

Lo sguardo della Pedagogia Speciale ai processi di letto-scrittura

Nuove tecnologie e prevenzione pedagogica

Special Education's view of reading-writing processes

New technologies and pedagogical prevention

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RIASSUNTO: Le nuove frontiere aperte dall'intelligenza artificiale (IA) conducono la ricerca in Pedagogia e Didattica Speciale a incontrare nuove discipline e a realizzare progetti che ripensino alla formazione dei futuri professionisti del campo sia della medicina che dell'educazione. Da tali considerazioni, l'articolo propone una proposta che entra nel campo della prevenzione dei Disturbi Specifici di Apprendimento e che riformula percorsi di prevenzione grazie alle nuove tecnologie e al dialogo interdisciplinare. A tal fine verrà illustrato il progetto PRIN E-Hand come esemplificazione di nuove metodologie innovative e inclusive.

PAROLE-CHIAVE: prevenzione, processi di letto-scrittura, nuove tecnologie, Intelligenza artificiale.

ABSTRACT: The new frontiers of Artificial Intelligence (AI) are leading research in pedagogy and special education towards the encounter with new disciplines to carry out projects that rethink the training of future

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professionals in both the medical and educational fields. Based on these considerations, the article proposes a project that enters the field of prevention of Specific Learning Disorders and reformulates prevention paths thanks to new technologies and interdisciplinary dialogue. To this end, the PRIN project E-Hand will be illustrated as an example of novel innovative and inclusive methodologies.

KEY-WORDS: prevention, reading-writing processes, new technologies, Artificial Intelligence.

1. Introduction

Special education evolves through the encounter with diverse disciplines and perspectives, as stated by Canevaro, following a path that can be traced back to the reconstruction of its epistemological status. In this sense, scholars of special pedagogy and didactics have created novel disciplinary connections, essential for understanding the field's epistemological identity and integrating multiple disciplines in the analysis of complex phenomena, both medical-clinical and educational.

This interdisciplinary approach also applies to the study of reading and writing processes, which includes physiological learning, effective didactic methodologies, dysfunction analysis, and the search for prevention, empowerment, enablement, and rehabilitation interventions. In this area, special education has made significant contributions, from the topic of prevention to inclusive didactics and teacher training.

The theme of prevention can be investigated by special education in its specificity and in dialogue with other disciplines as well, giving rise to potential interpretative pathways of educational phenomena and inclusive processes. This issue becomes even more urgent in the contemporary scenario, considering how the latest advances of information and communication technologies (ICTs) and Artificial Intelligence (AI) are affecting both the fields of medicine and education.

The new frontiers of Artificial Intelligence lead special education and didactics research towards the dialogue with new disciplines, realising projects of considerable social impact, and rethinking the training of future professionals in both the medical and educational fields. This perspective

draws attention towards relevant themes that range from ethics to the experimentation of new action-research paths and the conscious training of professionals.

In this context, this article proposes an initiative for the prevention of Specific Learning Disorders (SpLDs) that reformulates prevention paths thanks to the integration of new technologies and interdisciplinary dialogue. Specifically, the Project of Great National Interest (PRIN) E-Hand. Empowering middle childhood Handwriting will be illustrated as an example of innovative and inclusive methodologies to this end.

2. Action trajectories

The topic of Specific Learning Disorders offers a rich context for exploring connections between special education and other disciplines, facilitating research progress and the professionalisation of central figures for inclusion, such as educators. A central aspect of this exploration is SpLDs prevention. Prevention involves both studies aiming to identify early indicators and risk factors for SpLDs, and the training of teaching staff in recognising such indicators and using essential tools for risk detection.

To this end, it is crucial to consider developmental windows, which are periods of heightened sensitivity where risk indicators are more predictive and educational interventions are more effective, which makes the role of trained teachers particularly crucial.

In this sense, teachers in early childhood education and the initial stages of primary school play a fundamental role in early detection and the activation of targeted educational programs within classrooms. If difficulties persist, they can promptly inform families so they can seek specialised services, facilitating necessary diagnostic pathways. It is important to clarify that the screening discussed here is not a functional diagnosis but a widespread examination to detect potential SpLDs indicators. This practice should not be confused with certification as it does not provide diagnoses, but rather highlights risk conditions, underscoring the crucial interaction between special education and medicine.

The evaluation dimension, which falls within the medical field, enables special education to guide the training of teachers in observing and understanding the differences between students with learning difficulties and

those with SpLDs. Research emphasises the discrepancy criterion, identifying a significant gap between the expected performance for the person's age and the specific abilities related to the general intellectual functioning. This approach requires standardised tests to assess performance compared to the peer population. The diagnosis timeline is also agreed upon and is typically established at the end of the second year of primary school. Positive results in constructing and standardising diagnostic tests for SpLDs extend to high school students, though research is still ongoing.

