DIGITAL SKILLS OF TEACHERS IN THE AGE OF ARTIFICIAL INTELLIGENCE

LE COMPETENZE DIGITALI DEI DOCENTI NELL'ERA DELL'INTELLIGENZA ARTIFICIALE

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ABSTRACT
As required by the EU guidelines and DigCompEdu, the use of AI requires the adoption of critical thinking on the risks and opportunities of technology. Understanding the "grammar" of algorithms is essential for digital literacy. In this context, research on the level of competence, perception and use of AI and digital technologies in inclusive teaching by teachers fits in.

Come previsto dalle linee guida UE e dal DigCompEdu, l'utilizzo dell'AI richiede l'adozione di un pensiero critico su rischi e opportunità della tecnologia. Capire la "grammatica" degli algoritmi è essenziale per la digital literacy. In questo quadro si inserisce una ricerca sul livello di competenza, percezione e uso dell'AI e delle tecnologie digitali nella didattica inclusiva da parte dei docenti.

KEYWORDS
Artificial Intelligence; Digital competence; interdisciplinarity
Intelligenza Artificiale; Competenze digitali; Interdisciplinarietà

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Introduction

In the text One-Dimensional Man, published in 1964, Herbert Marcuse analyzes the negative and manipulative dimension of technological progress, highlighting how it can translate into a form of social control capable of annihilating – or neutralizing – critical thinking.

According to Marcuse, the one-dimensionality of thought manifests itself in the tendency to simplify and to face the spread of prepackaged and simplistic messages (think of the spread of tweets or hashtags on the web that sometimes go viral generating fake news), Marcuse identifies critical thinking as the last bastion to defend humanity from technical drifts.

Critical thinking therefore becomes an essential tool for decoding the complexity of the present and for recognizing the risks associated with improper use of Artificial Intelligence.

From this perspective, critical thinking is not only an intellectual practice, but represents an educational model that restores meaning to human action and gives sense and meaning to things.

The spread of Artificial Intelligence applications in schools is profoundly redefining learning processes and educational interaction (European Commission, 2022; Ranieri et al., 2024). In fact, in line with the recent indications of the European DigCompEdu framework (Redecker, 2017) and the Ethical Guidelines of the European Commission, teachers are required to have advanced digital skills and solid ethical preparation that implements an effective and responsible use of Artificial Intelligence in students. However, the current guidelines offer a framework for addressing the risks and opportunities related to Artificial Intelligence, but do not provide operational indications on how to implement these principles in a school context. It is therefore necessary to identify possible theoretical models that allow ethical principles to be translated into concrete teaching practices. In this sense, the TPACK model (Mishra & Koehler, 2006) represents a possible useful framework to support teachers in the pedagogical, disciplinary and technological integration of Artificial Intelligence. Alongside it, the Teacher Digital Competency (TDC) Framework (Falloon, 2020) extends the analysis by including personal, ethical and professional aspects that are fundamental for a conscious use of technology in the educational field. In fact, the “digital competence” includes, in addition to technical use, also ethical, legal, digital citizenship, well-being and critical use of technology aspects not through

standardized evaluation tools or checklists, but through a conceptual framework that can be used to systematically integrate ethical issues into didactic design and disciplinary content (Falloon, 2020).
Numerous studies (Nguyen et al., 2022; Di Rosario, Ciastellardi, 2025; Anastasi, Biuso, 2020) highlight the importance of including digital knowledge in school curricula such as equal access to technologies, privacy, security, autonomy, as well as an introduction of ethical education to develop critical awareness and responsibility among students and teachers (Sibilio, 2023).
To promote transformative curricula, it is essential to adopt laboratory and project approaches that make students reflect on how to use artificial intelligence in the best way. A concrete example are the Creative AI, Dancing with AI and How to Train Your Robot programs (Williams et al., 2022), in these paths, students actively experiment with the potential of Artificial Intelligence — from the generation of texts, images and music, to the creation of interactive projects based on body movement or robots controlled by machine learning algorithms — while developing a critical awareness of risks, such as deepfakes and integrating reflections on digital ethics into technological design (Williams et al., 2022).

