Exploring the Intersection of Artificial Intelligence and Special Education

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Abstract

Special Education (SE) self-determination includes the theoretical background of inclusive education, while its hetero-determination is based on policy changes and potential technological advancements (e.g., Artificial Intelligence – AI advances). As a self-determined scientific area, SE refers to general parameters, such as pedagogical methods, practices, techniques, instruments, and materials for enhancing learning activities for groups who have traditionally been excluded. As a hetero-determined scientific subject, SE reflects the instantiation of these parameters on a case-by-case basis in order to solve a specific problem, under certain conditions and constraints. In the context of instantiating the well-known general parameters to specific particularities, AI, due to its manifold nature, has been suggested as a valuable means to transform SE, making it more effective. Given that SE and AI are disproportional evolving scientific fields, it is considered necessary to explore where is their meeting point, by focusing on the analysis of real-world applications of AI in SE (e.g., speech and language, physical and behavioral therapy, intelligent tutoring), as well as of challenges associated with integrating AI in SE (e.g., ethical and lawful use of data, digital divide, absence of empathy). This paper provides a literature review of both real-world applications of AI in SE and the challenges associated with integrating AI in SE.

Keywords

Special Education, Artificial Intelligence

1. Introduction

The issues arising from advances in the field of matching Artificial Intelligence (AI) and Special Education (SE) are already of increasing concern to scientific bodies, businesses, and public authorities. On the one hand, AI is a manifold term, whose clear definition does not exist [32]. It is a sub-field of computer science which encompasses many techniques (e.g., machine learning, natural language processing, computer vision, deep learning, data mining, robotics), is applied to many contexts (e.g., healthcare, industry, finance), displays specific human-like features (e.g., intelligence, autonomy) in different degrees, and takes tangible or intangible forms (e.g., a robot or a program run on network computers) [21]. On the other hand, SE is a complex term that involves educational policies and organizations, has political implications, and its research branches out in several directions [69]. In this perspective, it can be self-determined by the theoretical background of inclusive education and hetero determined by policy changes [14] and potential technological advancements [27].

Although SE and AI are not clear-cut concepts, they have a substantial impact on the functioning of societal reality, which aims at ensuring the stability and continuity of society cohesion. Their in-depth investigation falls outside the scope of this study. Instead, this article focuses on the debate on

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the current AI impact on SE transformation. It is generally accepted that societal transformations are triggered by the synergy of education and technology fields. Indeed, technological innovations such as AI have the potential to revolutionize education, and simultaneously, education flourishes by using AI technology [39]. In this vein, the vast majority of policy makers have suggested the incorporation of innovative digital technologies, such as AI applications, in educational and SE settings, given that they support the idea that AI tools can successfully contribute to the educational process [12], [19], [20]. Indeed, AI technology has already influenced SE practices by providing tools to enable development of students suffering from disabilities (i.e. learning, hearing, visual and mobility impairment) [22], assist teachers in evaluating and forming personalized learning plans according to students' special needs [56], help special scientists diagnosing and planning intervention strategies per special educational need [47], and, among others, assist parents in supervising children's development [63].

In this context, SE, as part of the educational system, and AI, as a technologically innovative educational tool, are intertwined terms that are defined too imprecisely; their conceptual lines get blurred. This is due to their multifaceted nature, which is context-dependent, and their manifold manifestations. Within the educational field, apart from the benefits of using AI applications in SE practices, their matching entails a connotation of pedagogical (understanding how AI affects the individual's learning), legal (ensuring that AI follows the Law), and ethical (making sure that AI behaves fairly and responsibly) implications. At present, developers, policy makers, administrators, teachers, students, and parents can use AI tools in SE, which include intelligent tutoring systems, smart learning, and social robots, in order to easy and improve their access to educational procedures. Although there have been an important number of studies which address how AI technology is effectively used in practice in order to improve the quality of education of students with special needs, emphasizing to numerous benefits, some researchers argue that the use of AI in SE settings, along with benefits, also poses significant pedagogical, social, ethical and legal challenges [58], [64], [8].

