Distance and Inclusive Teaching of School Computer Science: Instructional Practices and Learning Experiences

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***Abstract*—This study examines the effectiveness of teaching Computer Science (CS) skills to children with Autism Spectrum Disorder (ASD) through distance education within an inclusive education. Twelve students, aged 10–12 years, participated in a twenty-week online platform using Code.org. A single-case descriptive and explanatory approach was used. Data were collected through observation, teacher feedback, and analysis of student task performance. Quantitative results showed that 75% of participants demonstrated measurable improvement in task completion rates, and the average score on programming-related exercises increased by 21% between the first and final sessions. Qualitative findings revealed increased engagement, motivation, and independence in solving algorithmic tasks, although some challenges persisted in sustaining attention and managing sensory overload. The results indicate that children with ASD can successfully participate in CS learning through structured and visually supported distance education. The study adds to current discussions about inclusive digital pedagogy and offers practical guidance for educators designing adaptive online CS instruction for students with ASD.**

***Keywords*—inclusive education, distance learning, computer science, children with special educational needs, autism**

I. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by persistent difficulties in social communication and interaction, accompanied by restricted or repetitive patterns of behavior, interests, or activities. These characteristics significantly affect the way children with ASD perceive, process, and respond to educational information. Worldwide, and in Kazakhstan in particular, the number of diagnosed children has increased steadily over the past decade, resulting in a greater demand for inclusive educational provision that can accommodate diverse cognitive and behavioral profiles [1].

In Kazakhstan, the inclusion of children with ASD in mainstream schools has become a key priority within national educational policy. Since 2020, the Ministry of Education of the Republic of Kazakhstan has introduced the position of assistant teacher to support learners with ASD in general education settings. While this initiative represents an important step toward inclusive education, many teachers still face difficulties in adapting lessons to the cognitive and behavioral profiles of students with ASD. These difficulties become especially visible in Computer Science, which require sustained attention, logical reasoning, and abstract thinking.

In this study, inclusive education refers to the practice of providing equitable learning opportunities for all students regardless of disability, language, or socioeconomic background within mainstream classrooms through necessary pedagogical, technological, and social supports [2]. It emphasizes participation, accessibility, and individualized adaptation as key components of quality education.

Distance learning, as used in this research, denotes instructional delivery in which students and teachers are physically separated but connected through digital platforms, online resources, and interactive communication tools [3]. In the context of Computer Science education, distance learning integrates synchronous and asynchronous activities that use structured visual interfaces and digital tasks to support learners with ASD and their peers in inclusive classrooms.

Computer Science (CS) was selected as the primary focus of this study because it offers distinctive pedagogical and cognitive advantages for children with ASD. Unlike other subjects, CS emphasizes logical sequencing, rule-based problem solving, and visual representation, which correspond well with the cognitive strengths of many learners with ASD such as a preference for structure, attention to detail, and visual–spatial reasoning [4, 5]. Furthermore, CS education increasingly employs interactive, gamified, and visual platforms that minimize social pressure and provide immediate feedback, making it particularly suitable for inclusive and distance-learning contexts. International policy frameworks [2, 3] also underscore digital literacy and computational thinking as essential twenty-first-century skills, reinforcing the significance of exploring CS learning accessibility for diverse learners, including those with ASD.

The COVID-19 pandemic further revealed the complexity of ensuring quality education for children with ASD during distance and hybrid learning. Many learners with ASD struggle with maintaining concentration, coping with transitions, and communicating effectively through digital platforms, which can lead to reduced engagement and academic performance [6]. Consequently, educators must identify and implement effective teaching strategies and digital tools that are sensitive to the sensory, cognitive, and social characteristics of this group.

A growing body of research indicates that visual, interactive, and technology-mediated approaches can enhance learning for children with ASD. Educational applications, digital games, and interactive simulations have been shown to render abstract concepts more concrete and accessible, while also promoting motivation, task independence, and self-efficacy [7, 8]. These tools are especially valuable in inclusive and distance learning contexts, as they allow teachers to personalize content, provide visual structure, and ensure immediate feedback—elements that are particularly beneficial for

learners on the autism spectrum.

Given these considerations, this study aims to explore effective methods for teaching Computer Science (CS) to children with ASD in inclusive and distance learning settings. Specifically, it investigates how adapted pedagogical strategies and digital resources can enhance engagement, motivation, and learning outcomes among children with ASD.

Study addresses the following two Research Questions (RQ):

RQ-1: Is distance learning of Computer Science effective for children with ASD in inclusive education settings?

RQ-2: What challenges do children with ASD face during distance learning in Computer Science?

II. Literature Review

A. Training of Children with ASD in the Context of Inclusive Education

Previous studies have shown a significant worsening of symptoms in children with attention deficit hyperactivity disorders during COVID-19, highlighting the need to focus on particularly vulnerable groups during the pandemic [7].