In this sense, it would be possible to overcome a merely technical vision of digital literacy and promote an AI literacy based on critical reflection and equal access to digital.
In order to promote meaningful educational experiences for students, active participation, in line with the principles of constructivism (Vygotskij, 1996; Wilson, 1995), is considered indispensable to mobilize significant learning. However, in order to mobilize meaningful learning it is necessary to involve students in collaborative and motivating activities, such as hands-on workshops (Andrews et al., 2023; Jonassen, Strobel, 2006).
Teachers' personal motivation is essential to overcome a technical vision of digital literacy, in fact curiosity and the will to experiment with new technologies are determining factors for adopting new interdisciplinary frameworks (Jiang, 2025; Esenalieva et al., 2023, Falloon, 2020). Therefore, it is necessary to reflect on what are the possible reference models that allow teachers to mobilize the skills needed to generate transformative processes. One of the reference models promoted by the European Union is the Teacher Digital Competence (TDC), an innovative model that defines what digital skills teachers should be required. Famework, in order to overcome the simple technical use of digital tools, proposes a model based on three

interconnected dimensions: the didactic integration of technologies (focusing attention on the practical use of tools, on pedagogical planning and on the critical understanding of the educational role of technology); ethical and personal aspects (focusing on a conscious, safe and responsible use of digital, with attention to online well-being, information ethics and social and environmental impact); continuous professional growth (focusing on digital literacy). In short, the framework outlines a teacher capable of using technology in an effective, reflective and sustainable way, at the service of learning and inclusion. The framework allows us to reflect on existing skills and identify new opportunities for integrating new skills, overcoming technical and disciplinary aspects in order to promote teaching capable of educating aware and critical citizens in the digital age.

In addition to the TDC Framework, we must also refer to the TPACK model, which was created to help teachers put technological, pedagogical and disciplinary skills into practice in daily teaching activities (see figure 1 “Reproduction of the TPACK”).

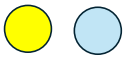
Acronym	Full Name	Color (Original Scheme)	Simplified Description
TK	Technological Knowledge		Knowing how to use digital devices, software, online tools, and staying updated on technologies useful for teaching.
PK	Pedagogical Knowledge		Understanding strategies, methods, and teaching practices for effective instruction.
CK	Content Knowledge		Mastering the subject matter to be taught (e.g., math, history, science).
PCK	Pedagogical Content Knowledge		Knowing how to effectively teach a specific subject, adapting strategies to the discipline.
TCK	Technological Content Knowledge		Understanding how technology can represent, modify, or enhance understanding of subject content.
TPK	Technological Pedagogical Knowledge		Being able to choose and use technologies that enhance teaching strategies and improve learning.
TPACK	Technological Pedagogical Content Knowledge	Dark gray/black (central area) 	Effectively integrating content, pedagogy, and technology: knowing what to teach, how to teach it, and with which tools.
Contexts	Contexts (educational environment/situation)	Blue dashed outline 	The environment in which teaching occurs influences how technology is used and integrated.

Figure 1. Reproduction of the TPACK model from Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers College Record, 6, 1017–1054.

Research Methodology: Research Context and Sample

This survey adopts a mixed research approach that combines both quantitative and qualitative methodologies, with the aim of detecting perceptions, skills and practices of trainee teachers regarding the use of digital technologies and Artificial Intelligence in inclusive teaching.

The main tool used was a structured online questionnaire, consisting of:

- Personal data section (age, gender, educational qualifications, school order of service, school and support experience);
- Closed Likert scale items (from 1 to 5) on:
    - Perceived skills in the use of technology for inclusion;
    - Knowledge and attitudes towards Artificial Intelligence;
    - Previous experiences and propensity for the educational use of Artificial Intelligence;
    - Knowledge and application of teaching micro-design strategies;
- Open questions on the real use of digital tools and Artificial Intelligence in the classroom.

