies. In *The direct digital integrated apprenticeship (TDDI)*. The experimental project for the development of teachers' and teachers' skills (pp. 49-60). Florence University Press.

Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu*. Luxembourg: Publications Office of the European Union. https://doi.org/10.2760/159770

Riquelme-Plaza, I., Cabero-Almenara, J., & Marín-Díaz, V. (2022). Validation of the digital teaching competence questionnaire in Chilean university teachers. *Revista Electrónica Educare, 26*(1), 1-15. https://doi.org/10.15359/ree.26-1.22

Streiner, D. L., & Norman, G. R. (1995). *Health measurement scales: A practical guide to their development and use*. Oxford Medical Publications.

Tammaro, R., Iannotta, I. S., & Zanazzi, S. (2020). Assessing digital competence: A review of assessment practices in Primary Teacher Education degree programs. *Form@re – Open Journal Per La Formazione in Rete, 20*(1), 187-202. https://doi.org/10.13128/form-8744

Tsankov, N., & Damyanov, I. (2019). The digital competence of future teachers: Self-assessment in the context of their development. *International Journal of Interactive Mobile Technologies (iJIM), 13*(12), 4-18. https://doi.org/10.3991/ijim.v13i12.11004

Vaske, J. J., Beaman, J., & Sponarski, C. C. (2017). Rethinking internal consistency in Cronbach's alpha. *Leisure Sciences, 39*(2), 163-173. https://doi.org/10.1080/01490400.2015.1127189

Italian Journal of Educational Technology, 32(2), 35-48, 2024
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1348
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

ISTITUTO TECNOLOGIE DIDATTICHE

Paper versus screen: The impact of annotation tools on reading strategies among university students

Su carta o su schermo? L'impatto degli strumenti di annotazione sulle strategie di lettura degli studenti universitari

Corrado Petrucco

University of Padua, Italy, corrado.petrucco@unipd.it

HOW TO CITE Petrucco, C. (2024). Paper versus screen: The impact of annotation tools on reading strategies among university students. *Italian Journal of Educational Technology*, *32*(2), 35-48. https://doi.org/10.17471/2499-4324/1348

Received: May 9, 2024; *Accepted:* October 15, 2024; *First Published:* November 6, 2024

ABSTRACT Previous research has shown that many students still prefer reading and annotating academic material in print form rather than on a screen, despite the increasing availability of digital reading material provided by instructors. This study aims to investigate the mediating effect of an Annotation Tool on digital reading as notetaking and underlining can enhance the capacity to understand and memorize digital written material by reducing cognitive load and facilitates comprehension. It involved 112 first-year students of a Master's Degree Course on Educational Technologies. The results confirmed that most students prefer academic texts on paper and that the use of a social annotation tool with digital academic texts can positively change perceptions of digital reading and comprehension. A significant correlation exists between reading others' annotations to summarize concepts, clearer content understanding, and satisfaction with digital academic texts, suggesting improvements for academic teaching practices in digital material provision.

KEYWORDS Digital Reading; Social Annotation Tools; University Students.

SOMMARIO Numerose ricerche hanno dimostrato che molti studenti preferiscono ancora leggere e annotare materiale accademico in formato cartaceo piuttosto che su uno schermo, nonostante la crescente disponibilità di materiale digitale fornito dagli insegnanti. Questo studio mira a indagare l'effetto di mediazione di uno strumento di annotazione nella lettura in digitale: prendere appunti e sottolineare può migliorare la capacità di comprendere e memorizzare materiale riducendo il carico cognitivo e facilitando la comprensione. La ricerca ha coinvolto 112 studenti del primo anno di un Corso di laurea Magistrale all'interno dell'insegnamento di Tecnologie Educative. I risultati hanno confermato che la maggior parte degli studenti preferisce testi accademici su carta e che l'uso di uno strumento di annotazione sociale con testi accademici digitali, può cambiare positivamente la percezione della lettura e della comprensione dei testi sullo schermo. Sono emerse una correlazione significativa tra la lettura delle annotazioni altrui per riassumere concetti, una comprensione più chiara dei contenuti e la soddisfazione per i testi accademici digitali; tali risultati possono essere utili per il miglioramento delle pratiche di insegnamento accademico quando si utilizzano materiali digitali.

PAROLE CHIAVE Lettura Digitale; Strumenti di Annotazione; Studenti Universitari;

1. Theoretical overview

1.1. Reading on screen and reading on paper

Study texts have always played an important role in the university curriculum. Today, many of these texts are provided in digital format. Many past studies has suggested that reading on digital screens can impair comprehension compared to reading on paper (Lenhard et al., 2017; Delgado, 2018), even though more recent meta-analyses have shown mixed results (Clinton, 2019; Li & Yan, 2024).

This activity of reading on a screen is often made difficult by multiple factors: among the most obvious physical ones we can mention for example "computer vision syndrome", which includes eye-strain, dry eyes, headaches, and neck pain (Al Tawil et al., 2020; Mowatt et al., 2018). From a cognitive point of view, texts read on the screen of a PC, Smartphone or Tablet seem to make the process of reading and interpreting the content less effective. Different reading media therefore would seem to possess different physical characteristics that enable different sensorimotor experiences and affect the cognitive processing of the reading text. One of these is the size of the device screen, which is a relevant factor if it is too small and is capable of displaying a few lines of text that are broken between multiple pages: this negatively affects reading comprehension and speed by overloading working memory (Sheen & Luximon, 2021) (Elliott et al., 2020).

It's important to note that the relationship between reading medium and comprehension is complex and can be influenced by various factors. Li & Yan (2024) found that digital reading can be more effective when readers use specific reading strategies or when the digital text provides interactive features. The layout and representation of text on screen can also play a role. Studies have shown that when the on-screen representation of the text is similar to the layout of the text on paper, perceived difficulties are reduced (Mangen et al., 2019).

However, the process of reading and interpreting a text is not only a purely cognitive or visual act of perception but is also multi-sensory physiological (McLaughlin, 2016; Spence, 2020). For example, the physical handling of books constitutes a sensory experience that connects as much on an emotional level as it does on a rational level (Griffiths & Starkey, 2018), also utilizing the nonvisual senses in the reader's experience. Indeed, digital texts to date have not been able to successfully reproduce the sensation associated with haptic contact with the paper or a book (Hou et al., 2017). Many factors contribute to the difficulty in perceiving and comprehending digital text, including how the reader moves through the text itself. For instance, there are two common methods: scrolling and paging. Studies have shown that readers, especially students, tend to have better comprehension when reading page by page rather than scrolling through the pages (Haverkamp et al., 2022). Page structure is important: in print reading, our brain builds a cognitive map of the text, with precise landmarks in the layout; in digital reading, the map becomes dynamic and variable, and easily causes visual landmarks (spatial cues) to be lost, requiring more effort from our working memory (Hou et al., 2017).

Some research confirms that if the on-screen representation of the text is similar or equal to the layout of the text on paper, the perceived difficulties are less (Hou et al., 2017; Porion et al., 2016). Then, if the text contains distractors such as hyperlinks connecting it to other texts, this hinders the reader even more in the construction of the cognitive map, generating disorientation (Payne & Reader, 2006). Generally, therefore, it appears that reading on paper is associated with better comprehension than reading on screen, and the effect size was greater in studies that used longer or more complex texts, as well as in studies that used a within-subjects design, in which participants read the same text in both media (paper and screen). In particular, the effect size is greater when the text is expository (Delgado et al., 2018).

Other authors also suggest how the mode of reading digital content to which we are now accustomed on social networks or the Web has become extremely fast, superficial (Annisette & Lafreniere, 2017) and distracting, now also capable of affecting the reading of all other kinds of digital texts, including those without the potential distractions generated by hypertext links and beyond (DeStefano & LeFevre, 2007). Screen reading is inherently distracting because of frequent multitasking activities. When people read a text on a digital medium they are always connected to the Net anyway and are constantly dealing with external distractions such as social media notifications, email alerts, and pop-ups (Rosen, 2017; Luke & Jensen, 2022) (Mangen et al., 2019) or internal distractions when the decision to switch between tasks can be decided independently, as people feel compelled to constantly check their devices for fear of missing something (Dontre, 2021). According to this cognitive "shallowing" hypothesis, study texts would also be subject to it, requiring more concentration and more careful processing of content (Delgado et al., 2018; Latini et al., 2019).

Other elements may influence reading in a given medium whether digital or print, such as time, the level of difficulty required for reading, motivation, interest, and emotionality aroused by the topic (Kaakinen et al., 2018). The results of an experimental study highlight that printed texts were more likely to activate areas of the brain involved in emotion processing (Venkatraman et al., 2016) while the time available for reading seems to affect comprehension and supports the hypothesis of superficial processing of information on the screen especially under time pressure (Delgado & Salmerón, 2021).

Concerning motivation, there seems to be a strong connection between intrinsic motivation for reading and text comprehension: for example, many college students lack the motivation to read assigned academic texts even though they recognize their importance and are driven rather by extrinsic motivations such as grades and deadlines for completing assignments (Mokhtari et al., 2009; Ihara & Del Principe, 2018). In this sense, the development of intrinsic motivation for academic reading is critical for text comprehension (Andrianatos, 2018; Boakye et al., 2014). Other recent research has explored the role of teacher support and guidance in promoting students' motivation to read academic texts: providing explicit guidance on reading strategies and engaging students in discussions about the text can increase their motivation to read (Muñoz, 2016; Pelletier, 2022).

1.2. Study strategies on print and digital academic texts

Generally, academic texts are considered a difficult read because of the complex content expressed in technical vocabulary and because of the way they are presented, although the overall perceived degree of difficulty might depend on the type of discipline: for example, Pecorari et al. (2012). textbooks are evaluated differently by engineering students and humanities students: the former rated their textbooks negatively for readability but positively for the quality of the content, and the latter found their textbooks very readable but not visually appealing. Digital texts are mostly enjoyed through a device connected to the Net and thus benefit from many affordances: for example, it is easier and more immediate to search for the meaning of specialized terms, which improves the text comprehension process (Wright & Cervetti, 2017).

One element that seems to be crucial to the improved ability to comprehend and memorize texts are the study strategies adopted by students such as note-taking, underlining, or highlighting. Many studies point out that underlining a keyword and adding notes minimize cognitive load and facilitate comprehension of content and its retrieval during the rereading process. However, students highlight texts and annotate much more when reading a printed text than when reading a digital text (Schugar et al., 2011; Goodwin et al., 2020), and this is probably one of the reasons why college students seem to prefer read-

ing academic texts in paper format (Baron et al., 2017) precisely because they can use highlighting and note-taking more easily on paper (Mizrachi et al., 2018). This is because the corresponding digital marking/noting activity on screen is perceived as manually more difficult and more time-consuming than the action of annotating or highlighting with highlighters or pens/pencils directly on the paper text. Not surprisingly in this context, memory retention is significantly higher among students who take notes by hand than among those who take notes directly on their notebooks or tablets (Smoker et al., 2009).

In the university context, materials provided in digital format are often used by faculty precisely to support active teaching strategies, for example by making it easier for students to then find/copy parts of the text to discuss and reflect on by reporting them in specific Forums (Foasberg, 2014). However, Forums have acknowledged cognitive criticalities: for example, the threads certainly allow sufficient space to generate long and articulate comments, but they are often rich in digressions and thus constitute a potential obstacle to students' ability to gain an in-depth understanding of texts. In addition, the chronological and topological/hierarchical organization of posts in very long threads causes a dispersion of attention due to the difficulty in maintaining focus on the most important topics (Sun & Gao, 2017). The traditional forum does not make it easy to visually manage the discussion structure and relationships between posts in different threads (Wise et al. 2013; Marbouti & Wise, 2016).

1.3. The Social Annotation Tools

Annotation software is often used to try to solve these difficulties. The interface of such software offers the possibility of highlighting individual words or phrases in the document and displaying in adjacent space discussions constrained to those specific parts of the text, thus overcoming the cognitive overload typical of traditional Forums (Chen et al., 2014). Here the social and collaborative component is very important since annotation and highlighting have a significantly greater impact on text comprehension when conducted together with others and not alone (Johnson et al., 2010).

The use of annotation tools also has critical issues, such as when cognitive overload is created due to a large number of comments fixed on a single part of a text or perceived limitations if there are possible constraints on the number of comment lines that can be inserted. Finally, one may experience visual/cognitive fatigue due to the effort of interpreting text when it is marked with very strong colors and/or by underlining. It should be said that these collaborative annotation tools are not to be considered as a better alternative to traditional Forums, but rather as the most appropriate tool for interactive activities that teachers can use to stimulate students to critically read and comment on study texts in digital format. The combination of reading strategies and interactive functions provided by this tools may positively moderate the understanding effect of digital reading (Li & Yan, 2024). This aligns with our findings on the positive effects of social annotation tools, which will be discussed in detail in the results section. This explorative research aims to verify the results of similar studies and in particular to understand whether the use of collaborative annotation software can change students' perceptions of reading and comprehension of digital texts.