This paper delves into the complexities of matching AI and SE, based on the imbalance between rapid AI innovation and the slower pace of educational settings adaptation. It critically evaluates the advantages and drawbacks of integrating AI within SE, by focusing on the analysis of real-world applications of AI in SE (e.g., speech and language, physical and behavioral therapy, intelligent tutoring), as well as of challenges associated with integrating AI in SE (e.g., ethical and lawful use of data, digital divide, absence of empathy), based on the SE conceptualization. The paper is structured as follows. Section 2 explores the conceptual background that semantically forms the term SE. Next, realworld AI applications, within SE environment, are discussed in Section 3. In Section 4, various challenges of integrating AI in SE are identified. Future research directions are discussed in Section 5, including contributions to the scientific community.

2. SE self- and hetero- determination

Special Education (SE) self-determination includes the theoretical background of inclusive education, while its hetero-determination is based on policy changes and potential technological advancements (e.g., Artificial Intelligence – AI advances). On the one hand, SE self-determination is bounded by lines drawn between its scientific and social purpose, as well as its legal establishment. From the scientific point of view, the overall purpose of SE is to provide educational services to students whose disabilities adversely affect their learning [52]. Its social purpose is the inclusion of groups who have traditionally been excluded [43]. From a legal perspective, SE philosophy focuses on safeguarding the fundamental human rights of equality and social justice [49]. On the other hand, SE hetero determination is strictly connected with changes in political landscape and technological innovations. Indeed, the transition from the traditional educational scenery to a more democratic educational paradigm, which intends to promote "value-for-money" knowledge for all, meant sharp policy shifts. According to existing contemporary educational policies, SE as a distinct part of the educational system, must exhibit quality assurance requirements, such as transparency, accountability, safety, and fairness. Another key aspect that influences SE implementation is advancements in digital technologies, especially the rapid integration of AI within the educational environment.

The United Nations Educational Scientific and Cultural Organization (UNESCO), the World Health Organization (WHO), the United Nations Convention on the Rights of Persons with Disabilities [60], [61] and the European Agency for Special Needs and Inclusive Education (EASIE) are the pioneering stakeholders that laid the theoretical foundations for Special Education (SE). According to UNESCO, SE, as a sub-part of inclusive education, is defined as the process of enhancing the ability of educational system to address the needs of all learners, even those with physical or mental impairments – that is, children with medical, social, or holistic biopsychosocial model of disabilities - that require additional support [3] in order to be given the right to be educated in the general educational system [61], in a way that reflects their formally assessed needs [63]. In the light of these guidelines, SE has become an overall international trend [25], [48]. However, despite consensus on the importance of SE, finding ways of implementing its strategies and practices, as well as of recognizing specific disabilities differ across countries. For example, some countries focus on serving students with disabilities in the mainstream educational setting, giving emphasis to students' social interaction with their peers, while others focus on special settings from the fear that mainstream settings do not have the expertise or the capacity to support students with more complex needs [23].

Despite SE universal design, its implementation differs widely across the world, especially due to its ambiguous conceptualization among different stakeholders' perspectives, that is, parents, teachers, researchers, and policymakers. Indeed, existing empirical literature explains the interaction between parents' beliefs, expectations and experiences and SE's achievements [37], [42]. Moreover, research studies focus on parental involvement in SE by analyzing their role as active participants in the educational process. Parental involvement has a tripartite hypostasis, parent as "mediator", parent as "client", and parent as "implementer". The role of parent as mediator emphasizes constructing a relationship with the educational environment by attending school meetings, providing information to teachers, and volunteering at school events [54]. The role of parents as client especially refers to their engagement with their children's special education needs assessment system [34]. The role of parent as implementer encompasses actions that parents can perform at home, such as providing support with homework based on student's individualized learning plan and behavior modification [44]. Another key factor of achieving successful SE is teachers who must adequately prepare specially designed instructions for students with disabilities. Researching the role of special educators is important since they align theoretical approaches to pedagogical practices. There is much research currently available on this specific topic, discussing teachers' attitudes towards inclusive education [33], [36], special teachers' professional development [37], [38], as well as teachers' preparation in using digital technology in a pedagogical and meaningful way [16].

