Towards Trustworthy AI in Inclusive Education: A Co-Creation Approach Rooted in Ecological Frameworks

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Abstract

The integration of digital technology and AI systems has prompted extensive inquiries into their ethical design and implementation. Trustworthy AI, essential for fairness, robustness, safety, and transparency, is recognized as fundamental, transcending pure technological interaction. This is particularly pivotal in contexts involving minors, and especially within technologies fostering inclusion for students with disabilities and special educational needs (SEND). Inclusive education hinges on trustworthiness due to inherent asymmetries in learning structures and the relational aspect of educational environments. This paper starting from a case studies, i.e. an AI interface tailored to children with text comprehension difficulties, it introduces a co-creation strategy with different stakeholders. It develops an ecological framework for trustworthiness, rooted in value-sensitive design. Our approach emphasizes ethical and trustworthy AI development, prioritizing responsibility, reliability, and inclusivity. It addresses the concept of trustworthiness as a systemic relationship between multiple contexts (such as clinical and school environments) in the development of children's proximal processes and scaffolding, as outlined by Bronfenbrenner's system ecological theory.

Keywords

Trustworthiness, Inclusion, Natural Language Processing, Text Comprehension

1. Introduction

In recent years, the increasingly technologically mediated nature of our societies, fueled by the systematic integration of digital technology and the escalating ubiquity of AI systems have prompted increasingly profound inquiries into the ethical, responsible, and trustworthy design and implementation of AI. This trend is further underscored by the ongoing legislative endeavors at an European and international level.

While there is no universally accepted definition of trustworthy AI, it is widely acknowledged as a fundamental principle [1], underpinning the validity of other essential characteristics such as fairness, robustness, safety, and transparency. Contrary to the notion that trust is solely tied to technology interaction, as suggested by Luhmann, trust is deemed indispensable for any form of interaction to occur [2]. Consequently, in the domain of AI ethics, the concept of trustworthiness is probably the most multifaceted and the most interconnected with all the others domains.

This is especially true and even more crucial if we think about the use of AI with and by minors and, particularly, within technologies aimed at fostering inclusion in contexts of students with disability and special educational needs (SEND). Within the framework of inclusive education and learning, the aspect of trustworthiness is pivotal for several reasons:

- The inherent asymmetry in the structure of learning, educational, and rehabilitative interactions.
- The relational aspect of educational and rehabilitative environments, grounded in trust and communicative exchanges.
- The developmental trajectory of the child, which encompasses cognitive and psychological dimensions.

Considering the intricate nature of the educational and learning dynamics, the conscientious and trustworthy integration of AI-based technologies within this domain, particularly when involving vulnerable subjects, necessitates a thorough evaluative analysis. Such an analysis should encompass an examination of the interplay among the different systems and players involved.

In this paper, we start by a case study to illustrate the example of a technology built for therapeutic and educational purposes, with a focus on inclusivity, ethical considerations, and trustworthiness. More, in particular,

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we first introduce the ARTIS project, which aims to develop software using natural language processing (NLP) tailored to therapeutic practices for children with text comprehension difficulties. Unlike technologies primarily targeted at disabilities and later repurposed for education, ARTIS is conceived as an inherently educational tool and subsequently tailored for the clinical world.

Secondly, we propose a co-creation approach grounded in value-sensitive design, involving key stakeholders to ensure the ethical development of the AI interface. Drawing from ecological frameworks, such as Bronfenbrenner's ecological systems theory [3] , and considering that learning environments are both physical and social contexts [4], we emphasize the importance of considering the systemic interaction between individuals and their environments in the design process. Our strategy prioritizes the responsible and trustworthy introduction of AI technology, reflecting our commitment to ethical, reliable, and inclusive development practices.

The issue of AI trustworthiness is therefore positioned at the crossroads of various interaction systems known as proximal processes. These processes are pivotal because they serve as the conduit through which individuals learn and adapt over time within their interactional environments [5].

2. AI and Inclusion

The ARTIS project presented in this paper positions itself in the debate on the relationship between AI and inclusion in an innovative way. It develops a technology that assists children with special educational needs and learning disorders, thus aligning itself with the field of assistive technologies. Yet, it doesn't stop at the deterministic association that sees inclusion as directly conveyed by technology, but problematises this relationship through a systemic vision of inclusion and through an approach based on the ethics of AI and the active involvement of numerous stakeholders in all phases of the project. While there is extensive literature on AI and inclusion, few studies explore the intersection of these fields, such as those by Kazimzade et Al. [6] and Gibellini et Al. [7]. Similarly, in the domain of AI ethics in education and learning, research is limited, with Mouta et Al. [8] being among the few contributors. The only paper addressing this gap is Song et Al.'s recent study [9] introduces a framework grounded in Universal Design for Learning principles [10], guiding the development of inclusive AI education. By incorporating essential AI concepts and diverse pedagogical examples, this framework aims to foster broader participation and bolster competitiveness within the AI workforce.