2. The research background, objectives and method

2.1. Research questions

Given the premises set forth in the theoretical part, the research therefore sought to answer the following questions:

1) Which format, print or electronic, do students prefer for reading academic materials provided by faculty during courses?
2) How do different digital media (e.g., desktop, laptop, tablet, smartphone) affect students' perceptions of reading preference?
3) Do students annotate and engage with paper-based academic materials differently compared to digital materials?
4) Can the use of the NowComment social annotation software have a positive impact on students' perceptions of digital reading comprehension, compared to traditional digital reading methods?

2.2. Participants, method and data collection

This study employed an exploratory mixed-methods approach that involved 112 first-year students of a Master's Degree Course (M= 29, F= 83) on Educational Technologies, with an average age of 23.6 years (StDev=2,7). The students came from a university population of predominantly middle-class: this is an important factor that can be a powerful predictor of study skills and text comprehension, even when mediated by digital technologies. All participants either had a predominantly humanistic academic background (Kulo et al., 2014). This orientation is particularly relevant to our study, as this may influence the generalizability of our findings to other types of academic texts, that use images, graphs or formulas, for example.

The study tried to gather both quantitative and qualitative data through a structured questionnaire designed to assess students' perceptions of digital and paper-based reading formats. It included both Likert scale questions and open-ended responses that allowed students to elaborate on their preferences and experiences and give detailed feedback. To provide a deeper understanding of how the NowComment tool influenced learning behaviors, we also tracked and logged detailed interaction data within the software including 1) metrics such as time spent on each page, 2) number of annotations made, 3) types of annotations (e.g., highlighting vs. commenting), and the interaction between students within the tool (e.g., responses to others comments).

Both printed text and digital texts in PDF format were provided during the Course. All texts covered similar topics. There were four digital texts, and they had a total length of 21,000 words with an average length of 5,250 words each, while the printed text was 50,000 words. The four digital texts were entered into NowComment and then opened to student comments. Each student was required to enter at least two comments per digital document for a minimum total of eight comments to be made asynchronously within two months. It was left free to use any device to complete the task (Desktop PC, Tablet, Notebook, Smartphone). Comments required for the social annotation task could be either new comments or feedback on comments already entered by other students. Finally, as specified in the limitation section, it was not possible to have a control group, and this means that while our findings can suggest associations and potential effects, we cannot make strong causal claims.

2.3. Software tool

NowComment was selected as the annotation tool for this experiment due to its straightforward interface and specific functionalities suited for our study goals. NowComment is an online collaborative platform that facilitates discussion and annotation on various formats such as text, Word files, PDFs, images, and videos. This software was selected instead of similar tools like Perusall to avoid

introducing complex variables related to the scoring of student comments: NowComment allows to focus on direct interactions with the text, rather than on peer-to-peer evaluation, which can complicate the analysis of individual comprehension and engagement.

The tool enables users to highlight specific sections of text with different colors—each representing a distinct response type (e.g., red for disagreement, green for agreement, blue for uncertainty), simplifying the process of tracking cognitive and affective reactions to the content. Users can comment directly on the text with a simple click, and these comments become a focal point for further discussion. Importantly, the instructor can control the visibility of comments, delaying their display to manage the flow of discussion and to moderate the influence of dominant voices, thereby minimizing performance anxiety among students and promoting a diversity of perspectives.

2.4. The questionnaire

In an attempt to answer the research questions, a questionnaire adapted from the Academic Reading Format Questionnaire by Mizrachi et al. (2018) was developed and consisted of 26 closed-ended items for which participants were asked to select an answer (or multiple answers) and 4 open-ended questions. A 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) was used. At the end of the Course, students were asked to complete the questionnaire only after the exam, which required studying the materials in both formats and completing the annotations on the NowComment site. The questionnaire investigates students' perceptions of their reading preference for academic materials provided by faculty in digital and hard copy formats. Specifically, the questions explored a total of four dimensions:

- the reading format preference and the reasons for it,
- the types of devices most frequently used for digital reading and any physical or cognitive problems that may make reading difficult (i.e., the need to wear glasses/contact lenses),
- the potential distractive effects of reading on screen versus on paper,
- the perceived effect of using NowComment in reading/commenting on digital texts, and concentration and comprehension of specific concepts.

The open-ended questions allowed participants to clarify why they had reading preferences and how using the NowComment social annotation tool changed their perceptions of on-screen reading. Statistical elaborations were then carried out with Jamovi v. 2.3.22 software and text analysis ones with Voyant Tools 2.2.

3. Analysis of results and Discussion

3.1. Reading medium preferences

The following results should be interpreted as preliminary findings due to the exploratory nature of this study; anyway most students (66%) confirm the findings of the literature on the subject and say they prefer reading academic texts on paper, and as many as 55% would like to have the texts in both formats (Tab. 1). If they are provided only digitally as many as 73% say they would still print course materials on paper rather than read them on the screen. The choice also seems to be a function of the length of the digital text: it will definitely be printed if it is longer than 5 pages by 75.9% of students and if longer than 10 pages by 85.8%.

Responses to the corresponding open-ended question asking them to explain why they prefer one format or the other, or both, highlight that students give different answers based on their personal

Table 1. Students' preference for reading academic texts. Likert scale 1=not at all, 5=very much.

	1	2	3	4	5	M	StD
All texts on paper	7.1%	5.4%	21.4%	33.9%	32.1%	3.79	1.17
Texts on screen and on paper	6.3%	18.8%	19.6%	22.3%	33.0%	3.57	1.29

needs and study modes, but still reflect perceived positive/negative affordances for the two formats. Printed academic texts are more convenient to read for extended periods and offer an embodied reading experience, but they can be heavier to carry (if they are books) and more expensive to purchase, while in digital format does not have these problems and allows for utility features such as searching for key terms. The most significant categories of reasons for preference that emerged from the textual analysis of the responses are six. We report them here along with some of the responses:

Readability and accessibility

The majority of participants, as we have seen, are for reading on paper because they find it less tiring especially for their eyes and because they feel they have more control over the content and without being distracted by interruptions that come from online connected Apps. Conversely, others prefer to read on screen because they can enlarge the text, change the background color, and use other accessibility tools to make reading easier.

"*I find it easier to read text on screen because I can adjust the font size or use accessibility features.*"

"*on the screen my eyes get tired more easily.*"

"*Reading a book on paper is more comfortable for me because I can concentrate better on the text without being distracted by notifications.*"

Searching, Selecting, Organizing, and Copying Information

Within this category, digital texts are favored because they allow you to copy and paste the most important parts, quickly search for terms that define important concepts, and easily add links to other content.

"*I prefer the paper format, but the electronic format is more convenient for searching for information.*"

"*In paper documents I can mentally fix concepts better, while those in electronic format make it easier for me to retrieve key words to quickly find a specific concept.*"

"*I work with digital texts when I need to do copy-paste or cut-paste to arrange my notes on the computer.*"

Annotation

Here most preferences for annotations are for paper because it is perceived as an easier and more immediate medium to use. Others prefer digital texts because they can be easily copied and pasted and are always available.

"*I would want both because I would be able to take notes and underline on the paper text, but I would also always have the electronic format available for quick reference at any time.*"

"*I like taking notes and being able to underline, cross out, mark or stick post-it notes on texts when I read and study. Although there are applications that allow you to do this kind of work on the computer for me it will always be better to have a piece of paper at hand.*"

Portability, availability, space

Here most participants find it useful to have a choice between the two formats depending on their preferences and contextual needs at the time.

"…I find myself far better off studying on paper but sometimes it is convenient to have the materials in digital format so that I always have them at hand."

"*electronic texts I can consult and they don't take up space in the bookstore. The paper ones I use to study but then I am forced to give them away because of lack of space*".

"*I would like both to be able to consult the book even from my PC or Smartphone when I don't have the paper book at hand.*"

Translation from/to other languages

Some students pointed out the importance of the digital format when there is a need to read and study materials in a foreign language.

"*The digital format is useful in case there are foreign language texts that can automatically translate with an App.*"

Ecology and sustainability

Students often express environmental concerns but also the desire for a more tangible reading experience.

"I *would prefer the texts to be in electronic format for an ecological issue, but then I would feel the need to summarize the content on paper because it makes it closer to me.*"

"*I prefer the digital format because it reduces environmental impact and paper consumption.*"

3.2. Devices used for digital reading between vision difficulties and portability needs

The responses are interesting in that much research shows how the limited screen size of devices can affect reading difficulty and consequently content learning. The first preference is for reading on Desktops and Notebooks but those for Tablets and Smartphones are also consistent. The fact that many students still use portable devices with small screens for reading academic texts probably indicates that in their life context portability is perceived as more important, or at least equal, to readability. In this sense, students also report using multiple devices for reading: the most frequent combination is Desktop PC & Smartphone (14.3%), followed by Notebook & Tablet (8.9%), and finally Notebook & Smartphone (7.1%).

One unexpected result concerns those with physical vision problems that force them to wear glasses or lenses (Tab. 2), these do not seem to significantly influence students' reading preferences, when asked whether reading on paper is less stressful than reading on a screen, participants with aids such as glasses or lenses answered very or very much at 76 percent, while those without vision problems answered with a higher 84 percent. This difference of almost ten percentage points could be an indication of undiagnosed vision problems in the group not wearing visual aids or also from other factors such as reading habits or type of text.

Table 2. Reading preference on paper in relation to visual problems. Likert scale 1=not at all, 5=very much.

	1	2	3	4	5	M	StD
With Glasses/Lenses	4.5%	4.5%	14.9%	28.4%	47.8%	4.10	1.10
Without Glasses/Lenses	4.4%	4.4%	6.7%	35.6%	48,9%	4.20	1.06

3.3. Distraction, stress and boredom in digital and paper-based reading of academic texts

Responses to questions about the perceived level of stress and boredom associated with reading on screen or on paper (Tab. 3) reveal that nearly 80 percent of students tend to perceive reading on screen as more stressful than reading on paper, while 60 percent perceive it as more boring. In this context, boredom refers to the level of emotional engagement and ability to maintain attention while reading, while stress refers to the level of emotional and physical tension experienced while reading (Weinerman & Kenner, 2016). Regarding boredom, one possible explanation is that screens offer fewer tactile experiences than reading on paper, such as holding a book and flipping through its pages while physically interacting with the text to take notes or highlight important parts. If the text is then perceived as long, other factors come into play related for example to visual stress.

Stress can be generated by distractions from notifications or other online-connected Social Apps that are present in the same device used for reading: these force multitasking actions and thus a feeling of less engagement when reading academic texts (Baron et al., 2017) The feeling of stress can also be felt due to physical effects such as increased visual tension due to prolonged screen fixation (Mowatt et al., 2018). This condition of visual fatigue is generally characterized by prolonged use of digital devices: factors such as brightness, contrast, and possible flicker can contribute greatly to visual stress. In this sense, students' responses on the effects of the length of the text, and thus the time required for reading, are significant: if it exceeds 5 pages, 65 percent of students would like it printed, while if it exceeds 10 pages, the percentage rises to as much as 86 percent.

Significant in this regard is the preference of more than 80% of the participants in re-reading to review academic texts on paper rather than on screen: this behaviour seems to correlate significantly with "ease of memorization on paper" (Pearson r=0.611, p-value <.001) and "more concentration on paper" (Pearson r=0.618, p-value <.001) and could also be due to the length factor as indicated by the correlation index between the "preference to read on paper if the text is greater than 10 pages" and the propensity to "re-read on paper to review" (Pearson r=0.518, p-value <.001).

Table 3. Preference for reading: students' perception of stress, boredom and interruptions reading academic texts on screen and on paper. Likert scale 1=not at all, 5=very much

	1	2	3	4	5	M	StD
Reading on paper is less stressful than on screen	4.5%	4.5%	11.6%	31.3%	48.2%	4.14	1.08
Reading on paper is less boring than on screen	5.4%	8.0%	25.9%	35.7%	25.0%	3.67	1.10
Reading on the screen, I sometimes interrupt myself to surf the Web to understand more on some important point	4.5%	14.3%	43.8%	27.7%	9.8%	2.44	1.18
Reading on the screen, I sometimes interrupt myself to use some App or browse the Web on sites that have nothing to do with the study	28.6%	24.10%	25.9%	17.9%	3.6%	3.24	0.97

3.4. Social Annotation and the facilitation of the comprehension process

During face-to-face classes, 45.1% of students say they use their Notebook to take notes and 54.9% of students on paper. Interestingly note, 23.2% of those who take notes on paper, however, also state that they later report their notes in digital format. While studying academic texts, almost all (92.9%) underline and annotate them if they are in paper format. The question whether the NowComment social annotation tool helped in understanding study texts in digital format had 63.6% positive responses (very much or very much). The question of whether it was easier to focus on important concepts in the digital text on NowComment than in the printed text received a positive response from 78.4% of the participants (very much or very much).