Some studies suggest that children and young people with ASD "may be vulnerable to the prolonged isolation caused by quarantine, developing maladaptive behavior and developing difficulties" [8]. Studies have shown that parents of children with ASD reported an increase in their children's behavior problems during the pandemic, such as aggression, hypersensitivity, and impaired communication skills [5–9]. It is also worth noting that there is limited attention paid to their special needs and strengths [10], including teachers who are distrustful of autistic students and do not know how to include them in the learning process [11, 12]. Building and maintaining trusting relationships between students with ASD feel connected to their school and have a sense of belonging [13, 14], especially when they develop deep relationships with their teachers who meet needs through innovative approaches that build on their abilities. It also highlights the need for easily implemented programs that into account the needs of children with ASD [15].

Quarantine or prolonged illness should not interrupt the educational process for children with ASD, as they need to be constantly in motion and connected [16]. Children with special needs can utilize distance learning technologies to minimize disruptions to their learning process. Information and communication technologies provide additional opportunities for people with ASD to develop skills [17].

Since there is no known cure for people with ASD, the use of technology can help prevent the progression of deficits in skills and behavior. For instance, utilizing information and communication technology can help repeat everyday activities and capture their attention through various audiovisual resources [18]. Advances in technology and its diverse applications have enabled people with ASD to rely on digital tools that support the development of their capabilities [19]. The technology has a wide range of applications, including teaching, emotion recognition and identification [20], assisting with social interaction [21], facilitating understanding and management of daily routines [22], and enabling communication [23]. All of these applications are intended to provide the skills and knowledge needed to work with people with ASD. That is, they are referred to as "Assistive Technologies" (AT). The term applies to a range of equipment, services, strategies, and practices designed and implemented to assist individuals with disabilities in enhancing their functional and learning skills. This has been identified as one of the problems to be addressed in CS research, as it enhances the user's experience with computers in the field of education [24, 25].

AT is now playing a significant role in inclusive education [26]. AT is any object, hardware, software, or product that is used to enhance, support, or improve the functionality of people with disabilities [27, 28].

There are both advantages and disadvantages to introducing computer technology into the lives of today's children, but it is impossible to overestimate the effectiveness and benefits of CS, especially for children with ASD. The following sections outline the advantages and challenges of computer technology for teaching children with ASD.

B. Distance Learning for Children with SEN

During the global pandemic, the forced long-term closure of schools and the sudden transition to distance learning had a negative impact on children with special needs [29–33]. The sudden switch to a different learning format has led to changes beyond the "usual" routine for children with ASD. Research has shown that daily routine disorders have been associated with several consequential outcomes, such as anxiety and aggression in children with autism and increased anxiety in their parents [34–36]. During the pandemic, parents said they were overwhelmed by anxiety about changes in their children with ASD [37]. In other words, the majority of the training took place at home. Teachers attempted to conduct classes for children in a distance learning format. However, based on research by Corbett *et al.* [38], distance learning, especially given the stresses associated with COVID-19, was believed to be a complex learning environment for many children with ASD [39]. Before that, at school, along with subject teachers, they were supported by specialists, so they were stuck in this process during distance education. According to some studies, there are certain advantages to teaching a special child remotely from home [40]. It is effective to reduce the sensory and social overloads that often hinder an autistic student's ability to learn at home [41, 42]. This was one reason why, in many cases, parents of children with ASD chose to teach their children from home [43]. At this time, parents believe that remote home learning can lead to greater success, compared to learning in a large classroom where their children receive less individualized attention [44].

However, in the context of distance learning, when teaching children with ASD in an inclusive environment, subject teachers may not know how to use effective methods or achieve the best results by working with the child [13, 43, 45]. Teachers may face challenges in organizing an effective educational process for children in an inclusive classroom due to their experience working children with ASD in the context of inclusive education and their lack of knowledge about the various types of autism. Computer Science (CS) education focuses on developing learners' problem-solving, logical reasoning, and computational

thinking skills through the use of programming, algorithms, and digital technologies. In the context of inclusive education, CS plays a vital role in fostering digital participation and equal access to learning opportunities for all students, including those with special educational needs. Researchers in computer science emphasize the importance of adaptive systems, user-centered design, and assistive technologies that enable diverse learners to engage meaningfully with digital content [46, 47]. Therefore, this study examined how to effectively implement distance learning within the context of inclusive CS education, while considering the positive effects of information technology on children.

C. Remote CS Education and Digital Tools for Children with ASD

Recent studies have increasingly focused on how remote and technology-supported learning environments influence the participation and achievement of children with ASD particularly in Computer Science (CS) education. Visual, interactive, and gamified platforms such as Code.org and Scratch have been shown to make abstract CS concepts more concrete, enhance engagement, and promote computational thinking among learners with diverse educational needs [5, 48, 49]. These tools align with the cognitive strengths of many children with ASD—such as attention to visual patterns, preference for structure, and rule-based learning. Moreover, digital technologies can offer flexibility, self-paced learning, and reduced sensory and social stressors compared to traditional classrooms, which is especially valuable for children who experience anxiety in group settings [50].

At the same time, researchers highlight that digital and remote learning tools also present several challenges. Some children with ASD may experience sensory overstimulation from bright colors, sounds, or rapid animations, leading to distraction or anxiety [51]. Others may find it difficult to sustain focus or navigate multi-step digital tasks without adult guidance. In addition, limited opportunities for real-time communication and collaboration can restrict the development of social and emotional skills, which are integral to inclusive education [52]. These findings emphasize that while digital CS education offers significant benefits, its effectiveness depends on careful instructional design, individualized support, and close cooperation between teachers, parents, and specialists.

