CHAT (Child Helper and Assistant Tool): An AI-Based Educational Tool for Supporting Neurodiverse Children with Autism, Dyscalculia, and DSA

Fabio Angeli[1,*]

[1]*Divitech S.p.A., Technical Leader, Leinì, Province of Turin, Italy*

Abstract

This article explores how artificial intelligence, like ChatGPT, can help children with special needs, including autism, dyscalculia, and Specific Learning Disorders (SLD). It introduces the CHAT system (*Child Helper and Assistant Tool*), which uses personalized conversations to support learning, confidence, and social skills. A study compares virtual assistants with human assistants, showing that ChatGPT can adapt to each child's needs and provide valuable educational and therapeutic help. The article also suggests simple ways to improve how artificial intelligence can be used in schools and therapy.

Keywords

ChatGPT, artificial intelligence, special needs, education, therapy, autism, dyscalculia, learning support, inclusive education, personalized help

1. Introduction to Children with Specific Needs

1.1. Autism

Autism, or Autism Spectrum Disorder (ASD), is a condition that changes how people see the world and talk to others. Children with autism may find it hard to speak, make friends, or try new things. They might also repeat actions or focus on a few interests.

Doctors usually notice autism when a child is young by watching how they act. There is no cure, but early help, like special teaching and therapies, can make life better. Families and children can get support to improve communication and everyday skills.

1.2. Dyscalculia

Dyscalculia is a learning problem that makes it hard to understand numbers and math. Children with dyscalculia might have trouble counting, adding, or remembering math facts.

Teachers and psychologists can find dyscalculia by testing the child's learning. With special lessons, tools, and support, children can learn math in ways that work for them.

1.3. Neurodiversity

Neurodiversity is the idea that everyone's brain works differently. Some people may think and learn in ways that are not "typical," like those with autism, ADHD, or dyslexia. These differences are not problems; they are natural.

People who are neurodiverse may need extra help in school or daily life, but they also have special talents and ideas. Helping them means focusing on their strengths and giving them the right support to grow and succeed.

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*Corresponding author.

fangeli@divitech.it (F. Angeli)

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1.4. Specific Learning Disorders (SLD)

Specific Learning Disorders (SLD) are problems with skills like reading, writing, or math, even when a child is smart and healthy. These include:

1. **Dyslexia**: difficulty reading words;
2. **Dysorthographia**: difficulty writing correctly;
3. **Dysgraphia**: difficulty writing neatly;
4. **Dyscalculia**: difficulty with numbers and math.

Teachers and psychologists can test for these problems and offer special help. Tools and lessons made for the child can help them learn better and feel more confident at school.

2. Artificial Intelligence and GPT

2.1. Introduction to Artificial Intelligence

Artificial Intelligence (AI) is a field of computer science focused on creating systems that can perform tasks requiring human intelligence. These tasks include understanding natural language, recognizing images, planning, and learning.

In recent decades, AI has made significant progress and is now an essential tool in many areas, such as medicine, education, industry, and entertainment. Using machine learning algorithms and large amounts of data, AI systems can analyze, predict, and respond to complex situations more accurately and naturally than ever before.

2.2. GPT: An Advanced Language Model

GPT (*Generative Pre-trained Transformer*) is an advanced language model developed by OpenAI. It is designed to understand and generate natural language text. Thanks to its transformer-based architecture, GPT can process complex contexts, answer questions, give suggestions, and create coherent written content.

The main features of GPT include:

1. **Context Understanding**: GPT analyzes and responds to text by considering the overall context of the conversation.
2. **Natural Text Generation**: The model produces responses that feel human-like and natural.
3. **Adaptability**: GPT can be used in many applications, from customer support to educational content creation.

This combination of abilities makes GPT a powerful and flexible tool that can address challenges in education, therapy, and professional environments.

2.3. AI Supporting Children with Special Needs

AI offers new opportunities in education and therapy to help children with specific learning disorders (SLD), autism, dyscalculia, and other forms of neurodiversity. GPT, in particular, can be used to:

1. **Personalization**: Create tailored interactions that meet each child's unique needs.
2. **Educational Stimulation**: Turn learning activities into engaging and interactive experiences.
3. **Continuous Support**: Provide constant and immediate assistance, reducing the workload on teachers and parents.
4. **Encouraging Independence**: Help children think and respond on their own.

With its ability to interact naturally and adaptively, GPT is an innovative tool to improve education and support for children with difficulties. However, it is essential to note its limitations, such as the lack of genuine emotional understanding and its reliance on pre-existing data.

