Education Technology for Students with ADHD in Secondary School: Preliminary Results of a Single-Case Study

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Abstract. This paper presents preliminary findings from a single-case study investigating inclusive learning through an education technology addressed to students with Attention Deficit and Hyperactivity Disorder (ADHD) enrolled in secondary schools. The study's objective was to explore the potential of technology to mitigate challenging behaviors and enhance attention, collaboration, and self-control among students with ADHD. Furthermore, the study concentrated on the impact of learning coding through the education platform, encompassing the development of positive social and relational skills. The methodology employed is grounded in naturalistic observations and qualitative data analysis. While the data collection process continues, certain intriguing outcomes emerged from interactions with teachers and students involved, suggesting potential future research directions on the application of education technology to students with ADHD.

Keywords: Education Technology · Students with ADHD · Secondary Schools · Single-Case Study

1 Introduction

Recently, researchers have investigated whether technologies can assist students with Attention Deficit and Hyperactivity Disorder (ADHD) in overcoming certain challenges they encounter in the educational setting. These challenges include behavioral expressions of inattention, disorganization, and/or hyperactivity-impulsivity, which negatively impact their psychosocial functioning. Often, students with ADHD also have comorbid diagnoses of specific learning disorders [1, 2].

Furthermore, students with ADHD exhibit difficulties in attention, executive function, processing speed, memory, narrative competence, self-regulation, and social deficits [3, 4]. Consequently, the intervention presented in this paper aims to assess the efficacy of an education technology based on LEGO bricks, electronic components, and software in promoting inclusive processes, participation, and learning of coding among students with ADHD in secondary upper schools.

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The observation and analysis of the intervention focused on examining how the technology can contribute to mitigating problematic behaviors, enhancing attention, communication, self-control, and other positive social skills among students with ADHD. Since research on the role of technologies in teaching and learning skills has demonstrated their effectiveness in supporting the improvement of attention, communication, and social relations [5–8]. Additionally, the World Health Organization Global Report on Assistive Technology [9] corroborates this finding [10].

1.1 The Framework of Intervention

The intervention was implemented within the context of the Spike project, which was designed to assess the efficacy of educational technology in enhancing the learning of coding, promoting inclusivity, and mitigating problematic behaviors among students with ADHD.

The project adopted the LEGO® Education SPIKE™, a learning tool that integrates LEGO bricks and electronic components with user-friendly software to teach students coding, problem-solving, and creative thinking skills engagingly [11]. Additionally, it facilitates social interactions, fostering a high level of participation and facilitating teamwork and collaboration among students. The organizations that participated in the project's implementation include:

- Territorial School Support Center of Verona (CTS);
- Vigasio Inclusion Center School;
- Behavioral Disorders Desk;
- University of Verona - Department of Human Sciences.

1.2 Participants

In this project, eight secondary upper schools in the Verona province participated voluntarily. The intervention started in October 2024 and will be concluded in October 2025. The project encompassed eight distinct classrooms, resulting in a total of 170 students aged between 11 and 13 years. Among the students, 13 received a diagnosis of ADHD, although there were also several students with similar challenges but who had not been formally diagnosed. A total of 36 teachers were involved in the project, including six support teachers.

1.3 The Activities Carried Out

The activities were designed to be repeated multiple times during classroom lessons, each lasting approximately one hour. Each group consisted of two students who were provided with a Spike Lego kit and a computer equipped with the corresponding coding application. The objective of each activity was for the group to collaborate on constructing a small robot with specific tasks that could be executed through coding instructions.

Here is a detailed description of the activities proposed for each lesson:

- *Lesson 1:* Warm-up: This session involves presenting the activities, establishing groups, and sharing the rules.