This result was also substantially confirmed by the response to the question of whether using the software made it easier to discuss important concepts than in a traditional forum, with 82.4 percent responding positively. The annotation process involves multiple possible actions for interacting with the text: highlighting, underlining, note-inserting, and note-reading: some students used all of these features, while others used only the last two since many significant passages in the text had already been underlined or highlighted by their peers.

Regarding the perceived effects of using the NowComment software, 61 percent of students claimed to have read all or most of their classmates' annotations, and 62 percent confirmed that the annotations made by others helped a great deal in better understanding concepts and extrapolating the most important ones. Analysis of variance indeed showed a significant positive correlation between responses on the "usefulness of annotations made by others" and "ease in focusing on specific concepts" (Pearson r = 0.589, p-value < 0.05). Tab.5 represents a correlation matrix showing the strength of the association between some variables related to the use of NowComment particularly regarding the feature of inserting annotations.

We can observe that:

1) the ease of focusing on specific concepts compared to reading on paper has a Pearson coefficient r =0.724 ($p < 0.001$), indicating a strong positive correlation between these two variables. This suggests students find it easier to focus on specific concepts when using annotation software to read digital texts than when reading on paper;
2) the usefulness of other students' digital annotations to better understand a concept has a Pearson coefficient r=0.662 ($p < 0.001$), indicating a significant positive correlation. Thus, students find it useful to read others' annotations to improve their understanding of concepts;

Table 4. Correlation Matrix of NowComment's Impact on Students' Perception of Textual Understanding and Annotation Enhancement.

	1	2	3
1 Helped me in understanding the texts in digital format	-	-	-
2 Has made it easier to focus on specific concepts than on paper.	r= 0.724 p-value <.001	-	-
3 Digital Annotations from other students have made it easier for me to better understand a concept.	r= 0.554 p-value .007	r= 0.662 p-value <.001	-
4 Digital Annotations from other students have made it easier for me to summarize important concepts	r= 0.551 p-value .008	r= 0.567 p-value .006	r= 0.853 p-value <.001

Notes. * $p < .05$, ** $p < .01$, *** $p < .000$, df=20.

3) the usefulness of other students' annotations to summarize important concepts has a Pearson coefficient of 0.853 ($p < 0.001$), indicating a strong positive correlation, and this suggests that students find it useful to read others' annotations to summarize concepts and get a clearer view of the content of the text.

In their open-ended responses, many students clarify in this regard that the Social Annotation Tool has helped them greatly in understanding the study materials especially because the comments summarize the important parts and because the NowComment interface allows them to see all the comments visually ordered and in the exact place in the text to which they refer:

"*Reading colleagues' comments is like reading a summary of a text, so it made comprehension more immediate*."

"*The interaction with peers and the ability to annotate in a more orderly manner seems to me to have facilitated the learning of some concepts*."

"*One can refer to a specific part of the text in a simple way, as well as comment and discuss with several people while keeping the key concept being discussed firmly in mind*."

"*Knowing that I had to pertinently comment on the articles with notions learned in the classroom and beyond allowed me to maintain a constant attentional threshold consequently facilitating reading*."

Few students, however, responded that NowComment did not help them with reading, such as because they have "vision problems and reading on the screen is always difficult" or that the software helped them only partially without specifying why. These findings align with recent meta-analysis results from Li & Yan (2024), which showed that when students use reading strategies or when digital reading devices provide interactive functions, the understanding effect of digital reading can be better than that of paper reading. In our study, the social annotation tool provided both a platform for employing reading strategies (through annotation and summarization) and interactive functions (through peer comments), which may explain its positive impact on perceived comprehension and engagement with the text. This aligns with Li and Yan's finding of significant benefits when these features are present in digital reading.

4. Conclusion

The mixed results in the recent literature on the topic, underscore the complexity of comparing digital and paper reading and highlight the need for further research in this area. Anyway, the results of this study confirm those of most of the literature: the majority of students would like academic texts on paper. Even when they only have access to their digital version, they still prefer to print it, and this seems to be related to the length of the text: the longer it is, the greater the propensity to read it on paper especially if it has to be re-read several times to facilitate memorization of the content (Baron, 2021). These preferences generally reflect their personal needs based on the perceived positive/negative affordances of the two formats, especially regarding readability, accessibility, text searchability and editing, and annotation. Most participants say they read digital texts on large screens, but a significant number also prefer to use portable devices such as Tablets and Smartphones because of their greater portability while admitting that small screens can negatively affect reading and learning of content. However, reading on screen is always perceived as more stressful also because of the "multitasking" distractions generated by notifications or social apps that can reduce concentration while reading on a device that is now always connected online (Liu, 2022).

In this highly paper-oriented context of reading academic texts, the use of a Social Annotation Tool such as NowComment had overall positive effects on students' perceptions of understanding academic

texts in digital format. In particular, one's annotations and especially those made by others, played an important role in the stated ability of focus and attention (Delgado & Salmeron, 2021) especially when it comes to identifying and memorizing concisely the most important concepts and thus facilitating their comprehension. The collaborative dimension and thus the ability to see and intervene in the annotations made by other students is certainly one of the factors that favored enjoyment in screen reading, probably interaction with others is an essential factor affecting the students' reading motivation (Li & Li, 2022).

The results of this research may lead to suggestions for improving academic teaching practices when it is necessary to provide study materials in digital format. Given that screen reading results in higher cognitive loads and inefficient learning strategies (Ackerman & Lauterman, 2012) (Delgado et al., 2018) it would be useful to provide students with the opportunity to read study texts consisting of many pages on paper, and at the same time provide an active reading activity with a Social Annotation Tool in which digital texts broken down in chapters or parts of the academic text not exceeding 10-12 pages (1,500-2,000 words). Students should also be reminded of the importance of limiting or eliminating distractions from Social or Web browsing as much as possible while engaged in on-screen reading. In this way, the benefits of both reading modes can be had while avoiding their criticalities.

5. Study Limitation

While our results are encouraging, they do not allow for definitive causal conclusions about the effectiveness of annotation tools in improving digital reading comprehension: in this explorative research it was not feasible to have both an experimental group using the software and a control group reading the digital texts without the software: this would have allowed for a comparison of perceptions of reading. This will be a focus for future research.

6. References

Ackerman, R., & Lauterman, T. (2012). Taking reading comprehension exams on screen or on paper? A metacognitive analysis of learning texts under time pressure. *Computers in Human Behavior, 28*(5), 1816-1828.

Al Tawil, L., Aldokhayel, S., Zeitouni, L., Qadoumi, T., Hussein, S., & Ahamed, S. S. (2020). Prevalence of self-reported computer vision syndrome symptoms and its associated factors among university students. *European Journal of Ophthalmology, 30*(1), 189-195.

Andrianatos, K. (2018). First year university students' reading strategies and comprehension: Implications for academic reading support (Doctoral dissertation, North-West University). https://repository.nwu.ac.za/handle/10394/30846

Annisette, L. E., & Lafreniere, K. D. (2017). Social media, texting, and personality: A test of the shallowing hypothesis. *Personality and Individual Differences, 115*, 154-158.

Baron, N. (2021). *How we read now: Strategic choices for print, screen, and audio*. Oxford University Press.

Baron, N. S., Calixte, R. M., & Havewala, M. (2017). The persistence of print among university students: An exploratory study. *Telematics and Informatics, 34*(5), 590-604.

Boakye, N., Sommerville, J., & Debusho, L. (2014). The relationship between socio-affective factors and reading proficiency: Implications for tertiary reading instruction. *Journal for Language Teaching = Ijenali Yekufundzisa Lulwimi = Tydskrif vir Taalonderrig, 48*(1), 173-213.

Chen, C. M., & Chen, F. Y. (2014). Enhancing digital reading performance with a collaborative reading annotation system. *Computers & Education, 77*, 67-81.

Clinton, V. (2019). Reading from paper compared to screens: A systematic review and meta-analysis. *Journal of Research in Reading, 42*(2), 288-325.

Delgado, P., & Salmeron, L. (2021). The inattentive on-screen reading: Reading medium affects attention and reading comprehension under time pressure. *Learning and Instruction, 71*, 101396.

Delgado, P., Vargas, C., Ackerman, R., & Salmerón, L. (2018). Don't throw away your printed books: A meta-analysis on the effects of reading media on reading comprehension. *Educational Research Review, 25*, 23-38.

DeStefano, D., & LeFevre, J.-A. (2007). Cognitive load in hypertext reading: A review. *Computers in Human Behavior, 23*(3), 1616-1641.

Dontre, A. J. (2021). The influence of technology on academic distraction: A review. *Human Behavior and Emerging Technologies, 3*(3), 379-390.

Elliott, L. J., Ljubijanac, M., & Wieczorek, D. (2020). The effect of screen size on reading speed: A comparison of three screens to print. In *Advances in Human Factors in Training, Education, and Learning Sciences*. Springer International Publishing.

Foasberg, N. M. (2014). Student reading practices in print and electronic media. *College & Research Libraries, 75*(5), 705-723.

Goodwin, A. P., Cho, S. J., Reynolds, D., Brady, K., & Salas, J. (2020). Digital versus paper reading processes and links to comprehension for middle school students. *American Educational Research Journal, 57*(4), 1837-1867.

Griffiths, F., & Starkey, K. (2018). Sensing through objects. In F. Griffiths & K. Starkey (Eds.), *Sensory Reflections: Traces of Experience in Medieval Artifacts* (pp. 1-21). Walter de Gruyter.

Haverkamp, Y. E., Bråten, I., Latini, N., & Salmerón, L. (2022). Is it the size, the movement, or both? Investigating effects of screen size and text movement on processing, understanding, and motivation when students read informational text. *Reading and Writing, 1-20*.

Hou, J., Rashid, J., & Lee, K. M. (2017). Cognitive map or medium materiality? Reading on paper and screen. *Computers in Human Behavior, 67*, 84-94.

Ihara, R., & Del Principe, A. (2018). What we mean when we talk about reading: Rethinking the purposes and contexts of college reading. *Across the Disciplines, 15*, 1-14.

Johnson, T. E., Archibald, T. N., & Tenenbaum, G. (2010). Individual and team annotation effects on students' reading comprehension, critical thinking, and meta-cognitive skills. *Computers in Human Behavior, 26*(6), 1496-1507.

Kaakinen, J. K., Papp-Zipernovszky, O., Werlen, E., Castells, N., Bergamin, P., Baccino, T., & Jacobs, A. M. (2018). Emotional and motivational aspects of digital reading. In *Learning to Read in a Digital World* (pp. 141-164).

Kulo, S., Indembukhani, K., & Onchera, P. (2014). Influence of background knowledge on reading comprehension ability in Kenyan secondary schools. *Journal of Emerging Trends in Educational Research and Policy Studies*, *5*, 592-599.

Latini, N., Bråten, I., Anmarkrud, Ø., & Salmerón, L. (2019). Investigating effects of reading medium and reading purpose on behavioral engagement and textual integration in a multiple text context. *Contemporary Educational Psychology, 59*. https://doi.org/10.1016/j.cedpsych.2019.101797

Lenhard, W., Schroeders, U., & Lenhard, A. (2017). Equivalence of screen versus print reading comprehension depends on task complexity and proficiency. *Discourse Processes, 54*(5-6), 427-445.

Li, M., & Li, J. (2022). Using Perusall to motivate students' curriculum-based academic reading. *Journal of Computers in Education, 1-25*.

Li, Y., & Yan, L. (2024). Which reading comprehension is better? A meta-analysis of the effect of paper versus digital reading in recent 20 years. *Telematics and Informatics Reports*, *14*, 100142.

Liu, Z. (2022). Reading in the age of digital distraction. *Journal of Documentation, 78*(6), 1201-1212.

Luke, S. G., & Jensen, T. (2022). The effect of sudden-onset distractors on reading efficiency and comprehension. *Quarterly Journal of Experimental Psychology, 76*(5). https://doi.org/10.1177/17470218221108355

Mangen, A., Olivier, G., & Velay, J.-L. (2019). Comparing comprehension of a long text read in print book and on Kindle: Where in the text and when in the story? *Frontiers in Psychology, 38*.