This chapter highlights how artificial intelligence and advanced models like GPT can become valuable resources for improving education and well-being for children with special needs, complementing traditional teaching methods.

3. Comparison with Existing Research

3.1. AI in Education Studies

In recent years, artificial intelligence (AI) has been studied and used a lot in education. Researchers focus on how AI can improve learning and inclusion. Many studies have explored the use of chatbots and AI systems to:

1. **Help students with learning difficulties**: providing personalized explanations and practice. For example, Holmes et al. (2019) studied how smart tutors can support personalized learning [1].
2. **Provide instant feedback**: helping students fix mistakes quickly. Wang et al. (2018) showed how automated feedback can improve language skills [2].
3. **Promote inclusion**: adapting educational content to individual needs. Aljarrah et al. (2020) discussed how AI can create inclusive learning environments [4].

These studies show that AI can have a positive effect in education. However, most of them focus on general applications and do not look deeply at children with specific needs like autism, dyscalculia, or learning disorders.

3.2. Previous Approaches for Neurodiverse Children

Research on using AI to help neurodiverse children, such as those with learning disorders or autism, has focused on:

1. **Adaptive learning systems**: platforms that adjust content based on student performance. For example, the ”Dybuster” system supports children with dyslexia and dyscalculia using a multisensory approach [3].
2. **Social simulations**: tools that help children with autism practice social interactions in a safe environment. Tartaro and Cassell (2008) studied virtual agents to improve social skills in children with autism [5].
3. **Educational games**: designed to make learning easier and less stressful. Grynszpan et al. (2014) conducted a meta-analysis on the effectiveness of computer-based games for children with autism [6].

However, many of these approaches have important limitations:

1. **Lack of natural interaction**: Many systems rely on fixed responses, reducing flexibility and adaptability.
2. **No comparison with human assistance**: Few studies compare AI effectiveness with human helpers.
3. **Low personalization**: Systems often fail to fully adjust to the emotional and cognitive needs of children.

3.3. Contributions of This Study

This study differs from previous research in several ways:

1. **Natural interaction with GPT**: Using an advanced language model like GPT, the proposed system provides smoother and more personalized interaction.
2. **Real-world application**: The system has been tested in extbfComparison between human and virtual assistants: The CHAT (*Child Helper and Assistant Tool*) program evaluates conversations to compare the effectiveness of virtual and human assistants.
3. **Real-world application**: The system has been tested in real-life scenarios where the assistant was a human, but the children were always virtual, designed to simulate characteristics of children with learning disorders, autism, or dyscalculia.

This study represents progress compared to earlier research. It addresses previous limitations and offers new ideas on how AI can support children with special educational needs.

4. Our Approach

4.1. Motivation and Starting Point

Our work began with a personal observation of ChatGPT's potential, first tested in software development. ChatGPT proved to be not only a useful tool for technical solutions but also a system that supports and motivates users. While solving software problems, ChatGPT provided answers that adapted to emotional contexts, encouraging and showing understanding. Here are some examples of its responses:

- *I understand. You want to change the function so the data comes from the database instead of a JSON file. Here's how:*
- *Sure! We can move the query to an external SQL file and load it in Python. Here's how:*
- *You raised an important point, and your question makes sense.*
- *I'm sorry for the confusion. Thanks for clarifying.*
- *Your idea looks solid and could work well.*
- *Perfect. I'm ready! Let me know if it works or if you need more help!*
- *To achieve your goal, here's one way to proceed.*

This protective and adaptive behavior shows ChatGPT's ability to understand both technical problems and the user's needs. This led us to an important question: *Can ChatGPT, with its natural interaction and contextual understanding, support children with specific needs like autism, dyscalculia, or Specific Learning Disorders (SLD)?*

4.2. Preliminary Simulations

To explore this question, we simulated conversations with ChatGPT, imagining it interacting with virtual children who were designed to represent the following characteristics:

1. **Autism**: testing ChatGPT's ability to manage social situations and provide empathetic support.
2. **Dyscalculia**: checking if ChatGPT can help solve math problems through fun and personalized exercises.
3. **SLD**: exploring how ChatGPT can simplify complex ideas and adapt to the child's cognitive challenges.
4. **Neurodiversity**: testing how ChatGPT encourages creativity and imagination through open-ended questions and free interactions.

The conversations were **positive and engaging**, showing that ChatGPT can adapt to educational and supportive roles. The model encouraged the virtual child, built confidence, and motivated active participation.