- *Lesson 2:* Creation: In this session, the Lego bricks and pieces are presented, and a spinning top is created. A video showcasing the spinning top competition is also displayed.
- *Lesson 3:* Motorization with Coding: This two-hour lesson focuses on creating a grasshopper robot. Students connect various sensors to the robot, enabling them to program the movements directly through the coding application.
- *Lesson 4:* Robotization: This session involves constructing a break-dancing robot that moves through coding instructions.
- *Lessons 5 and 6:* Machine Building: These lessons concentrate on constructing a simple machine that operates through coding instructions.
- *Lesson 7:* Fantasy Story: In this session, students create an original object that can be moved using coding. Additionally, they elaborate on a story associated with the object.
- *Lesson 8:* Conclusion: This session concludes the activities by facilitating a class discussion on the outcomes achieved. A questionnaire is administered to assess students' satisfaction with the activities and evaluate their critical thinking skills.

Teachers' Role During Activities Delivered: Both teachers and support teachers served as mediators between students and the activities to be conducted. Notably, the following strategies were employed to foster an inclusive environment and enhance collaboration among students:

- *Establishing a work environment:* Minimizing distractions to create a positive learning atmosphere.
- *Defining clear behavioral expectations:* Communicating rules to all students effectively.
- *Aligning realistic behavioral and educational objectives:* Setting achievable goals for students.
- *Implementing short breaks:* Providing opportunities for students to recharge and refocus.
- *Limiting activities requiring prolonged concentration or multiple steps:* Ensuring manageable workloads.
- *Providing immediate and frequent positive reinforcement:* Encouraging students to maintain a positive attitude.
- *Promoting positive relationships:* Fostering collaboration among classmates and adults.
- *Enhancing creative abilities:* Providing opportunities for students to express their creativity.

Students' Role During Activities Performed: The methodology employed for the activities centered around cooperative work in pairs. The personal skills of each student were shared with their peers, enabling students to experience cooperation, sharing materials and objectives in pursuit of a shared objective.

Additionally, the activities provided students with practical feedback on their collaboration through the creation of an engaging technological object aligned with their interests. This approach fostered the development of various transversal skills, including soft

skills (e.g., collaboration, participation, mutual support), digital skills, computational thinking, problem-solving, and decision-making abilities.

2 Methodology

A single case study was conducted to gather evidence and facilitate a critical examination. The study primarily focused on collecting the perspectives of teachers and students regarding the effectiveness, utility, and acceptability of the intervention. The methodology employed for this study adhered to a qualitative approach, which utilizes naturalistic observations to collect information on changes resulting from the intervention. This methodology, supported by the works of Braun and Clarke [12], Furlong [13], and Morgan [14], enables the analysis of initial findings and reflection on the insights gained through the exploration of the experiences of both students and teachers.

2.1 Research Questions

To assess the effectiveness of the intervention, evaluate the technology's efficacy in skill acquisition and the attitudes towards its utilization, three initial research questions were formulated. These questions are as follows:

Q1: What are the effects of the technology on the social relational skills of students diagnosed with ADHD?
Q2: What are the effects of the technology in reducing problematic behaviors and promoting positive conduct among students with ADHD?
Q3: What is the attitude of students towards the use of this technology for learning coding?

These research questions facilitate the observation and collection of data to evaluate the technology's effectiveness in promoting the inclusion process, participation, acquisition of skills (such as coding, attention, communication, time and task management), and positive social behaviors (like self-control, self-esteem, self-determination, group work, and collaboration).

2.2 Data Collection

The data collected thus far was obtained through observations, interviews, and focus groups conducted with teachers and students[1]. The information emerged was analyzed using a qualitative methodology [15, 16] that permitted some reflections on the intervention in terms of its impact on learning, social skills, and positive behaviors [17, 18]. Additionally, the exploration of the experiences of teachers and students during the introduction and utilization of the technology was included [19–21]. Consequently, a reflective analysis of the gathered information enabled us to collect the initial evidence regarding the impact and effectiveness of the intervention and the technology employed.

[1] Data collected from the questionnaires will be analyzed at the conclusion of the intervention.

3 Preliminary Results

The preliminary results that emerged facilitated a reflection on potential contributions of the technology employed to promote inclusive processes and participation, thereby reducing problematic behaviors and increasing attention, supporting self-control and collaboration among students with ADHD.