The questionnaire was administered via the digital platform Google Form between March and April 2025.

This research is part of a training program dedicated to indirect internships on the use of digital technologies and Artificial Intelligence in inclusive teaching. The survey was directed at a sample of teachers in training, with the aim of analyzing their perceptions, skills and educational practices in relation to the integration of Artificial Intelligence and digital tools in schools.

The questionnaire was administered to a total of 383 participants, mainly distributed in the 25-44 age group (77%). The sample is mainly composed of women (75%) and in terms of educational qualifications, the majority have a master's degree (58%), while the remainder are distributed between a bachelor's degree, doctorate and unspecified qualifications.

From the point of view of professional experience, a picture emerges that is consistent with an initial training context: over 65% of participants declare less than one year of experience in the school sector, and 86% have never worked in support. As regards the school level, the most represented component is that of secondary school (82%), followed by lower secondary school, primary school and nursery school.

Data Analysis

The survey was structured around key questions, aimed at highlighting:

- The general perception of the use of technologies in teaching for students with disabilities: the data show a positive evaluation, with an average of over 3.5 regarding their effectiveness and relevance.

- Skills and attitudes in using digital tools: although the majority of teachers feel comfortable, significant differences emerge related to the experience and training received.
- The most widely adopted technologies and previous experiences on the use of AI, highlighted through open-ended answers, range from tablets to IWBs, up to more sophisticated tools such as digital learning platforms and, in some cases, Artificial Intelligence applications.
- Knowledge regarding didactic micro-design and how to use AI in teaching practice.
- Awareness of the risks and opportunities of Artificial Intelligence: while the perception of the potential of Artificial Intelligence for personalization and inclusion is high, there is a lack of homogeneity in the knowledge of the ethical implications and in the ability to use it with awareness.
- The most used forms of Artificial Intelligence include tools such as ChatGPT, predictive software, automatic transcription tools, even if many teachers declare that they have not yet concretely experimented with these technologies (a summary of the questions can be found in Figure 2).

The data were processed with the support of Excel to calculate:

- Means and standard deviations of the closed items;
- Correlations between key variables with respect to the perception of AI and the real use or experimentation of AI in teaching practice
- Exploratory qualitative analysis of the open answers.

The analysis of the answers provided on a Likert scale (1 = completely disagree, 5 = completely agree) allowed us to identify the areas of greatest consensus and the most critical dimensions perceived by teachers in relation to the use of technologies and Artificial Intelligence in inclusive teaching.

The data show a high motivation to deepen one's skills: the item "I would like to further deepen my skills on the use of technology and Artificial Intelligence in inclusive teaching" obtained the highest mean (M = 4.13; SD = 0.89), followed by "The use of technology in inclusive teaching should be a priority in teacher training courses" (M = 4.09; SD = 0.83).

The item "The use of digital technologies allows for greater personalization of learning for students with disabilities" also received high ratings (M = 3.84; SD = 0.88), indicating a broad awareness of the pedagogical potential of technologies.

Regarding Artificial Intelligence, the items with the highest mean are:

- “The use of Artificial Intelligence represents an opportunity to improve the school participation of students with disabilities” (M = 3.77; SD = 0.91),
- “I believe that the use of Artificial Intelligence can promote greater involvement of students with disabilities” (M = 3.72; SD = 0.94),
- “I am aware of the potential of Artificial Intelligence in improving communication with students with disabilities” (M = 3.69; SD = 0.93).

Finally, the perception of comfort in using technology is also positive (“I feel comfortable using technology to support the learning of students with disabilities”, M = 3.71; SD = 0.91), an attitude that would seem favorable to the development of more advanced skills.