In the context of European and international guidelines, as outlined by UNESCO specifically for AI in education, inclusion is addressed primarily through the lens of non-discrimination and data accuracy [11]. While ensuring data quality and mitigating bias are crucial for trustworthy AI systems, this approach risks oversimplifying inclusion as a technical issue, detached from the complexity of learning environments. Therefore, it's imperative to broaden the discourse beyond technical considerations and adopt a perspective that encompasses diverse stakeholders, design aspects, and values promoted in the development and implementation process. Despite the recognized importance of stakeholder involvement, research indicates a lack of participation from clinicians, parents, and teachers in decision-making processes [12], [13], with limited focus on the broader impact of AI tools on learning environments [14]. This underscores the necessity for a more holistic approach to AI education that considers the multifaceted nature of inclusion and engages diverse stakeholders to ensure its effectiveness and relevance. This broader perspective aligns with the framework proposed by [9], which emphasizes inclusive AI education grounded in Universal Design for Learning principles.

The integration of Artificial Intelligence holds promise for children with special learning needs, including those with visual, mobility, or hearing impairments, offering opportunities for diverse learning materials and adaptable content strategies [15]. However, achieving true inclusion extends beyond technological solutions alone. Literature emphasizes the importance of striking a balance between individualization and socialization, valuing differences while addressing diverse needs [16]. Therefore, inclusive contexts must embrace both technological advancements and nuanced pedagogical approaches to effectively support diverse learners. This perspective aligns with the holistic framework proposed earlier, which advocates for inclusive AI education grounded in Universal Design for Learning principles and comprehensive stakeholder engagement. It It becomes crucial, therefore, to reflect on how the relationship between technology, disability, and inclusion should be conceptualized.

The concept of inclusion, related to that of disability, has changed significantly over time as the work of [17] and [18] testifies. In 1980, the International Classification of Impairments, Disabilities, and Handicaps [19] established the first definition of disability, which is commonly associated with a medical model of disability. According to this view, disability is interpreted as an individual problem, which must be corrected in terms of *restitutio ad integrum*. In this publication, an important distinction was made between *impairment* (an anomaly or loss of physiological or anatomical functions), *disability* (the loss or difficulty, resulting from the impairment, of performing activities considered normal for healthy individuals), and *handicap* (the condition of disadvantage resulting from the objectification of the impairment). According to this conception, disability is seen as something exclusively pertaining to the individual and limits her ability to live a full and satisfying life and to flourish in society [20]. Disability movement activists in the late 20th century posed a significant challenge to this prevailing paradigm. They critically examined the connection between impairment and disability, thus affirming the social model of disability [21]. This conception emphasises the role of the material organisation of society in creating conditions of disability from a deficit. Therefore, in this view an inclusive society is one that can eliminate the disabling contexts and barriers that society possesses in relation to the diversity of human functioning. One of the most significant steps in this debate was the development of the ICF model [22]. At the centre of the bio-psycho-social approach, there is the individual-environment interaction. Disabilities are considered beyond an exceptionalist logic and are placed at the centre of the human condition itself. What links disability and health, according to this model, depends on the *functionings* or, in other words, the *capabilities* that each human being in relation to the social context of reference is capable of having and being. Thus, the ICF model, and the Capability Approach (CA), [23],[24] although not totally overlapping, emphasise how well-being (individual and collective) arises from the dynamic between internal dispositions/opportunities and external dispositions/powers, a dynamic that is to be understood both as the absence of external impediments (negative freedom) and as an analysis of the conditions and quality of life that people are able to lead (positive freedom).

In this context, the role of technology acquires a central function, in fact, the use of technology in relation to disability could play a crucial role in the expansion of individuals' capabilities [25]. Technology finds a specific place within the Environmental Factors of the bio-psycho-social perspective of the ICF. Starting from the assumption that people can function in different ways depending on their environments and that disability is therefore the result of a mode of interaction between the individual and the environment, the ICF considers technologies as tools that mediate this interaction. Technologies thus, depending on the way they are designed, implemented, and used, can act as facilitators or, on the contrary, as barriers in performing normal activities and creating an inclusive society. It would be naive to consider technology's relationship with disability solely in instrumental terms. As extensively debated in the literature ([26], [27]), technologies always exist within a specific context and invariably embody certain underlying values and orientations. In the context of disability, technology assumes a pivotal role, often becoming an integral part of an individual's interaction with their environment. Technology's capacity to mediate this relationship between the individual and the environment renders it a critical resource for enhancing people's lives and expanding their opportunities. However, it is essential to recognize its situated nature, shaped by social and value determinants. Technology thus becomes a matter of justice. Consider, within the realm of education, the extent to which knowledge can be made accessible to diverse needs and characteristics through design—both technological and otherwise—that is attentive to differences, as articulated in Universal Design for Learning (UDL).