Marbouti, F., & Wise, A. F. (2016). Starburst: a new graphical interface to support purposeful attention to others' posts in online discussions. *Educational Technology Research and Development*, *64*, 87-113.

McLaughlin, T. (2016). *Reading and the body: The physical practice of reading*. Springer.

Miyazoe, T., & Anderson, T. (2012). Discuss, reflect, and collaborate: A qualitative analysis of forum, blog, and wiki use in an EFL blended learning course. *Procedia – Social and Behavioral Sciences, 34*, 146-152.

Mizrachi, D., Salaz, A. M., Kurbanoglu, S., Boustany, J., & ARFIS Research Group. (2018). Academic reading format preferences and behaviors among university students worldwide: A comparative survey analysis. *PloS One, 13*(5), e0197444.

Mokhtari, K., Reichard, C. A., & Gardner, A. (2009). The impact of internet and television use on the reading habits and practices of college students. *Journal of Adolescent & Adult Literacy, 52*(7), 609-619.

Mowatt, L., Gordon, C., Santosh, A. B. R., & Jones, T. (2018). Computer vision syndrome and ergonomic practices among undergraduate university students. *International Journal of Clinical Practice, 72*(1), e13035.

Muñoz, C., Valenzuela, J., Avendaño, C., & Núñez, C. (2016). Improvement in academic reading motivation: Motivated students perspective. *OCNOS Revista de Estudios sobre Lectura*, *15*(1), 52-68. https://10.18239/ocnos_2016.15.1.941

Nor, N. F. M., Azman, H., & Hamat, A. (2013). Investigating students' use of online annotation tool in an online reading environment. *The Southeast Asian Journal of English Language Studies, 19*(3), 87-101.

Payne, S. J., & Reader, W. R. (2006). Constructing structure maps of multiple online texts. *International Journal of Human-Computer Studies, 64*(5), 461-474

Pecorari, D., Shaw, P., Irvine, A., Malmström, H., & Mežek, Š. (2012). Reading in tertiary education: Undergraduate student practices and attitudes. *Quality in Higher Education*, *18*(2), 235-256.

Pelletier, D., Gilbert, W., Guay, F., & Falardeau, É. (2022). Teachers, parents, and peers support in reading predicting changes in reading motivation among fourth to sixth graders: A systematic literature review. *Reading Psychology, 43*(5-6), 317-356.

Porion, A., Aparicio, X., Megalakaki, O., Robert, A., & Baccino, T. (2016). The impact of paper-based versus computerized presentation on text comprehension and memorization. *Computers in Human Behavior*, *5*, 569-576.

Suhre, C., Winnips, K., de Boer, V., Valdivia, P., & Beldhuis, H. (2019, June). Students' experiences with the use of a social annotation tool to improve learning in flipped classrooms. In *Fifth International Conference on Higher Education Advances*.

Rosen, L. D. (2017). The distracted student mind-enhancing its focus and attention. *Phi Delta Kappan, 99*(2), 8-14.

Sheen, K. A., & Luximon, Y. (2021). Effect of in-app components, medium, and screen size of electronic textbooks on reading performance, behavior, and perception. *Displays, 66*, 101986.

Schugar, J. T., Schugar, H., & Penny, C. (2011). A Nook or a Book? Comparing college students' reading comprehension levels, critical reading, and study skills. *International Journal of Technology in Teaching & Learning, 7*(2).

Smoker, T. J., Murphy, C. E., & Rockwell, A. K. (2009). Comparing memory for handwriting versus typing. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 53*(22), 1744-1747. SAGE Publications.

Spence, C. (2020). The multisensory experience of handling and reading books. *Multisensory Research, 33*(8), 902-928.

Suhre, C., Winnips, K., De Boer, V., Valdivia, P., & Beldhuis, H. (2019). Students' experiences with the use of a social annotation tool to improve learning in flipped classrooms. In *HEAD'19. 5th International Conference on Higher Education Advances* (pp. 955-964). Editorial Universitat Politècnica de València.

Sun, Y., & Gao, F. (2017). Comparing the use of a social annotation tool and a threaded discussion forum to support online discussions. *The Internet and Higher Education, 32*, 72-79.

Swan, K., Shea, P., Fredericksen, E., Pickett, A., Pelz, W., & Maher, G. (2000). Building knowledge building communities: Consistency, contact, and communication in the virtual classroom. *Journal of Educational Computing Research, 23*(4), 359-384.

Venkatraman, V., Dimoka, A., Pavlou, P., & Vo, K. (2016). Effectiveness of print and digital media: Insights from neuroscience. *ACR North American Advances*.

Weinerman, J., & Kenner, C. (2016). Boredom: That which shall not be named. *Journal of Developmental Education, 18-23*.

Wise, A. F., Speer, J., Marbouti, F., & Hsiao, Y. T. (2013). Broadening the notion of participation in online discussions: Examining patterns in learners' online listening behaviors. *Instructional Science, 41*(2), 323-343.

Wright, T. S., & Cervetti, G. N. (2017). A systematic review of the research on vocabulary instruction that impacts text comprehension. *Reading Research Quarterly, 52*(2), 203-226.

Italian Journal of Educational Technology, 32(2), 49-64, 2024
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1360
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

ISTITUTO TECNOLOGIE DIDATTICHE

Tackling the digital divide: Exploring ICT access and usage patterns among final-year upper secondary students in Italy

Affrontare il divario digitale: esplorare i modelli di accesso e utilizzo delle TIC tra gli studenti dell'ultimo anno della scuola secondaria superiore in Italia

Donatella Papa[A,*], Marta Desimoni[B]

[A] *Istat, Rome, Italy, donatella.papa@istat.it**
[B] *Invalsi, Rome, Italy, marta.desimoni@invalsi.it*
**Corresponding author*

HOW TO CITE Papa, D., & Desimoni, M. (2024). Tackling the digital divide: Exploring ICT access and usage patterns among final-year upper secondary students in Italy. *Italian Journal of Educational Technology*, *32*(2), 49-64. https:// doi.org/10.17471/2499-4324/1360

Received: August 17, 2024; *Accepted:* October 28, 2024; *First Published:* November 6, 2024

ABSTRACT This study examines the access and usage of Information Communication Technologies (ICTs) outside the school environment among upper secondary students in Italy, based on data from the 2021-2022 INVALSI Field Trial. The study investigates the availability of digital devices such as desktops, laptops, and smartphones, and explores usage patterns through a questionnaire addressing the first and second digital divides, socio-demographics, and other relevant factors. The findings provide food for thought for those who need to manage technology and enhance learning. Notably, 96% of students reported having access to a computer at home for both learning and non-learning activities, and 88% had internet connectivity at home. While initial results suggest a reduction in the digital access gap, logistic regression models indicate that the first-level digital divide remains challenging for certain socio-economic groups. Using association rules data mining techniques, therefore, specific activities were identified as the most influential among students. Most of the grade 13 students possessed ICT tools and used them primarily for leisure activities such as social media, online communication platforms, entertainment videos and music, and web browsing.

KEYWORDS Digital Divide; Information Communication Technologies; Digital Home Environment; Educational Data Mining; Association Rules.

SOMMARIO Questo studio esamina l'accesso e l'uso delle Tecnologie dell'Informazione e della Comunicazione (TIC) al di fuori dell'ambiente scolastico tra gli studenti delle scuole secondarie superiori in Italia, basato sui dati del Field Trial INVALSI 2021-2022. Lo studio indaga la disponibilità di dispositivi digitali come desktop, laptop e smartphone, e esplora i modelli di utilizzo tramite un questionario che affronta il primo e il secondo divario digitale, le variabili socio-demografiche e altri fattori rilevanti. I risultati offrono spunti di riflessione per chi deve gestire l'uso della tecnologia e migliorare le esperienze di apprendimento. È significativo che il 96% degli studenti abbia riferito di avere accesso a un computer a casa per attività di apprendimento e non, e l'88% avesse connettività a Internet a casa. Sebbene i risultati iniziali suggeriscano una riduzione del divario di accesso digitale, i modelli di regressione logistica indicano che il primo livello di divario digitale rimane una sfida per alcuni gruppi socio-economici. Utilizzando tecniche di data mining come le regole di associazione, sono state quindi identificate le attività più influenti tra gli studenti. La maggior parte degli studenti di grado 13 possedeva strumenti TIC e li utilizzava prin-

cipalmente per attività ricreative come i social media, le piattaforme di comunicazione online, i video e la musica di intrattenimento, e la navigazione web.

PAROLE CHIAVE Divario Digitale; Tecnologie dell'Informazione e della Comunicazione; Ambiente Domestico Digitale; Data Mining Educativo; Regole di Associazione.

1. Introduction

The rapid digitization of society, accelerated by the COVID-19 pandemic, has had profound implications for adolescents and young adults worldwide. In Italy, this shift has been particularly pronounced, with significant changes in educational practices, parental involvement, and access to digital technologies. While the pandemic has undoubtedly contributed to increased digital adoption, it's essential to recognize that the digital divide – the disparity in access to and use of technology – existed long before the crisis.

Socio-economic status (SES), in particular, plays a critical role in shaping digital inequality. Reports show that students from low SES backgrounds frequently have less access to computers and the internet, resulting in limited opportunities for educational engagement compared to their wealthier peers. For instance, studies highlight that these students may spend considerably less time utilizing digital technologies for educational purposes, primarily due to access constraints and differing levels of digital literacy. Furthermore, the Italian National Institute of Statistics (ISTAT) has documented these inequalities, emphasizing that they persist despite efforts to bridge the digital divide (ISTAT, 2020b; Di Pietro, 2021). Similarly, the European Centre for the Development of Vocational Training (Cedefop, 2021) reports that low-SES students are 1.5 times more likely to lack the necessary digital skills to fully engage with remote learning platforms during the pandemic. These disparities have significant implications for educational outcomes, social mobility, and overall well-being, with digital exclusion perpetuating existing inequalities.

Previous studies have extensively documented the digital divide, which consists of understanding differences in access to Information, Communication and Technologies (ICTs) (Attewell, 2001; DiMaggio et al., 2001; Riggins & Dewan, 2005; van Dijk, 2005), highlighting persistent inequalities along the lines of social class, age, sex, and geographic location. For example, research from Goudeau et al. (2021) and ISTAT (2020a) reveals that certain groups, particularly those from lower-income families and rural areas, need to improve regarding access to and proficiency with digital technologies. These disparities can have far-reaching consequences for educational opportunities, social mobility, and overall well-being. Research on students' access to ICT outside of school shows mixed results. Chiu (2020) highlights that ICT access is mediated by socioeconomic status (SES), leading to differences in learning outcomes. Heo and Kang (2010), along with Fernàndez-Gutièrrez et al. (2020), note that using ICT outside of school can improve academic performance. SANFO (2023) confirms this, showing that ICT use supports learning, though its impact varies based on socio-economic factors. ICT use by upper secondary students can have both positive and negative effects (Olofsson et al., 2018), with challenges related to equity and integration into formal education (Nachmias et al., 2001). European studies (Wastiau et al., 2013; Ola Lindberg & Sahlin, 2011) emphasize the need for a balanced use of ICT in and out of school to maximize educational benefits.

Despite the wealth of existing research, important gaps remain in our understanding of the digital divide among Italian youth. Further, many studies focus on broad sociodemographic factors, but less is

known about the specific ways in which access to and use of digital technologies vary within this population. For instance, what are the patterns of device ownership and usage among Italian adolescents and young adults? How do these patterns differ based on factors like age, sex, socioeconomic status, and educational level? Furthermore, while some research has explored the impact of the pandemic on digital adoption, more nuanced studies are needed to disentangle the effects of the crisis from longer-term trends in the digital divide.

Our study aims to fill these gaps by providing a detailed analysis of access to and use of digital technologies among Italian upper secondary school students during the 2021-2022 academic year. We will go beyond simple measures of device availability and investigate the complex interplay between educational and leisure use of digital media. By examining students' digital habits in depth, we will explore the nature of the digital divide and its implications for this key demographic.

To analyse this complex data, we will employ Association Rules Mining (ARM), a powerful data mining technique that can uncover hidden patterns and relationships within the data. ARM will allow us to capture the nuanced ways in which access to and use of digital technologies intersect with students' sociodemographic characteristics and activities. By exploring these previously unknown patterns, our study will contribute some insights to the ongoing research on digital divides and provide issues for future investigations.

The following research questions will guide our analysis:

Does students' access to ICT vary as a function of their sociodemographic characteristics? We will examine multiple devices and different types of access to capture the full picture of digital inequality.