However, the question “How much are you able to relate technological resources to disciplinary content?” (M=3.59; SD=0.81) suggests that teachers perceive themselves as moderately competent in connecting technologies to disciplinary content, indicating a generally positive, but not yet consolidated, attitude.

Furthermore, the correlation of the questions "I believe that Artificial Intelligence can improve the school inclusion of students with disabilities" and "I have experimented with Artificial Intelligence tools in the context of inclusive teaching" indicates that experimenting with AI tools also translates into a more favorable perception of their inclusive potential ($r = 0.44$, with a p value < 0.001)

Competenze e attitudini sull'AI

	Conosco i principali strumenti di Intelligenza Artificiale (IA) applicabili alla didattica	Ritengo che l'IA possa migliorare l'inclusione scolastica degli studenti con disabilità	Sono in grado di utilizzare strumenti di IA per personalizzare l apprendimento degli studenti con disabilità	L'uso dell'IA nella didattica rappresenta un'opportunità per migliorare la partecipazione scolastica degli studenti con disabilità	Mi sento in grado di integrare strumenti di IA nel mio insegnamento per favorire l'inclusione	Ritengo che l uso dell'IA possa favorire un maggiore coinvolgimento degli studenti con disabilità nelle attività scolastiche	Sono a conoscenza delle implicazioni etiche dell'uso dell'IA nella didattica	Ritengo che l'IA possa migliorare la valutazione formativa degli studenti con disabilità	Sono consapevole delle potenzialità dell'IA nel migliorare la comunicazione con gli studenti con disabilità	Mi sento sicuro nell'integrare strumenti di IA in attività di insegnamento collaborative	Utilizzo strategie basate sull'IA per facilitare l'accesso ai contenuti didattici da parte degli studenti con disabilità	Vorrei approfondire ulteriormente le mie competenze sull'uso della tecnologia e dell'IA nella didattica inclusiva
media	3,351	3,673	3,494	3,765	3,399	3,723	3,515	3,531	3,594	3,276	3,103	4,13130155
deviazione standard	0,971147360 6219453	0,976400864 8319603	0,924351666 1620933	0,917953757 5691595	0,988849541 9609576	0,945092978 3100311	1, 00967	0,934875815 1575617	0,935001955 0704278	0,963518890 8115562	1, 06491018	0,88897447

Competenze percepite sulla tecnologia

	Ritengo di possedere competenze adeguate per l'integrazione delle tecnologie digitali nella didattica per studenti con disabilità	Mi sento a mio agio nell uso della tecnologia per supportare l'apprendimento degli studenti con disabilità	Ho ricevuto una formazione adeguata sull'uso della tecnologia nella didattica inclusiva	L'uso della tecnologia nella didattica inclusiva dovrebbe essere una priorità nei percorsi di formazione docenti	Quanto sei in grado di mettere in rapporto le risorse tecnologiche con i contenuti disciplinari?	Sono in grado di progettare attività didattiche integrate con strumenti tecnologici	Mi sento preparato nell'adattare le risorse digitali per rispondere alle esigenze degli studenti con disabilità	Sono in grado di valutare criticamente le tecnologie didattiche prima di adottarle nel mio insegnamento	Ho esperienza nell'uso di software educativi adattivi per studenti con bisogni educativi speciali	Sono in grado di adattare le tecnologie esistenti per rispondere alle necessità degli studenti con disabilità		
media	3,54822603	3,71986348	3,48558557	4,09406061	3,5953335	3,61708174	3,47718065	3,56921367	2,88084619	3,30327088		
deviazione standard	0,88902642	0,91565013	1,01767122	0,83395988	0,81866559	0,93873614	0,92419235	0,86706889	1,08795581	0,96997491		