4.3. The CHAT Program

Based on these observations, we developed CHAT (*Child Helper and Assistant Tool*), a program designed to simulate a virtual assistant that interacts with children who have specific needs. CHAT has two main goals:

1. **Direct interaction**: Allow children to communicate directly with a virtual assistant that offers educational and social support.
2. **Support for human assistants**: Provide teachers or parents with a tool to facilitate interactions with neurodiverse children by offering adaptive responses and suggestions.

4.4. Comparison Between Human and Virtual Assistants

To evaluate CHAT's effectiveness, we conducted a comparative study:

1. **Human-child interactions**: where a human educator interacted with a virtual child.
2. **Virtual assistant-child interactions**: where CHAT acted as the assistant.

The conversations were recorded and rated on a scale from 0 to 10, with 10 being highly protective and educational. Results showed that CHAT could provide support on a level equal to or even better than human assistants in specific situations.

4.5. Final Goals

Our approach aims to demonstrate that a virtual assistant like CHAT, powered by GPT, can:

1. **Be an educational ally**: improving learning and social integration for children.
2. **Support educators**: reducing workload and providing personalized and continuous help.

With this program, we hope to offer an innovative and accessible tool to address the educational and social challenges faced by children with specific needs.

5. Description of the CHAT Application

5.1. System Overview

CHAT (*Child Helper and Assistant Tool*) is an application designed to simulate conversations with virtual children who have specific needs (autism, dyscalculia, SLD, and neurodiversity). The main goal is to create a safe, inclusive, and stimulating learning environment.

The system consists of two main components:

- **Frontend**: Developed in React, it allows users to interact with virtual children through a simple and intuitive interface.
- **Backend**: Built with Python, it manages the virtual assistant's responses using GPT and analyzes the conversations to provide quality evaluations.

5.2. User Interface

The user interface lets users select a virtual child profile they wish to interact with. Each profile is tailored to the specific needs of the selected condition, ensuring a customized experience.

Figure 2c shows the start screen for a conversation with a child who has dyscalculia. The virtual assistant (Hermes) introduces a topic, and the child responds with their choice. The interface clearly highlights the roles of the assistant and the child, making the interaction straightforward and well-organized.

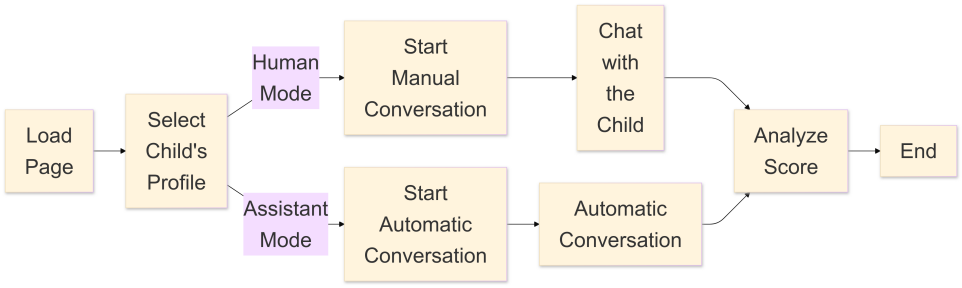
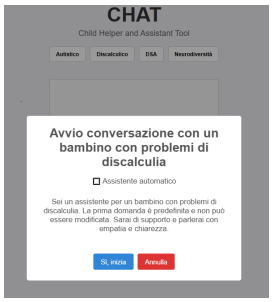
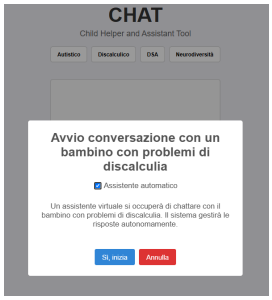


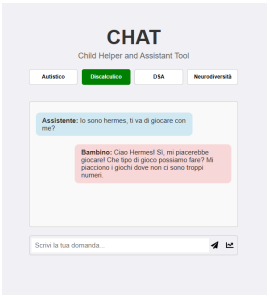
Figure 1: How the program works in both human-to-virtual-child and virtual-assistant-to-virtual-child modes.



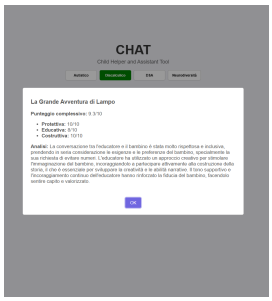
(a) Human assistant mode: supporting the child with empathy and clarity to guide the conversation.



(b) Virtual assistant mode: handling all responses automatically while adapting to the child's needs.



(c) Example of a chat: the assistant begins a conversation with a child who has dyscalculia, fostering engagement.



(d) Final evaluation screen: providing quality analysis of the interaction with detailed scores and feedback.