These considerations are particularly pertinent regarding AI-based systems. Fourth-order technologies [28], capable of replicating human actions in the absence of human intelligence, bring with them potentials, challenges, and risks well-documented in literature and institutional discourse. For inclusive learning objectives, AI-based technologies must be designed and implemented with adherence to various criteria to ensure accountability and reliability within an inclusive learning environment. Beginning with an assessment of the ethical treatment of data (bias, privacy) and algorithms (fairness, transparency, explainability), an inclusive perspective on technology prompts a critical examination of its embedding context and its interaction with and involvement of key stakeholders. Moreover, from a technical perspective, technologies for inclusion should be designed so that the users can personalize their interaction with the AI system through adjusting parameters and controls according to their preferences or specific needs.

3. ARTIS: system description

In designing AI-based technologies for inclusive learning objectives, such as the interface ARTIS developed by Sony Computer Science Laboratories Paris and Centro Ricerca e Cura, ensuring accountability and reliability within an inclusive learning environment is paramount. This necessitates adherence to various criteria, beginning with an ethical assessment of data and algorithms, encompassing considerations of bias, privacy, fairness, transparency, and explainability. An inclusive perspective on technology calls for a critical examination of its embedding context and its interaction with key stakeholders. ARTIS, as an interface powered by artificial intelligence to support text comprehension, exemplifies this approach by drawing on neuro-psycholinguistic models of reading comprehension, thus integrating linguistic components into its design to enhance accessibility and inclusivity in learning contexts. ARTIS [29] is an interface, powered by artificial intelligence, designed to support text comprehension. Born as a collaboration between Sony Computer Science Laboratories Paris [1] and Centro Ricerca

[1] https://csl.sony.fr/

e Cura [2] in Rome, Italy. The interface was developed from neuro-psycholinguistic models of reading comprehension, focusing on the linguistic components of text processing.

In particular, subjects with poor text comprehension present difficulties related to the processing of syntactic and semantic sentence components [30], the analysis of lexical components of words [31] and deficits in the syntactic representation of words and oral comprehension skills [32]. Moreover, [33] stated that the same subjects report significant deficits in receptive vocabulary and semantic processing. Finally, [34] and [35] addressed the issue of grammar, claiming that children and adolescents with problems in text comprehension show difficulties in understanding the role of pronouns within sentences, especially if these are in clitic form. Considering this approach, ARTIS allows for personalized practice on texts at different levels. Using AI algorithms, the interface can automatically extract keywords, associate pictograms, identify more complex vocabulary and generate semantic networks, and practice grammatical components. ARTIS is aimed at primary and secondary school children with difficulties in text comprehension, but it can also be used as a support for L2.

We had three main goals in mind when designing our prototype. Firstly, we aimed to develop a system specifically for children from second grade to adolescents diagnosed with reading comprehension difficulties. Secondly, we wanted an interface suitable for therapeutic sessions, always under professional supervision for younger age groups. Lastly, we aimed to involve end-users and stakeholders from the outset of the design process, collaborating with skilled speech and language therapists for evaluation and feedback. Drawing inspiration from Kitsch and Van Dijk's model, we integrated functionalities to enhance the superficial representation of language, focusing on lexical and morphosyntactic understanding. Our interface consists of three modules: the first aids in understanding words and sentences, the second focuses on coherent sequence representations, and the third aims at creating a broader mental model of language. We also implemented a Synset Networks feature to link words encountered in the text with previous knowledge. This approach fosters vocabulary expansion and deeper understanding of word meanings. Overall, our design reflects a comprehensive approach to address reading comprehension challenges

[2]https://www.crc-balbuzie.it/

4. Ecological framework for a trustworthy AI with children

The project description underlines how the objectives of this project are multifaceted. It emphasize rigorous research to ensure computational functionality, facilitating integration into rehabilitation and educational activities. Additionally, specialized research is essential to examine the impact, acceptance and feasibility within inclusive educational and rehabilitative contexts. To address this, we framed future research directions in a conceptual framework considering impacts on child development and the interplay between inter-subjective and objectual dimensions of proximal development.