Conoscenze sulla microprogettazione

	Conosco le strategie di microprogettazione didattica per pianificare interventi educativi mirati	Utilizzo la microprogettazione didattica nella pianificazione delle attività per studenti con disabilità	Ritengo che la microprogettazione didattica possa migliorare l efficacia degli interventi educativi per studenti con disabilità	L'uso delle tecnologie digitali consente una maggiore personalizzazione dell'apprendimento per gli studenti con disabilità								
media	3,01830809	2,89226473	3,63547682	3,84104178								
deviazione standard	0,96554427	1,07466071	0,92317029	0,88152409								

Esperienze pregresse sull'uso dell'AI

	Ho sperimentato strumenti di IA nel contesto della didattica inclusiva	La formazione ricevuta mi ha aiutato a comprendere il ruolo della tecnologia e dell IA nella didattica inclusiva	Qual è stato l ultimo strumento digitale che ha utilizzato nella sua pratica didattica?									
media	2,94585307	3,53846549	**domanda a risposta aperta**									
deviazione standard	1,23184599	1,03473176										

Figure 2. Summary of questions

Discussion

The survey conducted allows us to reflect on the current level of digital skills of teachers and on the degree of integration of Artificial Intelligence in inclusive teaching. The results describe a context characterized by a strong motivation towards learning and innovation, but at the same time characterized by some practical and cognitive limits, in particular regarding the advanced use of technologies in connection with disciplinary content.

In relation to the chronological age, a significant negative correlation emerges with the question

"I feel comfortable in using technology to support the learning of students with disabilities" ($r = -0.23$; $p = 0.017$) it would indicate that as age increases, the sense of comfort in using technology to support the learning of students with disabilities tends to decrease;

A further key element concerns the overall perception of the effectiveness of digital technologies in inclusive teaching. Most teachers consider these tools useful for promoting inclusion, with averages above 3.5 on a Likert scale. This perception is strongly correlated with the sense of comfort in using technologies ($r = 0.79$, $p < 0.00001$), indicating that those who feel more comfortable with the use of technologies also tend to evaluate them as more effective for school inclusion. Specifically, the correlation was found between the responses to the items “I believe I have adequate skills for integrating digital technologies into teaching for students with disabilities”, and “I feel comfortable using technology to support the learning of students with disabilities”.

This picture highlights how, alongside a generally positive attitude towards Artificial Intelligence, there remains a gap between theoretical awareness of its potential and the actual capacity for didactic implementation. In particular, the item relating to concrete experimentation (“I have experimented with Artificial Intelligence tools in the context of inclusive teaching”) records one of the lowest averages of the entire questionnaire ($M = 2.95$), confirming the still emerging nature of the use of Artificial Intelligence in the classroom.

This experiential lack also seems to influence the perception of one’s own effectiveness in personalising teaching through intelligent tools, as highlighted by moderate correlations with the dimension of didactic planning. In fact, in cases where teachers have had the opportunity to actively use Artificial Intelligence, the perception of competence in designing teaching activities integrated with technological tools also increases ($r = 0.41$; $p < 0.001$).

Furthermore, the correlation between direct experience with Artificial Intelligence tools and dimensions such as technological adaptability ($r = 0.64$) reinforces the idea that concrete use favors a more reflective, aware and critical approach.

At the same time, the open-ended responses confirm the importance of the intuitiveness and accessibility of the chosen tools. Teachers prefer technologies that lend themselves to immediate and shareable use, such as Kahoot, Google Jamboard, Canva and Book Creator, which allow the entire class to be actively involved and facilitate inclusive work thanks to visual, interactive and multi-format features. Collaboration tools such as Padlet and Google Classroom are often

associated with participatory teaching, while presentation environments such as PowerPoint and Prezi are used to support the explanation and memorization of content.

Practical experience with tools based on Artificial Intelligence — such as ChatGPT — is declared only by a minority of the sample analyzed. The item "I have experimented with Artificial Intelligence tools in the context of inclusive teaching" reported one of the lowest averages of the questionnaire (M = 2.95), confirming the still emerging and potential dimension of such technologies within the school.