What patterns exist among key items relating to students' activities, as well as among these items and students' sociodemographic characteristics? By investigating both educational and leisure use of digital media, we can explore the dynamics of the digital divide.

Through this comprehensive analysis, we will provide a clearer understanding of the digital divide among Italian young adults and contribute to the broader conversation on digital inequality in the context of rapid technological change.

2. Materials and methods

2.1. Participants and procedures

The present study is part of a larger research project on ICT-related constructs and digitally assessed mathematics among students in their final year of upper secondary school, conducted within the INVALSI 2022 Field Trial. The final sample comprised 3,254 students (49% males, 51% females; 4% first-generation immigrants, 5% second-generation immigrants, 91% natives), with 76% aged 19 years. Geographically, 29% attended schools in central Italy, 12% in the north-east, 25% in the north-west, and 34% in the south. The questionnaire and INVALSI tests were administered by INVALSI at school with an external observer present, and all data collection was anonymous.

2.2. Measures

First-level digital divide was assessed using two blocks of items: "What kind of internet connection do you have at home?" and "Do you have access to the following digital devices at home?" For internet connection, students could choose from: "slow," "medium," "fast," "I do not have access to the internet," or "I don't know/I prefer not to answer." For ICT access, devices included desktop computers,

Table 1. 95% Confidence boundaries for Cronbach's alpha.

Method	Lower Bound	Alpha	Upper Bound
Feldt	0.84	0.85	0.86
Duhachek	0.84	0.85	0.86
Bootstrapped	0.84	0.85	0.86

laptops, tablets, smartphones, smart TVs, game consoles, and e-readers. Responses were: 1 = "No"; 2 = "Yes, and only I use it"; 3 = "Yes, but it is a shared device"; 4 = "Yes, but I don't use it" (labelled as Not access, Alone, With others, and Not use, respectively).

Second-level digital divide was measured by the ICT Usage at Home (ICTUH) item, which included 24 items. These items assessed how and how often students engage in ICT-related activities outside of school. The ICTUH scale was developed by reviewing the literature on ICT use in secondary school, with a special focus on existing measures of ICT use in student populations, such as the PISA ICT Familiarity Questionnaire (OECD, 2017) and ICILS Student questionnaire (Fraillon et al., 2019). Items were tailored to Italian grade 13 students. Responses were on a five-point scale: 1 = "Never", 2 = "Once or twice a month", 3 = "Once or twice a week", 4 = "Almost every day" and 5 = "Every day". Items were reviewed for relevance, comprehensiveness of content, clarity of presentation, and ease of administration by experts in questionnaire development, researchers with expertise on students' use of ICT and digital inequalities, and secondary school teachers. Scale reliability was empirically tested. Specifically, given the ordinal nature of the raw scale, we computed ordinal alpha, which is more suitable for this type of data than the traditional Cronbach's alpha (Tavakol & Dennick, 2011). The ordinal alpha value was consistently found to be above 0.85 for each method employed, indicating good reliability.

ESCS was an index of economic, social, and cultural status computed by INVALSI, based on students' home educational resources, the highest level of education of the student's parents (PARED), converted into years of schooling, and the highest level of the parents' International Socio-Economic Index of Occupational Status (HISEI). Further details on the INVALSI methodology can be found in (Campodifiori et al., 2010).

Additional variables included student sex (0 for females, 1 for males), immigrant background (0 for natives, 1 for students born outside Italy or whose parents were born abroad), and school career (1 for repeating grades, 0 for regular students). The geographical location of the school was categorized as North-West, North-East, South, or Centre. These variables were analyzed to determine their impact on access to and use of digital devices.

2.3. Data analysis

To answer the first research question, we used logistic regression analyses to identify significant predictors of ICT access. In the logistic analyses, the dependent variable was access to each device ("0" corresponded to categories "not having access" and "not using" the device, and "1" to having access to the device, also including those shared with others). Further, a logistic regression was performed contrasting those having access neither to a desktop nor laptop computer (0) and other students (1). To account for the potential inflation of Type I error rates due to multiple comparisons, we applied the Bonferroni correction to our significance thresholds. Specifically, we divided the conventional alpha level of 0.05 by the number of tests conducted (in this case, the number of devices analysed) to deter-

mine a more stringent threshold for significance. This adjustment helps mitigate the risk of falsely identifying significant predictors and ensures a more robust interpretation of the results. This approach allowed us to systematically evaluate the influence of various sociodemographic factors on access to ICT while maintaining the integrity of our statistical findings.

To address the second research question, we employed Association Rules Mining (ARM) to uncover significant patterns in our ICTUH questionnaire data. ARM is designed to identify correlations and frequent patterns in datasets using an "if-then" approach. Unlike multivariate techniques, ARM focuses on finding associations between items. The process involves two main steps: identifying frequent items in the transactional database and generating association rules from these items (Agrawal et al., 1993; Attewell & Monaghan, 2015). The goal is to discover rules that meet specified minimum support and confidence thresholds (Abdullah et al., 2011):

- $Support = \frac{n(X \cup Y)}{N}$
- $Confidence = \frac{n(X \cup Y)}{n(X)}$

where n(X ∪ Y) is the number of events in which both X and Y are found together, N is the number of events and n(X) stands for the number of all events in which X was found.

Rather than verifying specific rules, our focus is on discovering all rules. The relationship between support and confidence represents a trade-off too little support can lead to many unattractive rules, while too much confidence can cut out. Experts typically set minimal support and minimal confidence, as noted by Zhang and Zhang (2002), which will be the approach in our subsequent study.

The data mining techniques employed in the research used R Studio and Python software, both widely used open-source software, selected because they are popular and easily reproduced in the data mining community. Specific libraries such as "caTools" for logistic regression and "mlxtend" for association rules were essential components of our analysis. (Tuszynski & Khachatryan, 2013; Raschka, 2018).

3. Results and discussion

3.1. Description of access to digital devices

This subsection illustrates the descriptive statistics for grade 13 students' access to digital devices and the internet at home. As shown in Table 2, 50.1% of students did not have a desktop computer at home, and a further 11.6% owned a desktop computer but did not use it. Otherwise, there was an increase in the percentage of laptops. Our questionnaire also considers that ICT access has evolved with mobile solutions such as tablets and smartphones replacing more traditional devices such as personal computers (henceforth PC). For tablets, 50.8% of the sample reported having access to and using them, whereas 33.7% of the sample reported not having access, and 15.5% reported not using these devices. Unsurprisingly, most students in the sample (98.3%) had access to and used a smartphone, although 9.5% shared the device with others.

The 96.1% of the sample had access to a personal computer (either a desktop or a laptop). The diagonal value in Table 3 for the intersection of desktop and laptop, denoted by the label "no access", indicates that 3.9% had no access to a PC (either a desktop or a laptop). The 27.6% of the sample used the

Table 2. Distribution of digital device usage: Percentage breakdown.

	Desktop	Laptop	Smartphone	Smart TV	Game console	e-reader	Tablet
Alone	15.5	48.6	88.8	15.4	27.9	10.1	28.6
With other	22.8	33.4	9.5	64.5	22.6	9.0	22.2
Not use	11.6	7.5	0.8	5.4	17.5	13.9	15.5
Not access	50.1	10.5	1.0	14.7	32.0	67.0	33.7
Tot.	100	100	100	100	100	100	100

Table 3. Relationship between desktop and laptop PC usage: Percentage breakdown.

Desktop/Laptop	Alone	With other	Not use	Not access	Tot.
Alone	6.4	3.2	2.9	3.0	15.5
With other	9.8	8.2	1.7	3.1	22.8
Not use	7.3	2.8	1	0.5	11.6
Not access	25.1	19.2	1.9	3.9	50.1
Tot.	48.6	33.4	7.5	10.5	100

PC (desktop and laptop) alone or shared it with others (sum of the labels 'alone' and 'with others' for desktop and laptop).

Regarding Internet access (missing values = 11%), only 1.2% of our sample reported having no access to the Internet at home and 2% reported having a slow connection. The internet connection was fast for 51.7% of the sample and medium for 35.9%.

3.2. Sex, socioeconomic, and geographical disparities in digital device access among late adolescent students

The digital divide between males and females is a topic that has garnered much attention in recent years. According to Table 4, late adolescent males tend to own and use desktop computers twice as often. However, this gap is offset by the fact that females tend to own more laptops and tablets. Considering desktop and laptop computers together, no sex gap emerged. Late-adolescent males were much more likely than females to have access to and use game consoles. This finding aligns with previous research showing that boys are more likely to use ICT heavily for entertainment purposes (Xiao & Sun, 2022).

The logistic regression analysis confirms existing literature that access to digital devices is strongly influenced by students' SES. Students in the first quartile of ESCS are significantly less likely than more affluent students to own and use a variety of digital devices, including smartphones, tablets, and PCs. This result highlights the persistent digital divide along socioeconomic lines.

The analysis suggests that students with an immigrant background show no significant differences in access to most digital devices compared to their native peers after adjusting for ESCS and other sociodemographic characteristics. These results may be partially explained by the fact that the study focuses on late adolescents in their final year of upper secondary school, a group less likely to include students who have dropped out. In Italy, dropout rates are higher among students with non-Italian citizenship, which might influence the findings (Cesareo, 2022). Further research is needed to explore \

Table 4. Odds ratios for access to digital devices: Logistic regression analysis (Bonferroni corrected).

	Desktop	Laptop	Smartphone	Smart TV	Console	e-Reader	Tablet	PC
Male	2.051***	0.505***	0.665	0.895	6.308***	0.954	0.754***	0.901
	(0.074)	(0.097)	(0.279)	(0.090)	(0.078)	(0.088)	(0.071)	(0.140)
ESCS (1st quartile)	0.589***	0.505***	0.328***	0.582***	0.863	0.691***	0.704***	0.260***
	(0.089)	(0.101)	(0.278)	(0.098)	(0.092)	(0.110)	(0.083)	(0.142)
Immigrant background	0.940	0.775	0.512	0.746	0.630	0.895	0.877	0.778
	(0.136)	(0.158)	(0.387)	(0.145)	(0.142)	(0.166)	(0.128)	(0.219)
Repeating	0.941	0.663***	1.003	1.042	1.085	0.891	0.868	0.536***
	(0.107)	(0.123)	(0.358)	(0.124)	(0.112)	(0.131)	(0.102)	(0.167)
North-East	0.834	1.137	1.026	0.757	0.814	0.855	1.045	0.892
	(0.125)	(0.161)	(0.486)	(0.145)	(0.133)	(0.154)	(0.121)	(0.245)
North-West	0.721	1.533	1.156***	0.757	0.844	1.081	1.073	1.400
	(0.101)	(0.136)	(0.391)	(0.118)	(0.107)	(0.119)	(0.097)	(0.215)
South	0.890	0.875	0.775	1.344	0.944	0.920	1.083	0.607
	(0.093)	(0.115)	(0.339)	(0.119)	(0.099)	(0.112)	(0.090)	(0.1728)
Constant	0.588***	8.611***	5.212***	5.212***	0.472***	0.293***	1.314***	30.165***
	(0.084)	(0.115)	(0.104)	(0.104)	(0.088)	(0.099)	(0.081)	(0.180)
Akaike Inf. Crit.	4,229	2,928	557	3,191	3,879	3,252	4,482	1,571

$^{***}p < 0.00625$; $^{**}p < 0.01$; $^{*}p < 0.05$.

digital access among late adolescents with an immigrant background who are not attending upper secondary school.

Geographical differences also emerged in the data, with students in the South of Italy being significantly less likely to have access to and use PCs, a finding that remains robust even after controlling for sociodemographic factors.

In conclusion, our results confirm that access to digital devices is heavily shaped by students' socioeconomic and cultural background, consistent with previous research on first-level digital divides (Benecchi et al., 2021). The geographical and gender differences, particularly in access to specific devices, with males more frequently using desktop computers and game consoles, while females tend to own laptops and tablets, highlight ongoing challenges in ensuring equitable digital access.

3.3. ICT usage at home items description

As technology continues to advance, it becomes increasingly important to understand and recognize how ICT is used in different aspects of daily life. Figure 1 shows the distribution of students' responses to the ICTHU questionnaire, providing a general overview of their ICT use outside of school time. Focusing on activities performed "almost every day' and "every day", no item has a frequency rate of zero or close to it.

Not surprisingly items related to communicating with others, using social media, and engaging in entertainment activities (Q2, Q4 and Q9), had the highest percentages.