From the confrontation with teachers emerged a positive impact of the technology on the following aspects:

- *Stimulation of executive functions*: Specifically, attention, the ability to plan, flexible thinking, and self-control were enhanced, leading to a reduction in behavioral expressions of inattention.
- *Reduction of stress:* The frequency of hyperactivity-impulsivity behaviors that negatively impact their psychosocial functioning was decreased. Additionally, group work activities facilitate movement and interaction.
- *Improvement of collaboration:* Participation in manipulative activities, such as using
- LEGO bricks to construct a robot designed to perform precise tasks, appeared to foster self-regulation, positive social attitudes, and the reduction of problematic behaviors.

Furthermore, the discussions and focus groups conducted with students revealed that technology facilitated:

- *Active role:* Students with ADHD demonstrated active contributions during group work, leading to an increase in self-esteem and self-efficacy.
- *Engagement and enjoyment*: Increased interest in learning STEM disciplines.

Additionally, the technology contributed to establishing a positive and inclusive environment. Ultimately, it demonstrated effectiveness in enhancing the learning process, fostering interest and enjoyment in coding, stimulating self-determination, and contributing to the strengthening of social and relational skills among students with ADHD.

4 Discussion

In response to the initial research questions, it was discovered that education technology's impact on fostering social relational skills, such as collaboration, participation, and cooperation, can be particularly beneficial for students with ADHD. Furthermore, technology can facilitate interactive and adaptive learning experiences, thereby contributing to maintaining students' focus and motivation [22, 23]. Notably, students with ADHD exhibited heightened engagement when interacting with their peers during group work.

Regarding the second research question, the reduction of stress, increased engagement, and enjoyment led to a decrease in the frequency and intensity of hyperactivity and impulsivity behaviors.

Lastly, considering the third research question, students perceived the proposed activities as more engaging and relatively straightforward. Additionally, students demonstrated increased confidence in utilizing technology, finding lessons more motivating, pleasant, and authentic. These findings align with research suggesting the efficacy of

technology in addressing the challenges faced by ADHD students, particularly in fostering creativity and self-efficacy [24, 25]. While generalizing these findings may be challenging, further research on this topic is warranted.

Observations and discussions with participants revealed several additional positive aspects of technology's potential utility for students with ADHD:

- *Practical Engagement:* Practical learning approaches can be highly effective for students with ADHD, as they maintain engagement and focus.
- *Immediate Feedback:* Interacting with robots provides immediate feedback on user performance, enabling students with ADHD to better comprehend the consequences of their actions and adjust their behavior accordingly.
- *Structure and Routine:* The structured environment of activities conducted with education technology can assist students with ADHD in adhering to a routine and developing organizational and planning abilities.
- *Problem Behaviors:* These tend to diminish when there is significant engagement.
- *Problem-Solving:* Solving problems with robots necessitates critical thinking and problem-solving skills, which can be challenging for students with ADHD. However, natural interest in technology can motivate students to confront these challenges more effectively.
- *Cooperation and Collaboration:* Working with robots in a small group can foster cooperation and collaboration, enhancing social and communication skills.
- *Self-Esteem:* Achieving success with robotics projects can boost the self-esteem of students with ADHD, providing them with a sense of accomplishment and competence.

5 Conclusions

In conclusion, this paper proposes novel trajectories for technology research that highlight its potential to enhance social and relational skills among students with ADHD, including cooperation, collaboration, and group work. Technology can also serve as both an engaging and instructive tool for these students. Further research should explore how technology can:

a) Provide feedback and reinforcement for positive behaviors.
b) Enhance the ability to learn and comprehend coding languages.
c) Stimulate attention, working memory, and executive functions.

Additionally, based on the preliminary results, replicating a similar intervention in other school levels, such as primary schools, could be beneficial. In summary, it is crucial to recognize the role of technology in potentially motivating, engaging students, and positively impacting their learning, behavioral, and inclusion experiences.

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