However, teachers who report having had concrete experiences with Artificial Intelligence tools present significantly different profiles compared to the sample average. In particular, they show:

- greater confidence in the possibility of adapting technologies to the individual needs of students,
- a higher awareness of the participatory impact that Artificial Intelligence can have in the classroom,
- a more developed planning and micro-planning capacity.

These skills are supported by a positive correlation (r = .64) between practical experience with Artificial Intelligence and the ability to use it effectively and inclusively. The data confirms what has also emerged in the literature: direct experimentation represents a crucial factor in the development of advanced digital skills, especially when applied to complex teaching contexts.

The qualitative analysis of the open-ended responses also highlights a tendency to favor intuitive, accessible and collaborative digital tools, consistent with laboratory-type teaching. Among the most frequently cited:

- Kahoot! (17.1%) – used for formative assessment in a playful and participatory way;
- LIM – Interactive Multimedia Whiteboard (14.4%) – used as a visual and interactive support to promote accessibility to content;
- Canva, Google Classroom, Jamboard, Book Creator – with percentages between 8% and 10%, tools chosen for their ability to support collaborative design, multimedia and adaptation of materials (see Figure 3 "The most used digital tools").

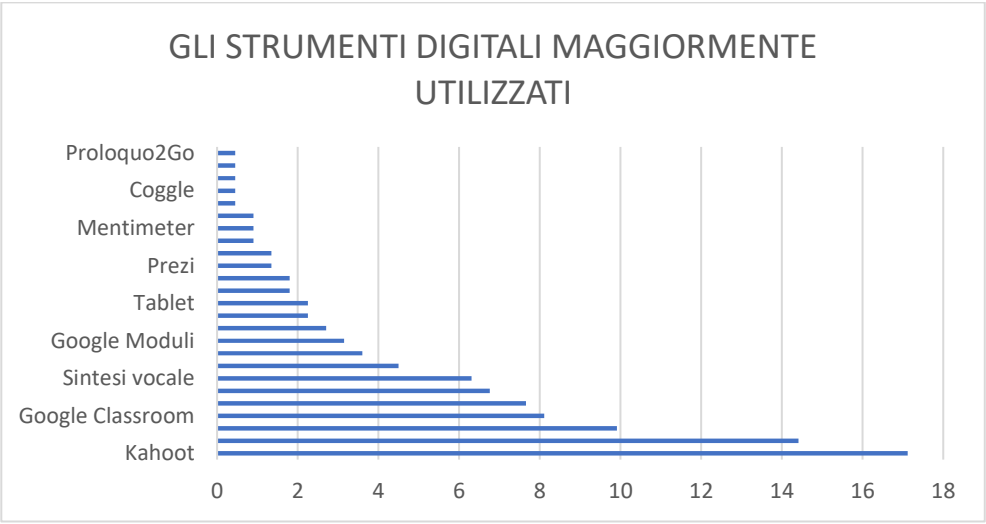


Figure 3. The most used digital tools

The main uses identified are:

- Collaborative tools (Padlet, Jamboard, Google Classroom) → used to promote equal participation, through the sharing of materials and visual communication;
- Multimedia tools (PowerPoint, Book Creator, Canva) → used to simplify disciplinary content and offer alternative representation paths;
- Specific disciplinary tools → in particular for mathematics and for students with DSA, the use of IWBs and visual/auditory supports allows greater customization and accessibility (see Figure 4 “The main uses declared in teaching practice”).