Most of the grade 13 students also used ICT for school-related activities, such as interacting with classmates and teachers and searching for information or materials for school assignments (Q3, and Q6). More than 40% of the sample reported using ICT for doing homework (Q1) and for uploading and downloading learning material from the internet (Q8).

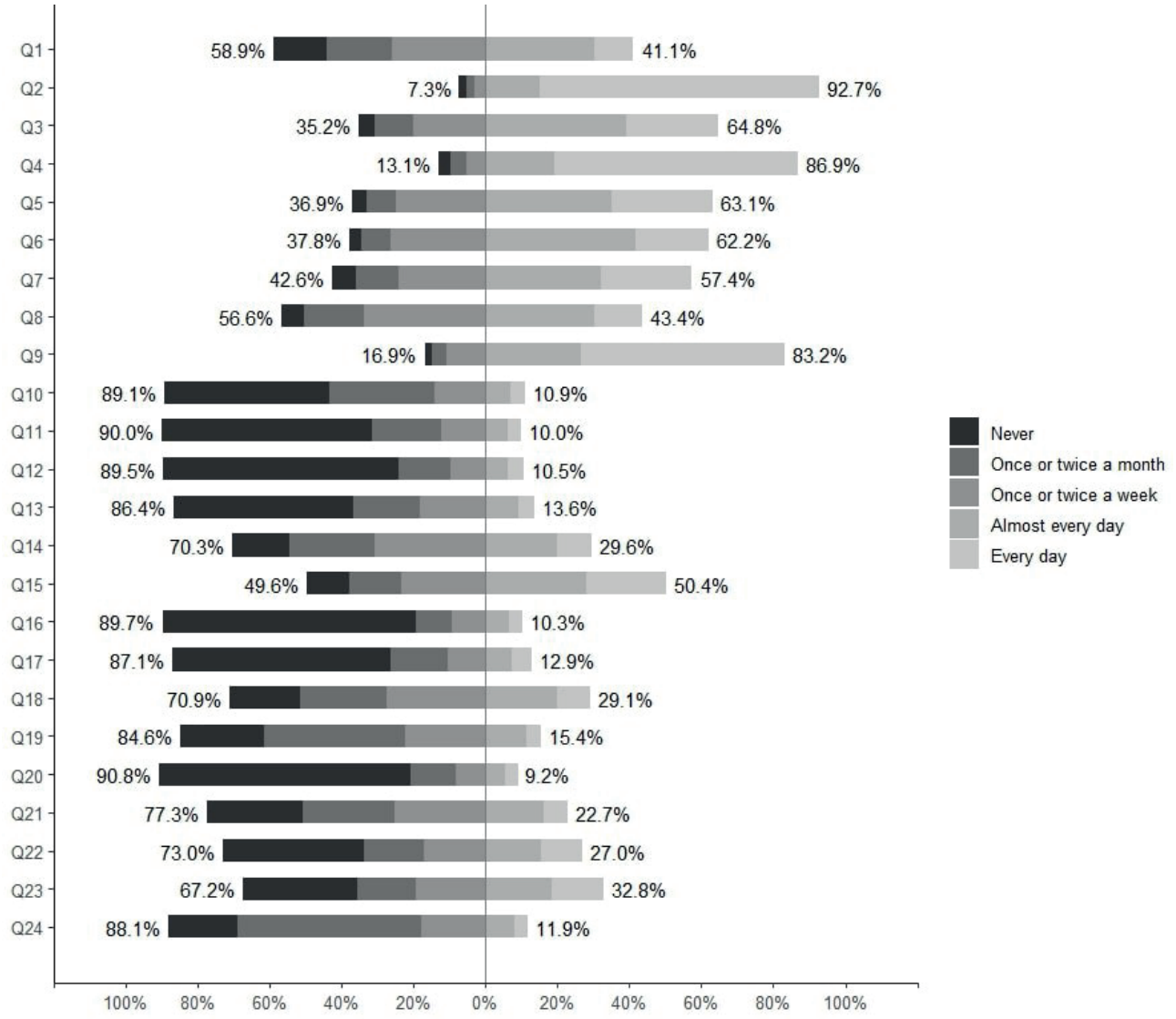

Figure 1. ICT Usage at Home items descriptive statistics (n = 3,254 students).
Legend: Q1=Doing homework with software or web applications; Q2=Communicating with friends, family or other people via chat or email; Q3=Interacting with classmates or teachers at school activities; Q4=Sharing or accessing content on social networks; Q5=Searching for information about places and events for the free time; Q6=Searching for information or materials for school assignments; Q7=Read online news or newspapers; Q8=Uploading or downloading educational material from the internet; Q9=Listening to music or watching streaming or downloading films; Q10=Accessing online courses for personal interest; Q11=Using educational games; Q12=Participating in forums or discussion groups on topics of personal interest; Q13=Doing maths homework with dedicated software on a PC, tablet or smartphone; Q14=View tutorials for personal interest; Q15=Deepen their knowledge on topics of personal interest; Q16=Write computer programs, scripts or apps; Q17=Produce creative content (music, poems, etc.); Q18=Search for reviews online about products or services before buying; Q19=Working in groups with other students in educational activities; Q20=Reading ebooks in free time; Q21=Writing or editing documents for educational activities; Q22=Playing online with others; Q23=Playing alone; Q24=Creating a presentation for learning activities.

These data are consistent with the heavy reliance on ICT in the context of the COVID-19 pandemic, even after most schools had reopened. Further, most students reported daily use of ICT for seeking information (Q5), such as reading news online (Q7) or finding information about free-time activities (Q5), and for deepening their knowledge of topics of personal interest (Q15).

3.4. Exploring association rule mining techniques for analyzing student activity patterns

The initial assumption of ARM was that a student had to engage in an activity at least once a day to be considered active in a transaction. The students' responses were converted to a binary format (0 for scores 1-3 and 1 for scores 4-5) to fit the model. In addition, we also included dummy variables for sociodemographic characteristics as suggested by Attewell and Monaghan (2015), such as ESCS (0 for scores 3-4 lower quartile and 1 for scores 1-2 higher quartile), sex (0 for female and 1 for male), immigrant background (0 for native and 1 for students born outside Italy), geographical area (each area category is represented as a one-hot vector, e.g., where 0 for those living in the south and 1 otherwise), student's school career (0 for regular students and non-zero values for other categories), and access to digital devices (each device is represented as a one-hot vector, where 0 for who owns one and 1 for other categories).

Initially, the Apriori algorithm was considered for AR analysis but was replaced by the FP-growth algorithm due to Apriori's high memory demands. FP-growth, which uses an FP tree and a divide-and-conquer method to find frequent item sets (Han & Pei, 2000), was more efficient. Although FP-growth initially generated 13,000 rules, refining support and confidence parameters led to 29 quality rules, focusing on those with a lift greater than 1, indicating independence between rules and elements.

To explore the strength of relationships between demographic variables and survey responses (Q1-Q24), we used Cramér's V, an index that measures the association between categorical variables. The results were visualized in a heatmap (Figure 2), where the colours represent the intensity of the associations: darker shades of blue indicate weaker associations, while brighter colours suggest stronger relationships. Overall, most associations between the survey questions and sociodemographic variables were weak, as reflected by the predominance of dark blue tones. For instance, variables like "not access to PC" (no_access_PC) "ESCS (4st quartile" (high_ESCS) and "not access to PC" (no_tablet) showed little correlation with the survey questions. However, a few moderate associations emerged, such as between the variable "student repeating a grade" (repeating) and other characteristics, although these cases were relatively rare. The heatmap allowed us to quickly identify these relationships and focus the association rule analysis on variables with significant associations. This approach ensured that we only considered the most relevant relationships, minimizing the risk of including random or insignificant associations in the ARM analysis.

3.4.1. Analyzing patterns of ICT engagement among grade 13 students: Insights from Association Rule Mining

Table 5 serves as a comprehensive repository of results for the exploration of key activities outside school hours among grade 13 students, shedding light on the various influences shaping their everyday lives.

Communication-related activities, such as engaging with friends and family (Q2), exhibit a strong connection with academic pursuits like information-seeking (Q5, Q6) and homework completion (Q1). This suggests a close relationship between interpersonal communication and academic engagement, highlighting the multifaceted nature of students' ICT usage, where social interactions are intertwined with scholarly activities.

Entertainment activities (Q9) emerge as central in the ICT engagement network, showing links not only with communication (Q2) but also with searching for materials (Q6) and homework (Q1). Using the FP-Growth algorithm, the analysis identified correlations between entertainment activities

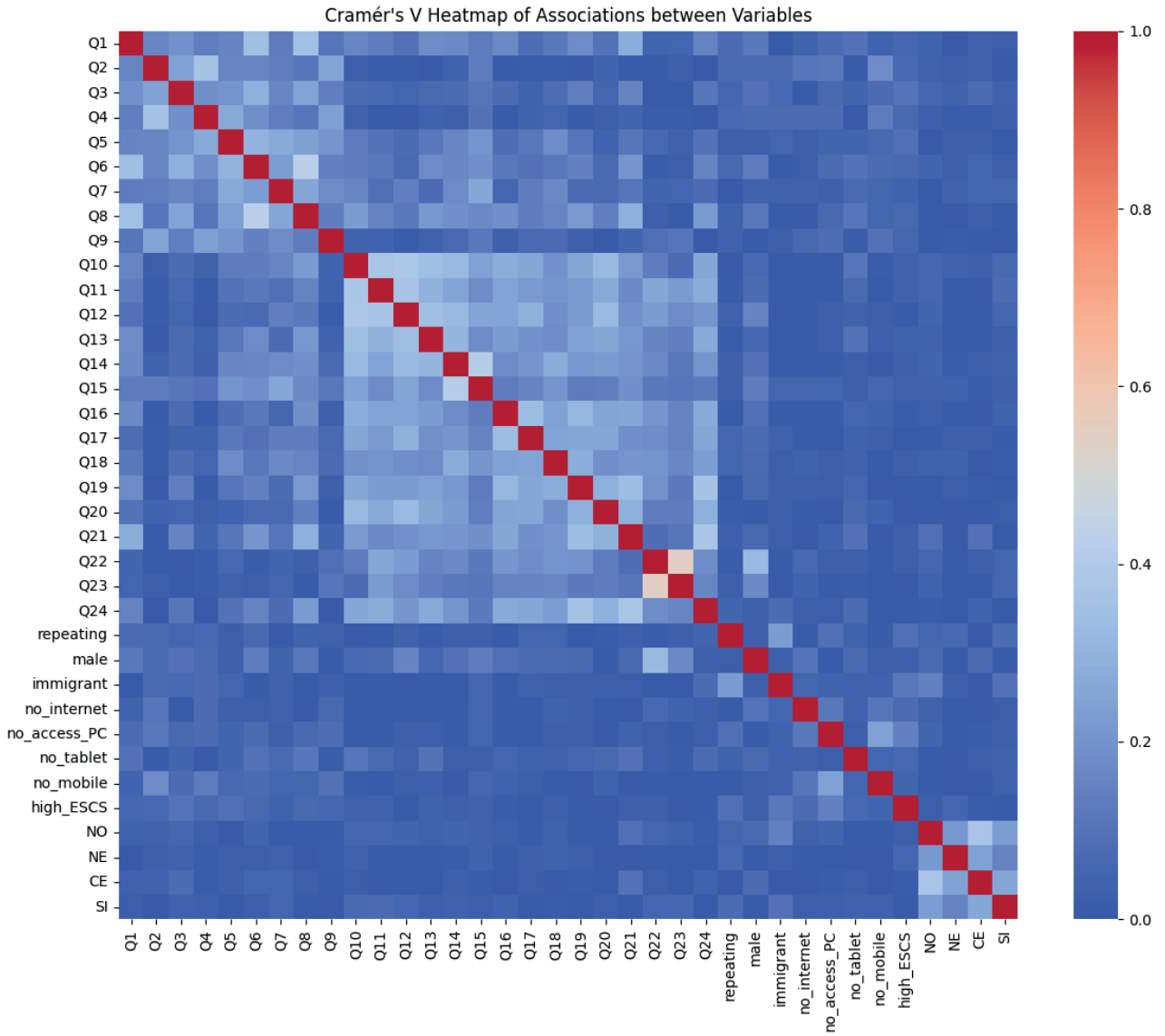

Figure 2. ICT usage at home items descriptive statistics (n = 3,254 students).
Legend: Q1=Doing homework with software or web applications; Q2=Communicating with friends, family or other people via chat or email; Q3=Interacting with classmates or teachers at school activities; Q4=Sharing or accessing content on social networks; Q5=Searching for information about places and events for the free time; Q6=Searching for information or materials for school assignments; Q7=Read online news or newspapers; Q8=Uploading or downloading educational material from the internet; Q9=Listening to music or watching streaming or downloading films; Q10=Accessing online courses for personal interest; Q11=Using educational games; Q12=Participating in forums or discussion groups on topics of personal interest; Q13=Doing maths homework with dedicated software on a PC, tablet or smartphone; Q14=View tutorials for personal interest; Q15=Deepen their knowledge on topics of personal interest; Q16=Write computer programs, scripts or apps; Q17=Produce creative content (music, poems, etc.); Q18=Search for reviews online about products or services before buying; Q19=Working in groups with other students in educational activities; Q20=Reading ebooks in free time; Q21=Writing or editing documents for educational activities; Q22=Playing online with others; Q23=Playing alone; Q24=Creating a presentation for learning activities.