By considering both the benefits and limitations of technology, the present study contributes to this growing field of inquiry by providing a context-specific example of how distance learning in Computer Science can be effectively adapted for children with ASD in Kazakhstan.

Emerging educational technologies have increasingly transformed inclusive and distance learning environments. Artificial-intelligence-driven tutoring systems, such as intelligent adaptive platforms, enable the personalization of instruction by analyzing learner data and providing real-time feedback [53]. Likewise, Augmented and Virtual Reality (AR/VR) environments foster engagement and social-emotional learning for children with Autism Spectrum Disorder by simulating safe, controllable interactions [46]. Gamification frameworks and interactive learning games, particularly those integrating visual coding and reward systems, have demonstrated positive effects on attention and motivation [54].

In inclusive education contexts, adaptive digital environments and multimodal interfaces—combining text, visuals, haptics, and speech-to-text tools—are being increasingly used to accommodate diverse sensory needs [55]. These technologies align with Universal Design for Learning (UDL) principles and offer flexible pathways for participation and skill acquisition, supporting the broader trend toward technologically mediated inclusion. Incorporating such tools into Computer Science (CS) instruction for children with ASD provides not only accessibility but also opportunities for developing computational and social-cognitive skills.

To situate these findings within a broader perspective, the following section summarizes international data on ASD prevalence and the global adoption of distance learning and digital Computer Science education. Globally, autism prevalence estimates indicate a substantial and rising identified population. According to the World Health Organization [56], approximately 1 in 127 persons worldwide is estimated to be on the autism spectrum, with significant variation across regions and limited data from low- and middle-income countries. U.S. surveillance reports show a continuing upward trend, with about 1 in 36 eight-year-olds identified with ASD in 2020–2022, reflecting both expanded screening and improved diagnostic awareness [57]. These figures underscore the international relevance of scalable and accessible instructional models for autistic learners.

The COVID-19 pandemic further accelerated the adoption of remote and technology-mediated instruction worldwide. UNESCO [2] reported that over 1.6 billion learners were affected by school closures at the peak of the crisis, while OECD analyses highlighted global disparities in system readiness and equitable access to digital platforms. Such rapid transformations prompted an unprecedented shift toward visual, structured, and interactive learning environments, particularly in subjects like Computer Science [2, 3].

Within CS education, international studies describe transitions between block-based and text-based programming, and the benefits and limits of visual, scaffolded tasks for diverse learners, including those with disabilities. Cross-case and classroom analyses [48, 49] demonstrate that these digital environments can foster computational thinking and inclusion when combined with explicit teacher guidance and adaptive supports.

The reviewed body of literature establishes the theoretical and empirical basis for this study's research questions. Prior research on assistive and digital learning technologies demonstrates how interactive, visually structured environments can improve engagement, social interaction, and cognitive development in children with Autism Spectrum Disorder (ASD) [5, 17, 25]. These studies collectively informed RQ1, which examines the effectiveness of distance CS learning for children with ASD in inclusive settings.

Simultaneously, evidence highlighting the barriers to distance and digital learning such as sensory overload, teacher readiness, and limited individualized feedback [40, 50, 51] directly shaped RQ2, which investigates the

challenges faced by learners during remote CS instruction.

Thus, the literature not only contextualizes the importance of technology-mediated inclusive education but also delineates the dual focus of this study:

- to determine whether structured, visual digital environments such as Code.org can facilitate algorithmic learning for children with ASD;
- to identify pedagogical and technological factors that hinder or enhance learning outcomes. This explicit alignment ensures that the study's design, data collection, and interpretation are firmly grounded in the existing body of research on inclusive, technology-supported pedagogy.

III. Materials and Methods

The study was reviewed and approved by the university ethics committee. This descriptive and explanatory case study [58] is a case study [59] focuses on the practice of special distance learning of CS in the context of inclusive education and changes that occur in the educational process (effectiveness, impact, obstacles, problems, etc.).

The following criteria were used to select participants: (1) school management and parents of a special child agreed to participate in the study of their children (agreement is saved), (2) ASD students received special education services, and (3) students had basic computer skills such as turning on a computer and logging in the study of participants was carried out in the first 4 weeks in a rehabilitation center for children with ASD and speech disorders and then at school. Many approaches to step-by-step triangulation of data have increased the reliability of case study results [60]. Data sources included interviews, observation results, and additional open conversations. A semi-structured interview guide was used to conduct the interviews, allowing respondents to express their thoughts freely [61]. Interviews were conducted with parents directly involved in children with ASD, a center specialist, a school psychologist, and a computer science teacher. Direct observation of students in the inclusive classroom participating in the research experiment (workspace, distance learning activities, student behavior, academic activities, interest in the lesson, etc.) was conducted. Open conversations (including the perception of learning by a special child, teacher professional development, parental support, and assistance from special professionals) were included.