Interventions for SpLDs are highly debated topics. Various studies aim to delineate the effectiveness of specific treatments in terms of performance improvement. It is crucial to demonstrate that interventions result in improvements beyond natural child development, thereby enhancing Quality of Life. Parameters are needed to evaluate the evolution of specific skills in children with and without disorders. This research direction is urgent due to the difficulty in accurately assessing the timing and outcomes of treatments, avoiding prolonged interventions that do not show superior results to natural development trajectories, leading to demotivation in children and families.

Although research on treatment efficacy is ongoing, a shared approach involves a comprehensive management of SpLDs, involving specialists, parents, teachers, and educators in a systematic and professional manner.

Following this perspective, in the next section we will present an innovative research project that applies this pedagogical knowledge to the use of technology for monitoring and training writing performance.

3. The research project

In line with the pedagogical references mentioned above, we are going to present a research project called E-Hand. Empowering middle childhood Handwriting¹. The project focuses on the use of technologies for the monitoring and training of handwriting performance to support the correct development of pupils' handwriting skills and the early detection and correc-

1. PRIN 2022 Project 'E-Hand. Empowering middle childhood Handwriting' No. 2022AWA-TR2 Funded by the European Union-Next Generation EU, Mission 4 Component 2 Investment 1.1 CUP D53D23012830006.

tion of dysgraphia. Indeed, since technologies have demonstrated suitability for noninvasive and cost-effective posture monitoring, they can result to be particularly beneficial for early identification of potential signs of dysgraphia and for students' self-awareness and personal coping skills enhancement.

Considering the lack of e-learning systems that fully integrate haptic technologies, Artificial Intelligence, and facial and emotional recognition to support early identification of writing-related motor difficulties, the project seeks to address this gap by developing an integrated system accessible to both teachers and therapists, thereby improving school inclusion and ensuring the proper development of writing skills, even for children facing challenges in this area.

Emotion recognition, based on facial expressions, eye movement, and head posture, can be achieved through deep learning algorithms, providing valuable insights into how students manage educational tasks. Therefore, the use of AI in this context makes it possible to create a customised, adaptive learning system that can respond in real time to the specific needs of each student. Specifically, AI is used to analyse a wide range of data, including handwriting micro-movements, facial expressions and posture, thus providing a complete picture of the child's learning process.

The research methodology involves the use of machine learning models to refine the recognition of students' emotions and posture. These models will be trained during a pre-test phase and subsequently implemented in large-scale studies, allowing for continuous, real-time assessment of student performance. In this context, AI will be used not only as an assessment tool to analyse data collected during longitudinal studies, thus allowing the identification of patterns and trends that may not be evident with traditional analysis methods, but also as a means to provide personalised feedback and dynamically adapt each student's learning pathway. Therefore, this data-driven approach allows the system to be continuously refined and adapted to the evolving needs of students.

3.1. Procedural steps

The research project proposes an innovative approach for early screening and support of writing skills, integrating advanced technologies into an e-learning system. The methodology is divided into four main phases: 1) Definition of experimental design and protocols; 2) Usability and acceptability evaluation; 3)

Small-scale validation; 4) Longitudinal studies in classrooms.

The first phase involves defining operational protocols for classroom activities. Validation objectives, measurement methods, and variables to be analysed are also defined in this step.

The second step involves the technological setup of tools to study micro-movements, graphomotor fluidity, and student motivation. Among these, haptic technologies with tactile feedback will be used to support the learning of writing, especially in cases of dysgraphia. The final result will consist in a technological infrastructure for digital writing to be used both in the classroom and in distance learning. The system will include a mechanical structure with haptic components, writing surfaces, and cameras, designed to adapt to different anthropometric dimensions in compliance with ergonomic principles. To collect information on students' posture and emotions, emotion recognition and body tracking tools based on RGB cameras will be adopted. Finally, the system will integrate hardware components (multimedia sensors, haptic displays, touchscreens) and a software platform to support dysgraphia diagnosis and improve writing skills.

The technological setup will be followed by pre-testing of the experiment for the acquisition of data to optimise the system design and refine machine learning models for emotion and posture recognition. The involvement of experts in special education and didactics and students will allow for the validation of the system and procedure.

Finally, in the fourth step, after an initial experiment with a small sample of 5-7 year-old children, larger-scale studies with longitudinal and cross-sectional designs will be conducted. The longitudinal study will evaluate writing development using different technological tools and the effectiveness of support strategies, considering micro-movements, emotions, and postural behaviour.

This multidimensional approach aims to provide a comprehensive tool for early identification and support of graphomotor difficulties, integrating advanced technologies in an innovative educational context.

3.2. Implications

The project E-Hand. Empowering middle childhood Handwriting represents a significant breakthrough in the field of education and assistive technology, with far-reaching implications for students, educators, thera-

pists and researchers. Indeed, this multidimensional approach to learning to write and early detection of dysgraphia has the potential to change the approach and support to writing difficulties in school-age children.

One of the most relevant implications of this project is its potential to improve scholastic inclusion. By integrating advanced technologies such as Artificial Intelligence, emotion recognition and haptic interfaces into an e-learning system, the project offers a personalised approach to the learning of writing. This could significantly reduce the gap between students with writing difficulties and their peers, promoting a more equitable and inclusive learning environment.