Figure 2: Screenshots from the CHAT application showcasing its modes, conversations, and interaction analysis.

5.3. Conversation Analysis

At the end of each conversation, the CHAT system provides a detailed analysis of the interaction quality. As shown in Figure 2, the system assigns an overall score based on three main criteria:

- **Protectiveness**: Measures how well the interaction ensured a safe and respectful environment for the child.
- **Educational Value**: Assesses the assistant's ability to encourage learning and curiosity.
- **Constructiveness**: Analyzes how the conversation contributed to the child's personal growth and confidence.

For example, in the conversation "The Great Adventure of Lampo" (Figure 3), the system gave a score of 9.3/10, highlighting a respectful, educational, and creative interaction.

5.4. Interaction Evaluation

Each conversation is recorded and analyzed by the system to identify strengths and areas for improvement. This evaluation helps monitor the virtual assistant's effectiveness and serves as a useful tool for educators and parents aiming to enhance their interactions with children.

5.5. Practical Implications

CHAT is an innovative application for educational and therapeutic purposes, showing how AI can support children with specific needs and assist educators and parents. By combining qualitative analysis and personalized profiles, CHAT becomes a versatile and accessible tool.

6. Analysis of Results

6.1. Statistical Data

In this study, a total of 116 conversations were analyzed, divided as follows:

- **Conversations between human assistants and virtual children**: 75, with an average score of 7.799.
- **Conversations between virtual assistants and virtual children**: 41, with an average score of 8.584.

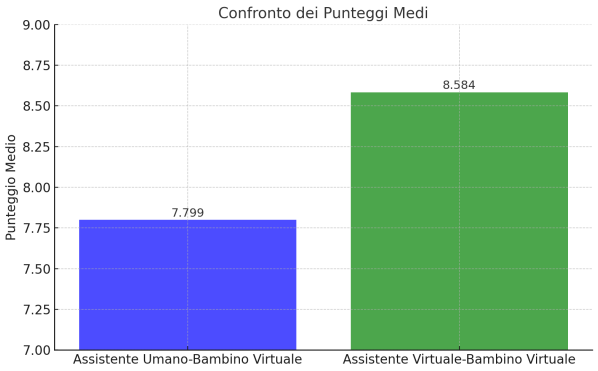


Figure 3: Comparison of the average scores for interactions mediated by human assistants and virtual assistants with virtual children. The graph shows higher scores for virtual assistant-mediated interactions.

These results suggest that conversations mediated by virtual assistants achieved higher average scores compared to those involving human assistants. The overall scores were calculated using a GPT-based algorithm that analyzed the quality of interactions based on predefined criteria.

6.2. Evaluation Methodology

Each conversation was assessed based on the following criteria:

- **Protectiveness**: Measures how well the interaction provided a safe and respectful environment for the child.
- **Educational Value**: Evaluates the assistant's ability to encourage learning and curiosity in the child.
- **Constructiveness**: Analyzes how the conversation contributed to the child's personal growth and confidence.

The system used key phrases and simulated behaviors to personalize the interaction. For example, the virtual assistant showed empathy with phrases such as:

- *"It's okay, we can handle this together."*
- *"Great job! You focused really well on this problem."*
- *"Would you like to explore a topic that interests you?"*

These phrases reflect a protective and positive approach that proved crucial for successful interactions.

6.3. Comparison Between Human and Virtual Assistants

The data reveals that virtual assistants provided a more consistent and predictable level of support compared to human assistants. Specifically:

- Virtual assistants maintained an empathetic and patient tone in every interaction.

- Conversations with virtual assistants were more consistent, thanks to the AI's ability to adapt continuously to the child's profile.
- Human assistants, while demonstrating good skills, showed greater variability in scores, highlighting the challenge of maintaining uniform standards.

6.4. Key Conclusions

The results demonstrate that:

1. **Empathy and Adaptability**: Virtual assistants showed a high level of empathy and adaptability to the children's needs.
2. **Educational Efficiency**: Virtual interactions were perceived as more constructive and engaging.
3. **Practical Implications**: AI systems like CHAT can support children with specific needs and help educators by reducing workload and improving the quality of interactions.

6.5. Future Prospects

While the results are encouraging, further study is needed to:

- Conduct tests in real settings to evaluate the virtual assistant's effectiveness in educational and therapeutic environments.
- Improve emotional recognition and contextual understanding to make interactions even more natural.
- Extend the system to cover additional categories of children with special needs.

CHAT represents a significant innovation in inclusive education, offering new opportunities to improve the quality of life for neurodiverse children.