A. Study Participants

The study was conducted over a period of 20 weeks in 1 school and "The Rehabilitation Center for Children with Autism and Speech Disorders" in Almaty, Republic of Kazakhstan. The study involved 1 CS teacher, 1 Speech pathologist-psychologist, 1 teaching assistant, 4 center specialists, 2 parents, and 12 students studying in an inclusive class (including 2 children with ASD). The study participants were assigned pseudonyms and were referred to by these pseudonyms throughout the study. While the sample was relatively small, it was sufficient for achieving the study's objectives and for ensuring data saturation within the context of inclusive education in Kazakhstan.

B. Teacher

Shynar has been working at the school for three years. At first, she was shocked by the aggressive behavior of a special child in an inclusive class. Shynar says that she was not ready to work with special children. The school where Shynar is employed features additional inclusive classrooms and a teaching assistant. This has helped Shynar a lot. Shynar teaches computer science to an inclusive class once a week (45 mins). A special student sometimes does not attend classes, and if he does, he does not sit for a long time. He acts out in various ways and sometimes interferes with typically developing children. At such times, the teaching assistant says, the special child is taken away separately. Shynar was directly involved in the research. She organized an inclusive class in each computer science lesson. She focused the students' attention on the lesson and participated in observing the experiment with the researcher.

C. Students with Special Educational Needs

Alisher is in the sixth grade at a comprehensive school. Alisher was diagnosed with an ASD. He doesn't engage in much play with his peers in the classroom. He is most active during the first lesson of each day. Alisher spends his free time from school in a rehabilitation center for children with autism and speech disorders. My mother says that this center has helped a lot.

Almas, a classmate of Alisher, is in the sixth grade at a comprehensive school. He spends a lot of time with teacher assistants. Loves physical education. In other words, he enjoys playing and interacting with his body. Does not stand still, hyperactive child.

They both love playing with gadgets. They only want to play games on the computer in CS class. They don't pay much attention to the teacher. Both have a teaching assistant with them at all times.

D. ABA Therapy Protocol

In the study, elements of Applied Behavior Analysis (ABA) were systematically integrated into the instructional process to support children with Autism Spectrum Disorder (ASD) during Computer Science (CS) learning in an inclusive digital environment. The ABA approach served as the pedagogical foundation of the intervention, ensuring structured learning, measurable progress, and replicability.

At the initial stage, each participant completed a two-session baseline assessment designed to determine their starting performance level, attention span, and task-response consistency. The data were gathered through direct observation and automatic logs within the Code.org platform. Based on these observations, individualized reinforcement strategies were designed to maintain consistency and motivation throughout the experiment.

The instructional phase spanned four weeks, with three online sessions per week, each lasting approximately 40–45 mins. Every session began with a brief warm-up and a review of the goals, followed by the main learning activity, and concluded with reinforcement and feedback. During instruction, children worked on video-based programming lessons with subtitles and interactive tasks. The process followed the ABA learning cycle, which included presenting a stimulus, receiving a learner response, providing immediate feedback, and offering reinforcement.

To maintain focus and gradual skill acquisition, ABA techniques such as Discrete Trial Training (DTT), prompting, and shaping were applied. Tasks were decomposed into

smaller, sequential steps, and learners received visual cues when necessary. As mastery increased, prompts were gradually faded to promote independence. A token-based reinforcement system was used throughout the sessions: for each correct or completed task, the child earned digital badges or stars within the application. These rewards served as motivational feedback and could be exchanged for short visual animations or mini-games integrated into the learning platform.

Progress was continuously monitored through automated performance data and teacher observation notes. Adjustments were made weekly to the reinforcement schedule and task complexity to maintain an optimal level of challenge. At the end of the intervention, participants were encouraged to apply the acquired programming skills to new problem-solving tasks to evaluate the generalization and maintenance of learning. A follow-up observation one week later confirmed that most learners were able to independently reproduce basic algorithmic sequences and transfer their learned skills to new contexts [62].

Overall, the structured ABA-based framework ensured consistent pedagogical conditions, objective tracking of behavioral changes, and replicability of the procedure for future research on digital inclusive education.

E. Data Collection

To gain an understanding of the behavior of students when using distance learning technologies in inclusive education, the basic form of data was employed. Interviews were conducted with individuals with SEN (parents, a specialist from the Rehabilitation Center, a speech pathologist, and a teacher at the school) who attend an inclusive class.

Observations in the classroom and distance learning were used to determine the level of academic activity of participants and the level of attendance in the classroom CS. In addition, the teacher was interviewed even after the observations were analyzed to obtain contextual information about the students as a whole and to determine the results.

The study began with the well-known "Rehabilitation Center for Children with Autism and Speech Disorders" in Almaty. The center has been working with special children for many years and has shown good results. The center specializes in the rehabilitation of children with special needs, utilizing the ABA therapy methodology. According to the center's head, learning this method is essential for specialists working with children in all educational systems. There are many types of modern traditional and non-traditional innovative work with children who have early childhood autism. One of them is unique; one of the most effective programs today is the "ABA" method. ABA therapy is the only method in the world for teaching children with developmental disabilities with scientifically proven effectiveness [63].