Except special educators and parents with children with special needs, the landscape of global SE involves states and institutions that have been active in developing international SE governance initiatives, as well as local authorities which instantiate the global trends. The transition from the abstract guidelines to their practical implementation varies across the countries due to unique challenges that each country faces. For instance, the decision of whether a child with special needs will attend special or mainstream education setting is made by different stakeholders in different countries [26]. Moreover, the resources available to implement SE differ widely across countries. For example, some students with special needs are excluded from special education settings, and thus attend ineffectively typical education because the curriculum has not been adapted to fit their needs and the teachers are not specialized to inclusive education pedagogy [28]. Nowadays, a crucial trend of instantiating global SE governance is the optimal use of available resources to enhance SE, including AI innovative technologies [67]. Research on matching SE and AI has been gaining attention worldwide, either focusing on benefits of using AI within special education environments or by emphasizing on challenges of integrating AI in special education pedagogy [2]. Another significant factor that impedes consensus on the implementation of a global SE is that its instantiation, that is, its spatiotemporal implementation, is influenced by cultural, historical, political, and socioeconomic indicators of each country [24], [31], [69]. Indeed, a variety of studies have been conducted using comparative analysis between different countries [1], [66]. Results have shown that SE is challenging to explore in a unified way and to achieve its social purpose in all educational situations.

Considering stakeholders engaged in implementing SE, resources needed, the broader sense of social justice that SE aims at, as well as, the general philosophy underpinning the idea of SE, it is apparent that SE is a complex term subjected to multiple interpretations. Its in-depth investigation, including pedagogical approaches, modes and methods, falls outside the scope of this study. Instead, this paper focuses on the debate on the current AI impact on SE transformation, by discussing some real-world applications of AI in SE (e.g., speech and language, physical and behavioral therapy, intelligent tutoring), as well as exceptional challenges associated with integrating AI in SE (e.g., ethical and lawful use of data, digital divide, absence of empathy).

3. Real-world applications of AI in SE

One of the primary drivers of the SE instantiations is the increasing demand for personalized learning experiences tailored to students' special needs. Integrating AI-powered solutions, apart from being challenging (e.g., it poses significant ethical barriers to adoption) and complex (e.g., it requires substantial investment and expertise), can boost the capability of educational system to provide more accurate recommendations to educators, parents and students. For instance, AI algorithms through predictive analytics by analyzing historical data can predict student performance patterns, allowing educators to identify at-risk students who may require additional targeted support. AI technology is also combined with virtual reality and augmented reality to allow students to explore and interact with history and science visual environments, thus gaining memorable learning experiences.

Personalized learning (AI algorithms are used in educational platforms that tailor learning materials and activities to students' needs) [39], [40], intelligent tutoring systems (systems that utilize natural language processing and machine learning algorithms to provide immediate explanations and customized feedback to students) [59], enhanced accessibility (the use of speech recognition, natural language processing algorithms and computer vision techniques make educational materials accessible to students, by providing alternative content formats) [65], intelligent data analytics (AI algorithms process vast amounts of data identifying patterns and trends in students learning performance, enabling timely interventions) [33], automation of administrative tasks (AI-based systems are capable of handling routine administrative tasks such as grading assignments and scheduling classes), intelligent feedback and assessment (automated grading systems and AI-driven assessment tools provide instant and personalized feedback to students) [18], collaborative learning and virtual classrooms (AI-powered tools facilitate groups communication and peer-to-peer interaction through virtual classrooms) [57], adaptive learning paths (AI-powered adaptive learning platforms leverage data analytics to track and analyze students' performance, behavior, and engagement patterns) [35], virtual reality and augmented reality (AI algorithms personalize virtual and augmented simulations based on individual learning needs) [51], virtual tutoring (software applications – chatbots - that use AI and natural language processing techniques to respond to user input queries and generate human-like answers) [53], intelligent content creation (AI algorithms analyze vast amounts of data and resources, such as articles and videos, to create up-to-date and comprehensive educational material suitable to students learning modes) [41], predictive analytics for student success (it uses a combination of big data technologies, algorithms and machine learning techniques to predict the probability of future trends that impact students outcomes and success rates), ethical decision-making and bias detection (AI services educate students about ethics in using AI applications and systems in order to understand the importance of data privacy and safety) [17], personalized career guidance (AI-enhanced learning analytics tools collect and analyze students' data to help them choose their academic paths) [9], emotional support and mental health (AI and big data analysis technology designs intelligent support systems for students emotional and mental health) [7], lifelong learning and skill development (AI-based learning platforms suggest relevant courses to students in order to continuously acquire new knowledge and skills) [30] are some of the prominent examples retrieved from recent literature that make apparent the potential benefits of integrating AI in education, thus reshaping the students learning modes, teachers pedagogical attitudes and educational system functions. In summary, AI transforms the way (a) teachers monitor, asses, and refine their teaching methods, (a) educational material becomes more personalized, (c) students experience new learning paths, (d) parents monitor their children progress, (e) administrative tasks are automated.