The literature on AI trustworthiness is vast and multidisciplinary. With regard to HCI (human computer interaction), the issues that are most focused on concern the design and perception of the user and the psychological mechanisms that impact the perception of trustworthiness and thus the subsequent usage behaviour [36],[37],[38]. Therefore, one of the main focuses is on predictability, transparency, explainability, robustness of the system. Trust is generally interpreted as a psychological mechanism that occurs in social or intersubjective interaction to reduce the uncertainty of the other's behaviour.

According to the OECD, Organisation for Economic Co-operation and Development : "*AI might be considered trustworthy when it does properly what it is supposed to do, but also when one can trust that human beings will use it in a fair and appropriate way*"[39]. The trustworthiness of AI is also considered a crucial element within the educational literature, and involves the aspects of reliability, fairness, transparency, explainability, data protection and bias.

However, we believe that the context of the ARTIS project poses an even greater challenge to the concept of trustworthy AI, because it must be ensured in such a way that this characteristic 'collapses' within different settings and interactions: rehabilitation, school, family and individual use. The interface, in fact, not only hybridises the educational and rehabilitative relationship in a consistent manner, but also assumes a scaffolding function for the child, crucial for proximal development processes: that is, the difference between an individual's actual level of development and the level that can be reached, through the help of a tutor or through social interaction [40]. Therefore, the ARTIS project shows how it is necessary to take a holistic view in order to correctly interpret the issue of trustworthiness within an inclusive learning context. In particular, the ecological system theory elaborated by Bronfenbrenner turns out to be a strategic framework.

According to the author of the ecological theory of human development, there are two forms of proximal development processes: a) those with other persons and b) those with symbols and objects; and these processes occur in a dynamic of reciprocal influence and determination of several environmental levels: the microsystem (in which interpersonal relationships occur directly and in defined contexts, such as family, school, peers), the mesosystem (relationships between microsystems, for example), the macrosystem (cultural and social norms), the exosystem (environments that influence indirectly, such as parental work) and the chronosystem (temporal changes, such as historical events and life transitions).

However, the nature of digital and AI technologies is precisely to hybridise these systems and their interactions [41]. The proximal process therefore occurs in a hybridised manner, involving both interpersonal relations and object relations, and collapsing the interactions between different levels even more directly, Therefore, it is crucial to ask, for example, in ARTIS how does the macrosystem and exosystem (the decisions made by the developers) affect the interactions in the microsystem? How does the hybridisation of the microsystem (class, family, rehabilitation) reshape the concepts and processes of inclusion? It's crucial to consider not only the impact of technology failures, such as malfunctioning algorithms or discriminatory biases, but also its intended outcomes. To address these questions comprehensively, a collaborative strategy engaging all educational stakeholders—teachers, clinicians, parents, and students—is essential for qualitative and quantitative insights.

5. Cooperation Strategies

As the project interfaces blend educational and rehabilitative dynamics, it becomes clear that a holistic approach is indispensable. In ARTIS, a collaborative strategy is essential, involving stakeholders across education—teachers, clinicians, parents, and students—to ensure AI trustworthiness in inclusive learning environments. This multifaceted cooperation strategy integrates academic and industry channels, with early involvement of speech and language therapists ensuring interdisciplinary engagement. After the initial proof of concept, the interface underwent testing by children, therapists, and the public, promoting User-Centered Design principles and enabling ongoing monitoring. Focus groups involving developers, therapists, and ethics experts ensured ethical oversight, fostering critical thinking and responsible technology usage.

6. Conclusion & Future Work

In this paper, we presented the ARTIS project as a significant case study illustrating a systemic approach to trustworthy in inclusive education and speech and language therapy through the cooperation with a broad number of stakeholders. Moreover, we outlined the general framework to carry on future research on the ARTIS project rooted in an developmental ecological theory and cooperation strategies. Future work in this area should focus on developing an integrated approach to assess the impact and acceptance of technology in educational settings, with a particular emphasis on engaging a more diverse range stakeholders such as teachers, children and families. Building upon existing research, future studies could explore innovative methodologies that combine quantitative metrics with qualitative insights to gain a holistic understanding of the complex dynamics involved. Additionally, there is a need to investigate the long-term effects of technology integration on learning outcomes and socio-emotional development across various age groups. Collaborative efforts involving researchers, educators, policymakers, and technology developers will be essential to address the multifaceted concerns raised by teachers, families, therapists, and children, thereby fostering a more inclusive and supportive educational environment.

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