That is, before working with a child with special needs, it is beneficial for every teacher to be familiar with the ABA method. Therefore, having studied numerous studies, we began our study at a center that conducts rehabilitation work using ABA therapy. The center has children aged 3–14. Focusing on school-going children, the work carried out with these children and the methods used were studied. The center's specialists teach children to behave properly at school and to communicate properly with peers and teachers. This is particularly important for children with special needs who attend inclusive classes. Parents of the children under observation were also met at this center and interviews were conducted. The interviews were conducted using pre-prepared, mixed-structured questions.

The mother of two school-age children who attend the center stated that her children had not been systematically participating in the learning process during the quarantine. They noted that distance learning has not been effective due to the lack of teacher training, the absence of suitable educational materials for distance learning, and the child's lack of interest in the online platform for conducting lessons.

Accordingly, the children were observed from a psychological perspective for four weeks. Seeing that the children played well on gadgets at a certain time, mastered and managed various games well, it was noticed that a special platform or service was needed when teaching the school program to the children remotely. Additionally, this learning platform needed to be visually appealing and incorporate elements that would engage the child. After all, when the children's mothers were interviewed, they said that learning platforms or services should incorporate game elements and cartoon/game characters that children are familiar with. Taking this into account, there was a need to search for the best platforms and services in world practice.

F. Convenient Platform for Distance Learning in CS

After a period of studying effective tools, a special survey was conducted among CS teachers. Among several platforms, the teachers who responded to the survey focused on the Code.org platform.

In this study, the Code.org platform served as the primary tool for distance learning in Computer Science. This platform is designed for school-age learners and offers structured lessons that combine short instructional videos with step-by-step interactive tasks. Each lesson begins with a visual explanation of the concept, followed by block-based programming exercises that allow students to apply what they have learned. The interface is highly intuitive, utilizing animations, icons, and visual markers that are particularly suitable for learners who rely more on visual processing. The platform includes built-in automatic feedback: after each attempt, the student receives immediate confirmation of whether the solution is correct, and if not, the system provides hints in a visual and non-verbal form. Additionally, the platform enables teachers to assign tasks, track student progress in real-time, and adjust task difficulty according to individual needs. These features are especially beneficial in inclusive settings, where children with ASD or other special needs require structured, consistent, and visually supported instruction to maintain engagement and understanding.

Code.org is a nonprofit organization dedicated to educational innovation that aims to make CS a part of the core curriculum for every school. Before using the platform for our research, we wrote to the platform's developers and obtained their permission.

The platform has been positively evaluated in many countries as a convenient resource for teaching computer science courses to students in schools.

The platform offers lessons and courses of varying levels and durations (1 hour, 1 month, 1 quarter, or 1 year) for students in grades 1–12. The platform allows the user to

choose the most convenient device type (computer, tablet or mobile phone).

The platform has many unique features. The platform also has a set of courses and tasks for children with ASD. This optimizes the lesson by explaining the subject of CS to a special child using various course elements. The subject teacher registers on the platform as a "teacher" and, depending on the child's characteristics, selects the type of task that is most convenient for the student and assigns it to the child's personal profile. At the same time, the student must also register on the platform as a "Student" in advance. After the teacher assigns the task to the student, he can send a letter to the student's parents. The letter will guide parents on how to use the platform, complete the assigned task, and utilize it effectively. This is because students with special needs must have a parent, teacher, or teaching assistant present with them during remote learning at home.

G. Data Analysis

The primary data were analyzed using a qualitative general inductive approach [64]. The recorded interviews were transcribed. Transcripts were loaded into the QDA Miner Lite database to facilitate organization and analysis [65]. The initial analysis began with the coding generated by the research questions. During the study, additional topics emerged and were incorporated into the coding process. The second stage of coding focused on the concept of distance learning and its associated problems. For reporting, the codes were grouped into the following categories to focus on answering the research questions: (a) adaption of a special child to school and interest in the subject, (b) additional special education for teachers, (c) the impact of distance learning in CS, (d) teacher readiness for distance learning of special child in an inclusive education setting. An iterative cycle of coding, research, linking findings, and further exploration identified a chain of evidence that made sense of the data, thereby increasing the credibility and validity of the findings. Qualitative research requires participants to be shown the data. During data analysis, the interview transcripts were reviewed with participants and approved.

Observation notes were taken after each lesson. Observations were made multiple times to gain insight into how children with ASD interacted with peers and teachers, as well as with platform tasks.

The case study design focused on in-depth exploration of a specific educational context to generate rich qualitative insights into distance learning for children with ASD.

IV. Results

A. Readiness of Subject Teachers

Since the main goal of the study was to determine the effectiveness of distance learning in Computer Science for children with ASD in an inclusive setting, during the observation, the researcher accompanied the child and the teaching assistant to a special inclusive classroom where the child completed tasks on the platform. While the childs were in the classroom, the CS teacher faced pedagogical and psychological challenges in managing all the children simultaneously. In the remote teaching of children with ASD, the subject teacher's lack of skills in maintaining the child's attention was observed. Thorell [66] and others encountered similar difficulties in their studies. Parents indicated that during remote teaching, teachers lacked specific methods and steps tailored to the child.