In line with the literature, the use of non-invasive technologies for posture monitoring and emotion recognition opens up new possibilities for the early identification of dysgraphia. This aspect of the project could lead to more timely and effective interventions, potentially reducing the long-term impact of writing difficulties on children's development. Furthermore, the AI-based approach to analysing micro-movements of handwriting, facial expressions and posture provides a more comprehensive and nuanced understanding of each student's learning process, allowing for more targeted and personalised interventions.

The adaptive learning system proposed by the project, which responds in real time to the specific needs of each student, could radically transform students' learning experience. This dynamic and personalised approach has the potential to increase student motivation, improve self-efficacy and develop more effective coping strategies to deal with writing challenges.

In this regard, Engel-Yeger et al. emphasise the importance of a multidimensional approach in the assessment of dysgraphia, including not only writing performance, but also self-assessment and perceived self-efficacy.

Narciss and colleagues also explore personalised feedback strategies, highlighting how these can be tailored to individual students' characteristics to maximise learning effectiveness.

From a research perspective, the project offers a unique opportunity to collect large-scale longitudinal data on the development of writing skills.

The use of machine learning models to analyse these data could lead to new insights into the learning processes of writing and the factors that influence the development of dysgraphia. This knowledge could inform future pedagogical practices and therapeutic interventions, further improving the support offered to students with writing difficulties.

The integration of hardware and software components into a single technology platform for digital writing could also have significant implications for distance education. In an era in which online learning is becoming increasingly common, a system that can effectively monitor and support the development of writing skills at distance could be extremely valuable.

However, the implementation of such an advanced system also raises important ethical and privacy-related issues. The collection and analysis of sensitive data such as children's facial expressions, body movements and writing performance will require strict protocols to ensure data protection and respect for students' privacy. Balancing the potential benefits of the system with the need to safeguard the rights and well-being of the young participants will be crucial to guarantee the framework's sustainability.

Moreover, the introduction of such advanced technologies in the educational context may require significant training of teachers and therapists. It will be essential to ensure that educators are able to use the system effectively and interpret the data it allows to collect in order to maximise the benefits for students.

In this context, the 'E-Hand' project has the potential to have a profound impact on the way we approach the teaching of writing and the diagnosis of dysgraphia. By combining state-of-the-art technology with a solid pedagogical basis, this innovative approach could significantly improve educational outcomes for students with writing difficulties, while promoting more inclusive and personalised education processes. However, its long-term effectiveness and scalability will depend on the proper addressment of the ethical, practical and educational challenges associated with implementing such an advanced system in the educational context.

4. Conclusions

In conclusion, we would like to emphasise some lines of action that, in the specificity of special education and the dialogue with other disciplines, can become significant inclusive trajectories.

The first line of action unfolds the importance of prevention and awareness raising on the culture of prevention itself. In the pedagogical field, prevention can be conceived and interpreted in four main profes-

sional directions: 1) Information and education for parents and teachers to promote early observation of children behaviour and to provide potential paths to work on prerequisites for reading, writing and mathematics; 2) Screenings in schools starting from the last year of kindergarten and the first two years of primary school; 3) Inclusive paths of enhancement activities for the whole class group; 4) The role of innovative technologies in pedagogical prevention.

The second line focuses on formation. When considering teacher training, the actions are oriented towards the design of an inclusive curriculum, in which different personalised didactic paths can be arranged. In the encounter of education with the other disciplines, the pedagogical relevance leads us, on one hand, towards the design of personalised didactic paths and scholastic and professional orientation strategies. On the other, it is directed towards teacher training. Prevention, as training, are fundamental actions to ensure an efficient communication and fruitful cooperation between schools and families, with the aim of creating spaces to activate awareness, joint responsibility and co-design processes through time. Indeed, such processes are often fragile, threatening the undertaking of people with SpLDs and their participation in the creation of a life project.

The third line focuses on the attention to people and contexts. Analysis and reflection insist as much on process-related dimensions as on people's encounter with their stories and their life contexts. Dimensions such as people's experience, suffering, support relationships, as well as the diverse and specific representations of the person with Specific Learning Disorders and their relatives are at the centre of the undertaking and the interdisciplinary debate. The encounter generates interesting research paths, oriented towards forms of narration and biography (often, also autobiography) that allow to understand the story of the person in its embodied expression and in its relationship with the professional (whether educator, public health operator, pedagogue, teacher, or doctor) and that became perspectives specific to special education.

The last line refers to the impact of new technologies and the latest frontiers of AI for professional training in the fields of health and education. The first significant issue concerns the awareness of AI's potential, as well as the available tools and their potential use. In particular, when Artificial Intelligence is used to create contents like texts, images, or sounds, it is essential to be able to discern its products from human-made contents

for the sake of a responsible use. Such a topic represents one of the key dimensions of AI: explainability, that is to say the ability to understand and explain what an AI-based system is and how it works. In other words, before implementing or even imagining potential applications of AI, it is essential to acquire full knowledge of these tools. In this sense, explainability is crucial to guarantee transparency, trust and an informed use of AI, especially in fields such as health and education.

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