and broader academic contexts. While these associations suggest potential overlaps between leisure and educational tasks, it is important to note that the method reveals frequent co-occurrences rather than causality. Additional qualitative research would be required to explore the underlying dynamics

DOI: 10.17471/2499-4324/1360

Table 5. Association rules filtering.

n.	antecedents	consequents	antecedents s.	consequents s.	support	confidence	lift	leverage	conviction	zhangs
1	Q2, Q6, Q9	Q1	0.527	0.411	0.301	0.572	1.389	0.084	1.374	0.592
2	Q4, Q3	Q2	0.594	0.927	0.584	0.983	1.061	0.033	4.302	0.141
3	Q4, Q9, Q3	Q2	0.526	0.927	0.518	0.985	1.063	0.031	4.831	0.125
4	Q2, Q6, Q5, Q4	Q3	0.428	0.648	0.352	0.823	1.270	0.075	1.993	0.372
5	Q9, Q2, Q5, Q4, Q6	Q3	0.392	0.648	0.323	0.824	1.271	0.069	1.997	0.351
6	Q2	Q4	0.927	0.869	0.837	0.904	1.040	0.032	1.358	0.519
7	Q9	Q4	0.832	0.869	0.753	0.905	1.041	0.030	1.381	0.236
8	Q2, Q9	Q4	0.795	0.869	0.731	0.920	1.058	0.040	1.624	0.266
9	Q4, Q6, Q9	Q5	0.509	0.632	0.403	0.792	1.255	0.082	1.774	0.413
10	Q4, Q5, Q9	Q6	0.534	0.622	0.403	0.755	1.214	0.071	1.545	0.379
11	Q6, Q9, Q5	Q7	0.418	0.574	0.309	0.740	1.288	0.069	1.635	0.384
12	Q2, Q6, Q9, Q5	Q7	0.406	0.574	0.301	0.742	1.293	0.068	1.652	0.381
13	Q2, Q15, Q9	Q7	0.427	0.574	0.312	0.730	1.272	0.067	1.579	0.373
14	Q6, Q3	Q8	0.470	0.434	0.303	0.645	1.486	0.099	1.594	0.617
15	Q6, Q5	Q8	0.463	0.434	0.305	0.658	1.514	0.103	1.652	0.633
16	Q2, Q5	Q9	0.605	0.832	0.545	0.900	1.083	0.042	1.692	0.194
17	Q4, Q5	Q9	0.592	0.832	0.534	0.901	1.084	0.041	1.708	0.190
18	Q2, Q5, Q4	Q9	0.573	0.832	0.520	0.907	1.090	0.043	1.806	0.194
19	Q15, Q9	Q14	0.440	0.297	0.215	0.488	1.645	0.084	1.373	0.701
20	Q2, Q15, Q9	Q14	0.427	0.297	0.208	0.487	1.641	0.081	1.370	0.682
21	Q2, Q7, Q9	Q15	0.494	0.504	0.312	0.633	1.256	0.064	1.351	0.402
22	Q7	Q18	0.574	0.291	0.206	0.358	1.229	0.038	1.104	0.437
23	Q5, Q9	Q18	0.563	0.291	0.203	0.362	1.241	0.040	1.110	0.444
24	Q2	Q21	0.927	0.227	0.212	0.229	1.008	0.002	1.002	0.105
25	Q4	Q21	0.869	0.227	0.205	0.236	1.037	0.007	1.011	0.271
26	male	Q22	0.515	0.270	0.210	0.408	1.511	0.071	1.233	0.697
27	Q23	Q22	0.328	0.270	0.202	0.616	2.283	0.114	1.902	0.837
28	male	Q23	0.515	0.328	0.209	0.407	1.239	0.040	1.132	0.397
29	Q22	Q23	0.270	0.328	0.202	0.749	2.283	0.114	2.681	0.770

Legend: Q1=Doing homework with software or web applications; Q2=Communicating with friends, family or other people via chat or email; Q3=Interacting with classmates or teachers at school activities; Q4=Sharing or accessing content on social networks; Q5=Searching for information about places and events for the free time; Q6=Searching for information or materials for school assignments; Q7=Read online news or newspapers; Q8=Uploading or downloading educational material from the internet; Q9=Listening to music or watching streaming or downloading films; Q10=Accessing online courses for personal interest; Q11=Using educational games; Q12=Participating in forums or discussion groups on topics of personal interest; Q13=Doing maths homework with dedicated software on a PC, tablet or smartphone; Q14=View tutorials for personal interest; Q15=Deepen their knowledge on topics of personal interest; Q16=Write computer programs, scripts or apps; Q17=Produce creative content (music, poems, etc.); Q18=Search for reviews online about products or services before buying; Q19=Working in groups with other students in educational activities; Q20=Reading ebooks in free time; Q21=Writing or editing documents for educational activities; Q22=Playing online with others; Q23=Playing alone; Q24=Creating a presentation for learning activities.

of these relationships more fully. While this correlation highlights a potential overlap between entertainment and academic engagement, further research would be needed to understand the nature and implications of this relationship.

Analysis of students' online news reading habits (Q7) reveals associations with interacting with classmates (Q6), listening to music (Q9), and leisurely information seeking (Q5). These connections emphasize the importance of a holistic approach to understanding information behaviour, where academic, social, and personal aspects converge in the digital realm.

The gender disparity in gaming activities (Q22, Q23), with males showing higher participation, highlights the importance of investigating how gamification elements, rather than pure gaming for entertainment, can be integrated into educational contexts to improve learning outcomes and address gender dynamics in student engagement. Unlike games designed for entertainment, gamification applies game-like elements to enhance motivation and engagement in educational tasks. While existing research does not indicate a direct link between gaming and academic achievement (Dindar, 2018), the differences in how various genders engage with gaming may provide insights into developing tailored educational strategies.

Group interaction (Q19) appears as an isolated aspect of students' ICT use, with no significant associations found with other activities. This suggests that collaborative efforts in educational activities may not be closely linked to other ICT-related behaviours. Exploring the factors contributing to this isolation could provide insights into the dynamics of collaborative learning beyond the traditional classroom. Recent studies (Gasaymeh, 2018; Chugh & Ruhi, 2018) highlight how specific online resources, such as Wikipedia and Facebook, support group work, suggesting that the choice of platform plays a crucial role in shaping collaborative interactions in ICT. Nonetheless, the rapid and significant rise in the adoption of Learning Management Systems (LMS) in educational settings deserves closer consideration. LMS platforms have become essential not only for course management but also for fostering structured, coordinated collaboration among students within a controlled and secure environment. This shift has been largely motivated by concerns over privacy, particularly in response to regulations like the General Data Protection Regulation (GDPR), which mandates the creation of safer, more regulated spaces for student interactions. As a result, it is important to reassess how these platforms might further influence collaborative dynamics in educational contexts.

Extending our analysis of association rules, key metrics such as leverage, conviction, and Zhang's metric were examined in Table 5 to identify patterns and relationships between different ICT-related activities.

Leverage measures the deviation from expected co-occurrence frequencies between activities. High leverage values, such as the association between Q1 (homework) and Q2 (communicating), indicate a strong likelihood of these activities occurring together, signifying a strong link between academic tasks and communication.

Conviction scores reveal the strength of dependency between activities, indicating the likelihood of one activity occurring when another is present. For instance, the association between Q4 (social networks) and Q8 (educational materials) suggests a strong association between social networks and access to educational resources, with conviction values greater than one.

Zhang's metric, which measures statistical significance, highlights robust and meaningful patterns. The association between Q2 (communication) and Q6 (seeking educational information) suggests that engagement in communication often coincides with the search for educational information, indicating a significant relationship between these activities.

This study also assesses the influence of sociodemographic characteristics such as ESCS, migrant background, repeat students, geography, and gender. Notably, none of these characteristics, except for being male and gaming, show a significant association with digital activities. This finding suggests that the relationship between sociodemographic variables, access to digital devices, and engagement in digital activities may be complex and context-dependent.

4. Conclusions

This study enriches the literature on ICT access by examining Italian grade 13 students' digital experiences post-pandemic, a period relatively less studied than earlier stages (OECD, 2023).

First, we examined whether students' sociodemographic characteristics were associated with differences in their access at home to a range of digital devices. On the one hand, our results showed that very few students reported having no access to a PC (neither a desktop computer nor a laptop). Most students reported having a PC at home and using it, although for some students, the PC is a shared device used by other family members. We also provided a picture of access to other devices, with smartphones being the most common, owned by almost all students in the sample.

On the other hand, the main results from our logistic regression analyses highlighted that there is still a digital divide in access to ICT between students from more disadvantaged backgrounds and their peers. This finding emerged not only when focusing on devices traditionally addressed in digital divide research (i.e., the PC) but also on other digital devices, except game consoles. These differences underscore the complex interplay between digital access and socioeconomic and cultural factors, necessitating strategies to close the gaps (Kenny, 2017; Vassilakopoulou & Hustad, 2023).

The current study also found no significant relationship between students' sex and their access to and actual use of PCs and almost all other devices. However, male late adolescents were more likely to have access to and use game consoles than their female peers; this finding aligns with existing literature on ICT use for entertainment among younger students (Burgess et al., 2007; Greenberg et al., 2010; Phan et al., 2012; Gómez-Gonzalvo et al., 2020).

Second, we examined how students use ICT outside school and the differences across sociodemographic groups using a data-mining approach. Association rule mining helped identify patterns in ICT activities and their connections to students' sociodemographic characteristics and digital device ownership. One notable finding was that ICT activities often bridged different dimensions, such as learning and leisure. This is consistent with Ludvìk et al. (2020), who found that learning with ICT can be influenced by its use in other areas. However, activities like playing games alone or with others were isolated and not strongly linked to other ICT activities. Contrary to expectations, we did not find a strong association between ICT use and students' ESCS, suggesting the need for further research. An exception was the significant association between being male and frequent ICT use for gaming, aligning with recent findings on the narrowing digital sex gap (Gebhardt et al., 2019). This underscores the importance of addressing potential risks and benefits associated with online gaming among male students. As we continue to navigate the rapidly changing landscape of ICT in education and other areas relevant to young people, it is critical that we remain mindful of the digital divide within the "digital youth" and work to create a more inclusive digital environment for all students. It is also important to understand how students engage with ICT. Data mining techniques can help discover patterns of ICT use in everyday life, providing useful insights to create a safe and supportive environment that encourages them to make the most of their ICT experiences.

4.1. Limitations and future directions for research

To make our findings more objective, we should recognize their limitations. First, the generalizability of our results is subject to certain limitations. Data were collected on a large and nationally representative sample of the target population, namely students attending the last year of upper secondary school in Italy. However, our results could not be fully generalizable to ICT access and usage among late adolescents and young adults from all walks of life. For instance, recent data (Crosier & Sigalas, 2022) suggest that early school leaving challenges the Italian education system, especially in the South of Italy and among the foreign-born population. Further research is needed to provide a more complete picture of digital inequalities among young people, also reaching early leavers from education and training. Second, the initial assumption of AR was that a student had to engage in an activity at least once a day to be considered active in a transaction; this allowed us to detect patterns of co-occurrence among more frequent activities. However, a further study may capture more detailed patterns in ICT uses, also including activities that are less likely to be carried out every day (such as coding), to provide more nuanced associations between sociodemographic characteristics and ICT pattern of usage. Third, the study is mainly based on students' self-reported data. Further research also integrating survey data from other sources (e.g. territorial data) would be a useful way of providing a more detailed picture of ICT access and use among students.

4. Acknowledgement

The authors would like to thank INVALSI for granting access to the data. The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of INVALSI.

5. Authors' contributions

All authors contributed to the study conception, design and writing. Data preparation and data analysis were performed by Donatella Papa. The first draft of the manuscript was written by Donatella Papa except for the conclusion, written by Marta Desimoni; and all authors commented and wrote on previous versions of the manuscript. All authors read and approved the final manuscript.