In the early stages of the research, a parallel interview was conducted with the CS teacher. Once the teacher was informed about the anonymity of the interview content, she provided candid responses. The observation revealed the teacher's willingness to work with and teach children with ASD. However, Shynar teacher noted that in the context of inclusive education, there is a lack of specialized skills and physical time to work with children with diverse needs.

... "First of all, I think that all children should be loved equally. Before teaching a child with special educational needs, you need to get complete information about the child and be ready to work with them. Special children are different. They need to be given individual tasks. The teacher should take this into account".

Teachers who have not worked with children with SEN for a long time, including young ones, have reported significant difficulties in their experience. When asked, *"What do you take into account when working with children with special educational needs? What principles do you adhere to?"* However, she acknowledged that sometimes, due to physical constraints, they may not have the time to assign specific tasks for each lesson. In such a situation, it seems that they have to perform tasks together with typically developing children.

According to the Shynar teacher, the conditions for working with special children are being improved in schools. In certain cases, schools provide special rooms for private play and relaxation, particularly if the child exhibits aggression or requires individual tasks.

Additionally, lessons were not conducted remotely on days when the child with special needs was unable to attend school due to specific reasons. In cases where permission was granted for home study for a certain period (due to a prolonged illness), the child was prepared with easy tasks and taught at home. However, the sudden emergency that swept the world, such as the pandemic, caused a number of difficulties in teaching a child with special needs remotely. First, it was challenging for parents and teachers to prepare kids for screen time and focus on lessons.

Although the findings in this study are based on a single teacher's reflection and observation, they align with a growing body of international research highlighting similar barriers in inclusive and digital education contexts. Studies across different countries emphasize that many teachers face challenges related to digital readiness, pedagogical adaptation, and confidence in using assistive technologies [27, 55]. Limited professional development opportunities and insufficient institutional support further hinder teachers' ability to implement inclusive digital instruction effectively [53]. Thus, the experience described in this study should be understood not as an isolated case but as representative of a broader, systemic issue observed in inclusive distance learning environments worldwide.

The lack of special teaching aid, the lack of online learning services, and Platforms focused on the specifics of the child, there were many inefficient aspects of distance learning (Fig. 1). In addition, CS teachers expressed the need for methodological assistance in distance learning of children

with special needs, and they would like to organize more pedagogical and psychological professional development for teachers who work with these children:

... "first of all, to prevent this problem, it is necessary to prepare future teachers, that is, students, for distance learning of children with special educational needs in inclusive settings. Then, it is necessary to conduct high-equality professional development courses for teachers currently working at the school. In that course, at first, it is important to teach how to work psychologically with a special child, the category most often found in an inclusive class. Because, without psychological work with a child, we cannot use pedagogical techniques. Methodological support is very necessary. Each class needs a manual on the use distance learning technologies in teaching computer science to a special child".

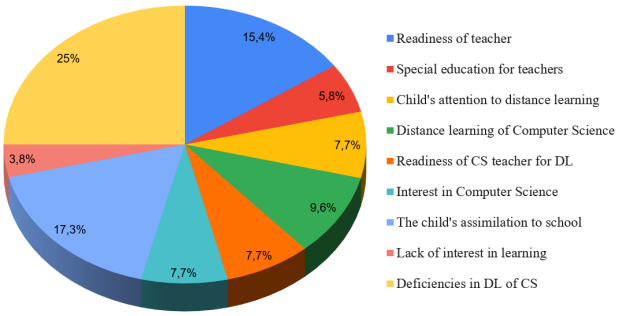


Fig. 1. Problems of distance learning of CS in inclusive education.

Studying the results of interviews with parents and teachers, we realized that the trio of "teacher-student-parent" needed a convenient and effective platform, which is an equally necessary tool during distance learning. That is, this proved the relevance of our research.

During the initial research period, the platform task was given only to children with ASD as an adaptation week. The child understood the task and was able to continue on his own. However, he always wanted to have someone with him. That is, during distance learning, parents, a teacher, or a teaching assistant in the classroom needed to provide support. It was noted that the ASD child needed a comfortable learning environment, both at home and in the classroom. This is because ASD children did not like noisy environments and long-term tasks.

The children completed the task on the platform without haste. "I don't know," they said. "Why don't I get results so quickly?", "He is ahead", "I must finish first" and showed a high emotional state. This sparked a competitive spirit within the children.

B. Distance Learning of CS in Inclusion

The next stage of our study describes the participation of students, including a special child, in distance learning of CS, their participation in classes, task completion, communication with peers, distance learning activities, academic activity, and cooperation with peers. The children who participated in our study were sixth-grade students studying in an inclusive class.

On the day of the CS lesson, students ask the teacher for a special code to complete the task. By entering the code, the student can view and complete the task. The student sees explanatory video lectures before completing the task.

Bandura and Jeffrey [67] described four processes that underlie observational learning: attention, retention, motor reproduction, and motivation. The focus was on the normalization of these four processes.

In order to capture the child's interest, we first provided special needs students and the CS teacher with information about the platform, along with an explanation of its use rules. Next, the teacher asked the students to select a curriculum-aligned topic from the platform, ensuring the topic lasted only one lesson.