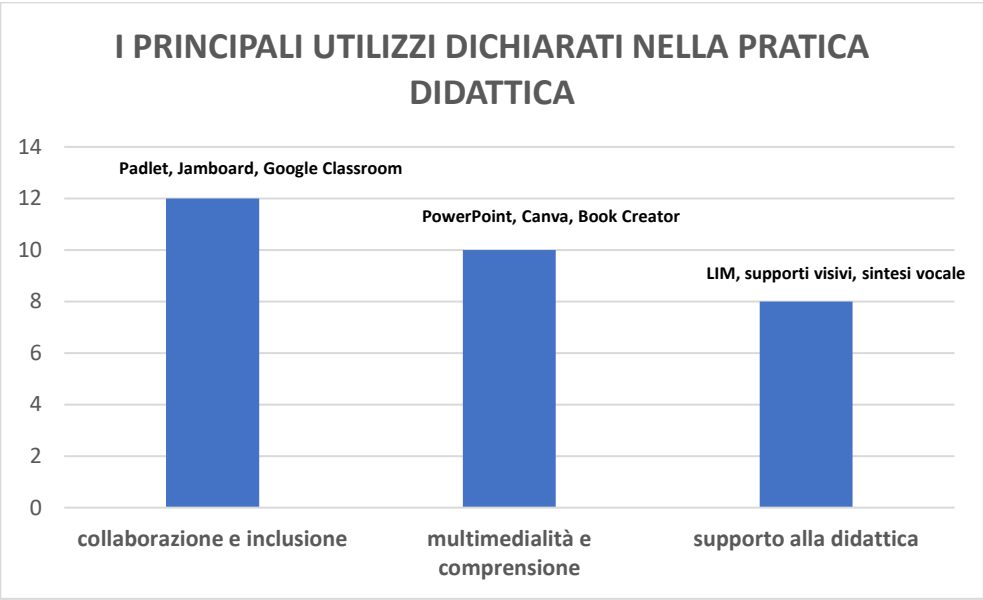


Figure 4. The main uses declared in teaching practice

Conclusions

This exploratory research aims to contribute to the development of a more integrated and critical vision of digital skills in the era of Artificial Intelligence, analyzing the perception, level of competence and use of Artificial Intelligence and digital technologies in the educational field.

The data that emerged outline a teacher profile positively oriented towards technological innovation, but still in a phase of development of application skills, especially in relation to Artificial Intelligence. The coherence between perceived skills, operational comfort and ethical knowledge suggests the effectiveness of integrated training paths, capable of connecting theory, practice and critical reflection. At the same time, the lack of concrete experience with Artificial Intelligence tools indicates the need to increase laboratory opportunities to experiment, evaluate and contextualize these technologies in everyday teaching.

The survey conducted provides an encouraging picture with respect to the integration of digital technologies and Artificial Intelligence in inclusive teaching. Teachers show a positive attitude and a strong motivation to deepen their skills, accompanied by a widespread perception of the usefulness of technologies to promote inclusion and personalization of learning. However, a gap emerges

between theoretical awareness and concrete experimentation, particularly in the use of Artificial Intelligence, which is still limited to a minority of the sample.

This scenario can be analyzed in the light of the TPACK (Technological Pedagogical Content Knowledge) model by Mishra and Koehler (2006), which emphasizes the need to synergistically integrate technological, pedagogical and disciplinary knowledge. The data show that, although many teachers are familiar with digital tools (technological knowledge), difficulties remain in effectively combining them with teaching methodologies (pedagogical knowledge) and disciplinary contents (content knowledge).

Teachers who have experimented with Artificial Intelligence tools report greater planning capacity, ethical awareness and confidence in the adaptability of technologies to the needs of students with disabilities. This confirms how direct involvement is crucial to develop applied pedagogical-technological knowledge, as foreseen by TPACK.

The intuitiveness of the tools, their accessibility and the possibility of collaborative and creative use (e.g. Jamboard, Canva, Book Creator, Kahoot) represent key factors to promote inclusive, participatory and personalized teaching. However, the effectiveness of these tools depends on the ability of teachers to consciously integrate them into their teaching practice (Di Tore et al., 2022), an objective that can only be achieved through transversal skills, or soft skills, that are able to connect theory, practice and critical reflection (Lecce 2024a; Lecce, 2024b).

Author contributions

Amelia Lecce is the author of this article and Stefano Di Tore is a Scientific Director.

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