6. Data availability

Data sets that have been analysed as part of this study and that are not in breach of data protection legislation can be requested from the institution that owns the data set (INVALSI).

7. Consent to participate

The protocol of data collection, also including the consent to participate, was handled by INVALSI. We obtained from INVALSI the formal consent to use the anonymous database to carry out all secondary analyses reported in the present paper.

8. References

Abdullah, Z., Herawan, T., Ahmad, N., & Deris, M. M. (2011). Mining significant association rules from educational data using critical relative support approach. *Procedia Social and Behavioral Sciences*, *28*, 97–101. https://doi.org/10.1016/j. sbspro.2011.11.020

Agrawal, R., Imielinski, T., & Swami, A. (1993). Mining association rules between sets of items in large databases. *ACM SIGMOD Record*, *22*, 207–216. https://doi.org/10.1145/170036.170072

Attewell, P. (2001). Comment: The first and second digital divides. *Sociology of Education*, *74*, 252-259. https://doi.org/10.2307/2673277

Attewell, P., & Monaghan, D. (2015). *Data mining for the social sciences: An introduction*. University of California Press. https://doi.org/10.1525/9780520960596

Benecchi, A., Ciapanna, E., Bottoni, C., Frigo, A., Milan, A., & Scarinzi, E. (2021). Digitalisation in Italy: Evidence from a new regional index. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4016669

Burgess, M. C., Stermer, S. P., & Burgess, S. R. (2007). Sex, lies, and video games: The portrayal of male and female characters on video game covers. *Sex roles*, *57*, 419-433. https://doi.org/10.1007/s11199-007-9250-0

Campodifiori, E., Figura, E., Papini, M., & Ricci, R. (2010). *Un indicatore di status socio-economico-culturale degli allievi della quinta primaria in Italia*. Invalsi.

Cedefop (2021). Digital skills: challenges and opportunities during the pandemic. *Cedefop*, https://www.cedefop.europa.eu/en/news/ digital-skills-challenges-and-opportunities-during-pandemic

Cesareo, V. (2022). Ventisettesimo rapporto sulle migrazioni 2021. *Ventisettesimo rapporto sulle migrazioni 2021*, 1–301. https://www.ismu.org/ ventisettesimo-rapporto-sulle-migrazioni-2021/

Chiu, M.-S. (2020). Exploring models for increasing the effects of school information and communication technology use on learning outcomes through outside-school use and socioeconomic status mediation: The ecological techno-process. *Educational Technology Research and Development*, *68*(1), 413–436. https://doi. org/10.1007/s11423-019-09707-x

Chugh, R. & Ruhi, U. (2018). Social media in higher education: A literature review of facebook. *Education and Information Technologies*, *23*, 605–616. https://doi.org/10.1007/s10639-017-9621-2

Crosier, D., & Sigalas, E. (2022). Towards equity and inclusion in higher education in Europe: Eurydice report. *Luxembourg: Publications Office of the European Union, 2022*. https://hdl.handle.net/11162/222272

Di Pietro, G. (2021). Changes in Italy's education-related digital divide. *Westminster Research*. https://doi.org/10.1111/ecaf.12471

DiMaggio, P., Hargittai, E., Neuman, W. R., & Robinson, J. P. (2001). Social implications of the internet. *Annual Review of Sociology*, *27*, 307–336. https://doi.org/10.1146/annurev.soc.27.1.307

Dindar, M. (2018). An empirical study on gender, video game play, academic success and complex problem solving skills. *Computers & Education*, *125*, 39–52. https://doi.org/10.1016/j.compedu.2018.05.018

Fernàndez-Gutiérrez , M., Gimenez, G., & Calero, J. (2020). Is the use of ICT in education leading to higher student outcomes? Analysis from the spanish autonomous communities. *Computers & Education*, *157*. https://doi.org/10.1016/j.compedu.2020.103969

Fraillon, J., Ainley, J., Schulz, W., Duckworth, D., & Friedman, T. (2019). *IEA International computer and information literacy study. 2018 Assessment Framework*. Springer International Publishing. https://doi.org/10.1007/ 978-3-030-19389-8

Gasaymeh, A. (2018). A study of undergraduate students' use of Information and Communication Technology (ICT) and the factors affecting their use: a developing country perspective. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(5), 1731–1746. https://doi.org/10.29333/ejmste/85118

Gebhardt, E., Thomson, S., Ainley, J., && Hillman, K (2019). What have we learned about gender differences in ICT? In *Gender differences in computer and information literacy: An in-depth analysis of data from ICILS* (pp. 69–73). https://doi.org/10.1007/ 978-3-030-26203-7_6

Gómez-Gonzalvo, F., Molina, P., & Devìs-Devìs, J. (2020). Which are the patterns of video game use in spanish school adolescents? gender as a key factor. *Entertainment Computing*, *34*. https://doi.org/10.1016/j.entcom.2020. 100366

Goudeau, S., Sanrey, C., Stanczak, A., Manstead, A., & Darnon, C. (2021). Why lockdown and distance learning during the covid-19 pandemic are likely to increase the social class achievement gap. *Nature Human Behaviour*, *5*(10), 1273–1281. https://doi.org/10.1038/s41562-021-01212-7

Greenberg, B. S., Sherry, J., Lachlan, K., Lucas, K., & Holmstrom, A. (2010). Orientations to video games among gender and age groups. *Simulation & Gaming*, *41*(2), 238–259. https://doi.org/10.1177/1046878108319930

Han, J., & Pei, J. (2000). Mining frequent patterns by pattern-growth. *ACM SIGKDD Explorations Newsletter*, *2*, 14–20. https://doi.org/10.1145/ 380995.381002

Heo, H., & Kang, M. (2010). Impacts of ICT use on school learning outcome. In F. Scheuermann, & F. Pedró (Eds.), *Assessing the effects of ICT in education. Indicators, criteria and benchmarks for international comparisons* (pp. 189-198). European Commission Joint Research Centre. https://erte.dge.mec.pt/sites/default/files/Recursos/Estudos/assessingtheeffectsofictineducation.pdf

ISTAT. (2020a). Il rapporto Istat sul BES. *ISTAT*. https://www.istat.it/it/ files//2021/03/BES_2020.pdf

ISTAT. (2020b). Italian multipurpose survey on households. *ISTAT*. https://www.istat.it/wp-content/uploads/2014/08/ISTAT_MFR_AVQ_2020_IT-2.zip

Kenny, E. (2017). Settlement in the digital age: Digital inclusion and newly arrived young people from refugee and migrant backgrounds. *Centre for Multicultural Youth*. https://www.cmy.net.au/wp-content/uploads/2020/03/ Settlement-in-the-digital-age_Jan2017.pdf

Ludvìk, E., Łukasz, T., Milan, K., Maria, P., & Gabriela, P. (2020). How do first year university students use ICT in their leisure time and for learning purposes? *International Journal of Cognitive Research in Science, Engineering and Education*, *8*(2), 35–52. https://doi.org/10.5937/IJCRSEE2002035E

Nachmias, R., Mioduser, D., & Shemla, A. (2001). Information & Communication Technologies usage by students in an Israeli high school: Equity, gender, and inside/outside school learning issues. *Education and Information Technologies*, *6*, 43–52. *h*ttps://doi.org/10.1023/A:1011367212148

OECD. (2017). *Pisa 2018 ICT familiarity questionnaire*. OECD Publishing. https://www.oecd.org/pisa/data/2018database/CY7_201710_QST_MS_ICQ_ NoNotes_final.pdf

OECD. (2023). *PISA 2022 Assessment and Analytical Framework*. OECD Publishing.
https://doi.org/https://doi.org/10.1787/dfe0bf9c-en

Ola Lindberg, J., & Sahlin, S. (2011). Bridging school-subjects and distances in upper secondary schools. *Campus-Wide Information Systems*, *28*(3), 144–153. https://doi.org/10.1108/10650741111145670

Olofsson, A. D., Lindberg, O. J., & Fransson, G. (2018). Students' voices about information and communication technology in upper secondary schools. *The International Journal of Information and Learning Technology*, *35*(2), 82–92. https://doi.org/10.1108/IJILT-09-2017-0088

Phan, M. H., Jardina, J. R., Hoyle, S., & Chaparro, B. S. (2012). Examining the role of gender in video game usage, preference, and behavior. In *Proceedings of the human factors and ergonomics society annual meeting*, Vol.56 (pp.1496– 1500). Sage Publications. https://doi.org/10. 1177/1071181312561297

Raschka, S. (2018). Mlxtend: Providing machine learning and data science utilities and extensions to python's scientific computing stack. *Journal of Open Source Software*, *3*(24), 638.

Riggins, F., & Dewan, S. (2005). The digital divide: Current and future research directions. *Journal of the Association for Information Systems*, 6:298–337. https://doi.org/10.17705/1jais.00074.

SANFO, J.-B. M. B. (2023). Examining student ICT use and learning outcomes: Evidence from Japanese Pisa data. *Computers and Education Open*, *4*. https://doi.org/10.1016/j.caeo.2023.100141

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53. https://doi.org//10.5116/ijme.4dfb.8dfd

Tuszynski, J., & Khachatryan, M. H. (2013). Package 'Catools'. https://cran.r-project.org/web/packages/caTools/caTools.pdf

van Dijk, J. (2005). *The deepening divide: Inequality in the information society*. SAGE Publications. https://doi.org/10.4135/9781452229812

Vassilakopoulou, P., & Hustad, E. (2023). Bridging digital divides: A literature review and research agenda for information systems research. *Information Systems Frontiers*, *25*(3), 955–969. https://doi.org/10.1007/s10796-020-10096-3

Wastiau, P., Blamire, R., Kearney, C., Quittre, V., Van de Gaer, E., & Monseur, C. (2013). The use of ICT in education: a survey of schools in europe. *European Journal of Education*, *48*(1), 11–27. https://doi.org/10.1111/ejed.12020

Xiao, F. & Sun, L. (2022). Profiles of student ICT use and their relations to background, motivational factors, and academic achievement. *Journal of Research on Technology in Education*, *54*(3), 456–472. https://doi.org/10.1080/15391523. 2021.1876577

Zhang, C. & Zhang, S. (2002). *Association rule mining: models and algorithms*. Springer. https://doi.org/10.1007/3-540-46027-6

Italian Journal of Educational Technology

Notes for the guidance of authors

The instructions below are specifically directed at authors who wish to submit a manuscript to the Italian *Journal of Educational Technology*.

AIMS AND SCOPE

The Italian Journal of Educational Technology (formerly TD Tecnologie Didattiche) is a refereed, open access journal that publishes theoretical perspectives, review articles, methodological developments, empirical research and best practice in the field of education and technology. The journal targets scholars and practitioners and welcomes contributions on any aspect of technology-enhanced learning in formal, non-formal and informal learning contexts, from early years through to technical, vocational and higher education, professional development and corporate training, in any subject domain.

Since 1993, when it was established as the first journal dedicated to this research area in Italy, it has been an essential reference point for researchers and educators at national level. Today the journal addresses the international arena and welcomes contributions from all over the world.

The digital version of the Italian Journal of Educational Technology is available free-of-charge and there are no Article Processing Charges (APCs).

TOPICS

Topics covered include any aspects related to supporting education through technology such as the following:

- Theoretical aspects of educational technology and technology-enhanced learning
- Innovative learning environments
- Open and online education
- Collaborative learning
- Design of learning environments
- Evaluation and assessment
- Mobile technologies and social media
- Game-based learning
- Formal, non-formal and informal learning
- Digital literacy
- Technology for inclusive learning
- Digital contents and educational resources
- Research methods in educational technology
- Policies for innovation in educational systems
- Artificial Intelligence and learning
- Educational applications of virtual and augmented reality

SUBMISSIONS

IJET accepts contributions on the above topics all year round. Alternatively, contributions can be sent in reply to the Journal Calls for Papers. The following types of contributions are welcome:

- Theoretical articles (about 6,500 words)
- Research articles (about 6,500 words)
- Reviews of the literature (about 7,000 words)

Contributions should be written in Italian of English. In text citations and references must strictly conform to the APA 7th edition style. Authors are kindly requested to refer to papers on the same theme previously published in the Italian Journal of Educational Technology and, where relevant, to cite them in their submission. For further information about writing and preparing your manuscript, please visit the journal website: https://ijet.itd.cnr.it and read the Instructions for authors.

PEER REVIEW POLICY

Manuscripts undergo a double-blind peer review process involving at least two reviewers and the editor of the issue.

OPEN ACCESS POLICY

ISSN 2532-4632 (print)
ISSN 2532-7720 (online)