In the first lesson, special needs students showed indifference and did not want to participate in the CS lesson. Students were given a code. They began to look at the task given on the platform. The teacher and researchers observed the children as they performed the tasks in the classroom. The teacher has the authority to see how each student is performing the task. This took place on the platform (Fig. 2).

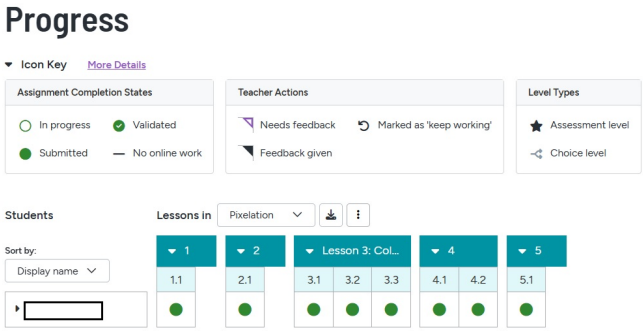


Fig. 2. Window for monitoring the progress of students' tasks.

In the first weeks, only the special children worked with the platform. The researcher, as an assistant, explained the task to the child. The special children sometimes showed impatience and did not want to complete the tasks. However, if they were able to complete the first task, they began to show some enthusiasm in moving on to the next task. However, they were unable to complete some tasks (Fig. 3). Since the task was too long or difficult to complete, the child showed aggressive behavior. Therefore, after the assistant said that it was possible to proceed to the next tasks, the child began to return to normal.

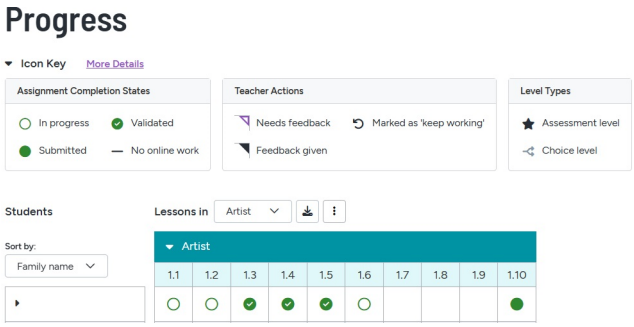


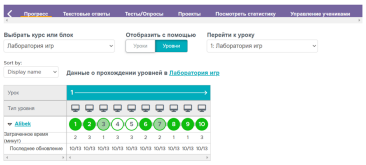
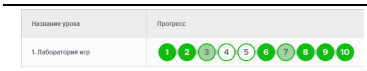
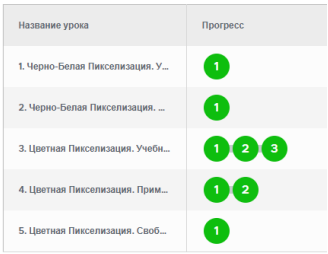
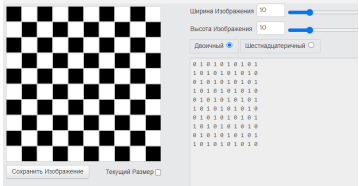
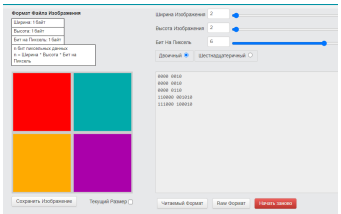
Fig. 3. The student's task execution window at the initial stage.

Starting from the fourth week, the children began to perform tasks alongside typically developing children in the classroom (Table 1).

The lesson plan guided the preparation of the tasks in advance. Both special children and typically developing children found the tasks engaging. We believe that this approach has significantly contributed to the effective learning of all children in an inclusive class, as well as the subject teacher. After completing each task, the platform

awards a specially designed certificate to the student as a form of support. The special children who saw this were also very pleased with the typically developing children. Since we were in contact with the parents of special children, we sent their children's certificates electronically after each lesson. The mothers were also very happy with their children's achievements.

Table 1. Task performance of children with ASD

Task Performance	Description
	The tasks were not fully completed
	As the typically developing child was completing the task quickly, the special children tried to keep up.
	Striving to complete tasks
	Special children completed the tasks in full.
	Special children were able to work with pixels through the binary code.
	Based on the hexadecimal number system, they understood the color transfer in the computer system and filled out the given squares themselves.

Over the next seven weeks, all students in the inclusive class (both typically developing and special needs children) used the platform as a form of distance learning. That is, 20 minutes of the 45-min lesson were devoted to this platform. Students were seated at a great distance from each other, and each was given a separate laptop. The teacher started the lesson via Zoom and explained the topic for the first 15 minutes. Students had to complete the task on the platform without leaving the Zoom meeting. At this time, special children sat in the inclusive classroom with a teaching assistant. It's beneficial that their parents are seated next to their children at home. For children who have adapted to the platform for some time, it was simple to work with the platform interface. All children in the class completed the task with minor difficulties. However, special children became passive and did not immediately start the task. They started the task with the help of the researcher. But the children were not as motivated as in the classroom. Nevertheless, they tried to complete the task in full. Since the teacher could see how each student was completing the task on the platform, he commented on the children's work on Zoom. When the teacher mentioned students who were successfully completing the task, one of the special children became motivated, saying things like "I need to finish quickly...," "Why don't I get results quickly...," and so on.