Although AI has the potential to enhance learning by providing numerous benefits to students and teachers offering innovative tools and resources, as it is apparent from the above indicative literature, there is little existing literature concerning the alignment of AI applications in SE. In particular, focusing on SE, the core component of its instantiation is the writing of the Individualized Education Program (IEP) per student. This complex and time-consuming task of special teachers requires a deep understanding of the students educational, social and emotional background, a strict knowledge of the legal framework, and the ability to collaborate with SE experts. AI tools, such language models like ChatGPT consist of a real-world application of AI integration in SE, since it enhances the process of drafting IEPs efficiently [56]. Another real-world application of AI in SE is using AI and robotic technologies to design therapies for children with autism spectrum disorders. These intelligent devices can improve the conversational skills of children with autism, assist professionals to teach them emotional intelligence, and help parents to introduce them to more complex social environments over time [46], [15]. Moreover, AI contributes SE by improving accessibility for students with disabilities through speech recognition and text-to-speech features [45], [4]. Within SE settings, various disabilities are addressed, such as limited sight, hearing, intellectual ability and motor disabilities. AI-empowered assistive technologies have been developed to significantly contribute to supporting children with these disabilities [13].

4. Challenges of AI integration in SE

Regarding the subject area of matching AI and SE, or alternatively, the AI integration in SE, the literature is mostly characterized by positive expectations of this technology in education, in general, and seldom address the challenges and ethical questions associated especially with SE. Indeed, according to UNESCO [68], the main challenging issues related to AI in education includes unequal opportunities to use AI, lack of teachers' expertise in using AI, lack of a unified policy in using AI for educational purposes, data privacy breaches, non-identification of quality requirements of AI educational systems, and lack of ethics [10]. In general, the challenges related to AI in education are discussed on a philosophical, pedagogical, psychological, technical, societal, and regulatory level [11], [6], [50]. Ensuring transparency, fairness, safety, reliability, and accountability, protecting privacy, preventing bias and discrimination, mitigating the risks of AI systems, preventing violations of fundamental human rights, and promoting innovation, are some of these challenges that also reflect the reasons to urgently regulate the governance of AI integration in SE [5]. This Section presents a panoramic, but non-exhaustive overview of these challenges by focusing on the use of AI in the SE context.

There is a lot at stake when it comes to the AI integration in SE. The reasons for AI integration growing importance in SE are various, which are related to its technological pervasiveness, its economic impact, as well as ethical and social considerations.

Firstly, there is the need to strike a delicate balance between fostering innovation and maintaining special education principles compliance. This balance is tricky, because it involves the rapid pace of AI advancements and the slower-evolving traditional mechanism of SE practice. This disproportionality between AI and SE poses a significant hurdle in matching both scientific fields in creating effective and timely AI integration in SE settings. Indeed, there are two interrelated critical issues that describe this imbalance. On the one hand, changes in SE process take a lot of time and must go through various rounds of consensus among educational authorities and institutions, and, on the other hand, SE policies that might be established may become obsolete as soon as or even before they can be installed.

Another significant aspect is the borderless nature of both fields, which necessitates international collaboration. But this collaboration proves challenging due to diverse cultural, ethical, political, and socioeconomic standards that exist across different countries. In comparison, the European Union's general approach contrasts with the goal-oriented method in the United States and the innovation-driven approaches in Asia. Indeed, Europe, based on an anthropocentric approach, provides general guidelines for integrating AI in SE. America, as the global economic leader, focuses on an industrial-based approach by producing AI applications oriented for specific problems, while China, as the secondlargest leader in the AI race, follows a more innovative-based approach that reflects its political attitudes.