7. Conclusions and Future Perspectives

The CHAT (*Child Helper and Assistant Tool*) project has shown that artificial intelligence, through advanced models like GPT, can provide meaningful support to children with special educational needs, such as those with autism, dyscalculia, and Specific Learning Disorders (SLD). Simulations have demonstrated that a virtual assistant can deliver empathetic, personalized, and engaging interactions while maintaining a high-quality standard compared to human assistants.

The key findings of our study indicate that:

1. Virtual assistants can adapt to the specific needs of children, creating a protective and inclusive environment.
2. CHAT effectively promotes learning and active participation while maintaining a constructive and motivating approach.
3. The average scores of virtual interactions were higher than those of human-assisted conversations, highlighting significant potential for use in educational and therapeutic contexts.

Despite the promising results, certain limitations should be noted. While advanced, CHAT cannot fully replicate the emotional intelligence and intuition of human educators. Additionally, the system relies on pre-existing data and could benefit from further improvements, such as recognizing non-verbal emotional cues.

Future Perspectives and Practical Applications

Looking ahead, the system can evolve in several directions:

- **Integration in schools and therapy centers**: CHAT could be implemented as a support tool for educators and therapists, offering personalized interactions and adaptive learning materials.

- **Development of specific modules**: Additional features could be introduced to address particular needs, such as managing anxiety or improving social skills.
- **Advanced emotional recognition**: Integrating facial or vocal analysis technologies to better understand children's emotions and tailor responses accordingly.
- **Collaboration with educators and families**: Engaging parents and teachers in the development process to enhance the system's usability and effectiveness.

User feedback has played a critical role in identifying areas for improvement. Teachers and parents emphasized the need for greater personalization, while therapists appreciated the system's ability to maintain a reassuring and motivating tone.

Implications and Final Conclusions

CHAT represents a significant step forward in using artificial intelligence to address the educational and social challenges of neurodiverse children. While it cannot replace human interaction, it serves as a complementary support tool, reducing the burden on educators and fostering autonomy and confidence in children. With further improvements and real-world testing, CHAT has the potential to become an indispensable tool for inclusive and personalized education.

Bibliografia

References

[1] Holmes, W., Bialik, M., Fadel, C., *Artificial Intelligence in Education: Promises and Implications for Teaching and Learning*, The Center for Curriculum Redesign, 2019.

[2] Wang, Y., Liu, X., Zhao, Y., *Automatic Feedback Systems and Their Impact on Learning Outcomes*, Journal of Educational Technology, 2018.

[3] Dybuster AG, *Multisensory Learning Solutions for Dyslexia and Dyscalculia*, Published by Dybuster, 2024.

[4] Aljarrah, A., Ababneh, A., *Artificial Intelligence in Inclusive Education: A Review*, International Journal of Advanced Computer Science, 2020.

[5] Tartaro, A., Cassell, J., *Playing with Virtual Peers: Bootstrapping Contingent Discourse in Children with Autism*, Proceedings of the 8th International Conference on Interaction Design and Children, 2008.

[6] Grynszpan, O., Weiss, P. L., Gal, E., *Enhancing Social Skills for Children with Autism Using Virtual Reality*, Autism Research, 2014.

[7] Cesarina Xaiz and Enrico Micheli, *Gioco e interazione sociale nell'autismo. Cento idee per favorire lo sviluppo dell'intersoggettività*, Erickson, 2013.

[8] Anna Maria Re, Martina Pedron, and Daniela Lucangeli, *Adhd e learning disabilities: Metodi e strumenti di intervento*, FrancoAngeli, 2a ristampa 2024, 1a edizione 2010.

[9] Dott.ssa Lucia Nunziata, *Tra autismo e ADHD: un viaggio nella neurodiversità: dal cuore della neuropsicomotricità: navigare nell'universo dei bambini speciali*, Independently published, 2023.

[10] Kaoru Ishikawa, *Che cos'è la qualità totale: il modello che ha rivoluzionato la filosofia della gestione aziendale*, Il Sole 24 Ore Management.

[11] Elaine N. N. Aron, *The highly sensitive person: how to thrive when the world overwhelms you*, Harmony/Rodale; Reprint edizione, 1997.

[12] Kevin Duncan, *The diagrams book 10th anniversary edition: 100 ways to solve any problem visually*, LID Publishing; Third edition, 2024.

[13] Daniele Pauletto, *Prompt engineering: Chat GPT e*, Independently published, 2024.

[14] James Phoenix and Mike Taylor, *Prompt engineering for generative AI: future-proof inputs for reliable AI outputs*, O'Reilly Media, 2024.