Additionally, achieving a global consensus on guidelines for AI integration in SE is a complex task that requires a most complete and nuanced understanding of the diversity of its stakeholders, including education experts, practitioners, policymakers and business leaders. In this vein, uncertainties in the development and deployment of AI in SE concerning absence of pedagogical philosophy, unpredictability in the outcomes of AI educational systems due to, for example, algorithmic bias, and unforeseen uses of AI systems by non-trained teachers, students, administrators, and parents reflect the challenging issue of the urgent need of governing AI integration in SE.

Moreover, the deliberate or neglectful replacement of teachers in integrating AI in SE is another challenging issue. AI should serve to enhance (e.g. by alleviating administrative burdens and focusing on personalized instructions to students with special needs), not to replace the role of teacher, which is not only improves learning effectively, but also highlights the indispensable element of empathy in SE environments.

Another well-known challenging issue is the digital divide that refers to general barriers including resources, curriculum and pedagogy, environmental setting, teacher attitudes, teacher training, as well as inequities in the way AI is used [55]. This critical issue is also related to factors such as gender, age, socioeconomic status and type of disability of students [29].

Despite AI's significance in education, there is a notable gap in the literature addressing the AI governance dimensions in SE. Here is a table (Table 1) summarizing the gaps identified in our review regarding the integration of Artificial Intelligence (AI) in Special Education (SE).

Table 1
Gaps regarding the integration of Artificial Intelligence (AI) in Special Education (SE).

Gap	Description
Lack of comprehensive literature	Limited research focused specifically on the intersection of AI and SE. More systematic reviews and studies needed.
Disproportionate pace between AI and SE	AI evolves rapidly, while SE adapts slowly due to educational policies and frameworks. This creates a mismatch.
Governance and ethical challenges	Lack of clear governance and ethical frameworks for AI in SE, including issues with data privacy, transparency, and accountability.
Digital divide and inequity	Unequal access to AI technologies for students with disabilities, exacerbated by socioeconomic factors and resource availability.
Teacher training and expertise	Educators lack training and expertise in integrating AI into SE practices, limiting the effectiveness of AI tools.
AI's limitations in empathy	AI cannot replicate the empathy and socialemotional learning crucial for SE, limiting its role in replacing teachers.
Pedagogical philosophy and AI integration	Uncertainty about how AI affects core pedagogical principles in SE, such as fostering communication, critical thinking, and adaptability.
International collaboration challenges	Cultural, political, and socioeconomic differences across countries hinder a unified global approach to AI in SE.

5. Conclusions and Future work

The main aim of this paper is to underscore the urgent need of governing AI integration in SE, by focusing on the complex nature of SE and its interplay with the AI advances. It is the preliminary step of an ongoing systematic literature review on the field of matching artificial intelligence ang special education, aiming at exploring the strategies for addressing the related challenges in AI integration in special education environments, and future directions for research and practice. On the one hand, AI has the potential to enhance learning by providing numerous benefits to students with special needs, their parents, as well as special educators offering innovative tools and resources. On the other hand, the integration of AI in SE poses significant risks of excluding teachers and students with special needs from acquiring essential skills, such as communication, adaptability, empathy, critical thinking. Meanwhile, the disproportional pace of AI advancements and SE instantiations magnifies the problems related to the AI governance in SE environments.

Future work includes a comprehensive analysis of the literature on matching AI and SE, as well as a study addressing the challenges and leveraging AI dynamics in ethical and lawful governance of the AI and SE alignment. To our knowledge, no previous comprehensive analysis of recent literature has been conducted to date on matching AI and SE. Following the three well-known phases of conducting a systematic literature review (i.e. planning the review, conducting the review, and reporting the review), this paper refers to the planning phase, in which the need for the review must be justified. Future research will analyze empirical studies, case reports, and theoretical frameworks to provide a nuanced understanding of trends in matching AI and SE. The results of the study are

expected to provide valuable knowledge on how to use AI empowered technologies in SE instantiations ethically and responsibly.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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