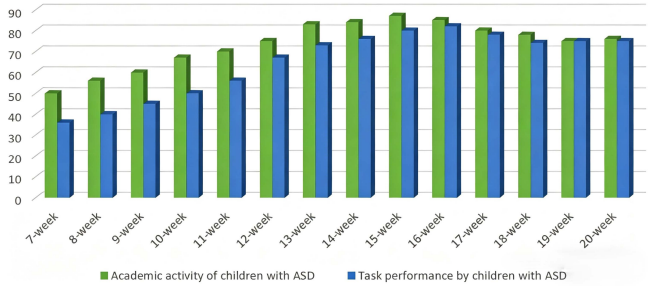


Fig. 4. Observation during research.

It was observed that children with ASD worked less actively than their peers in the classroom. Because when they were sitting next to other peers in the classroom, they had competition to learn. That is, even though they were special children, they wanted to act together with their peers, to be in the same environment. Thus, our long-term study was completed in two quarters (Fig. 4). Quantitative results showed that 75% of participants demonstrated measurable improvement in task completion rates, and the average score on programming-related exercises increased by 21% between the first and final sessions.

A number of problems and obstacles were encountered. The ready-made platform used in the study could be an effective example of distance learning in computer science in inclusive education. Both teachers and students had opportunities and limitations in using the platform. The platform offered both traditional and distance learning computer science lessons that were both interesting and effective for children with special needs. Special children were willing to participate in computer science lessons and looked forward to participating in this lesson. At the end of the study, we interviewed the subject teacher who had participated in the observation.

C. Challenges in Distance Learning

In inclusive education, organizing distance learning involves several steps. The students who participated in the study, including children with ASD, were able to turn on the computer, log in to the platform, and complete the log out. However, the observations identified several problems. Among them, they did not understand how to use small programs or how to assemble blocks. Since they were not sitting in the same classroom with the teacher, when such a problem arose, they became frustrated and refused to complete the tasks. In both cases, the students immediately sought support from adults or peers around them. Thus, it became necessary to think about how to conduct learning in a way that would not disappoint all students when complex multi-step problems arose.

The teacher and a peer of the children with ASD in the inclusive classroom, who participated in this study, provided various instructions to the special needs child during remote learning. These instructions often involved explaining

specific actions to be taken during the task. These instructions were implemented after the child with special needs encountered difficulties. For example, Almas could not use the necessary codes when working with pixels; that is, he had to use the pixels to compose colors. The teacher explained to Alisher which color corresponds to which code. Sometimes the special needs child did not understand what the teacher was saying or what the teacher wanted. This future research should focus on (a) the interaction between the teacher and the special needs child remotely, (b) the effective organization of the calculation task for the student, and (c) how to increase the academic activity of the special needs child during remote learning in inclusive education. The current study also addressed the need to investigate individual support for children with special needs. For instance, Snodgrass *et al.* [5] found that only during class did these students receive individualized support, resulting in an increase in their engagement. However, this individualized support was only one strategy for effective distance learning in CS. In addition, parents lacked the pedagogical support and guidance they need to teach their children CS remotely, and teachers lacked resources to teach this format. Many people with ASD prefer to learn through visual materials rather than through listening, as noted by Cohen [68]. This was also a significant issue.

D. Student Collaboration in an Inclusive Classroom

This study placed great importance on the interaction and cooperation of children in an inclusive classroom, both in traditional and distance learning formats. Each of the children participating in the study had different social and academic levels. For example, children with special needs in the class may not be able to fully communicate with their peers in a normal situation. However, thanks to the platform's user-friendly and understandable interface, along with new software, they were able to ask each other for help. This, at least in a small way, brought special children and their peers closer together. Peers, seeing the enthusiasm of the special children who were able to work with the platform, were initially surprised. However, this did not affect the interaction in real time during the lesson. When Alisher initially asked his peer, "What did you do to move forward?" he generally replied, "You put the appropriate codes". Alisher was not satisfied with this answer and did not want to ask for further clarification. Although the children with ASD received support from their peers and teachers, none of the children with special needs received sufficient support to enable them to complete the task successfully. In the second phase of the study, when the children with special needs performed the task remotely in a separate classroom, they received support from the adults around them (in our case, it was a teaching assistant, a research assistant, one of the researchers, and their mother). They took turns and tried to complete the task without rushing. This is because the special person who was found nearby paid attention to only that child with special needs and provided personal support, which contributed to the child's successful completion.

V. Discussion

The findings of this study demonstrate that structured distance learning environments can effectively support the development of algorithmic and computational thinking skills in children with Autism Spectrum Disorder (ASD). Through the use of the Code.org platform, participants were able to engage in step-by-step programming activities that gradually improved their problem-solving accuracy, persistence, and independence. The visual, interactive, and predictable structure of the platform created favorable conditions for learners with ASD, minimizing sensory distractions and promoting sustained engagement in Computer Science learning tasks.

These outcomes show that distance education is not merely accessible but pedagogically valuable for children with ASD when instructional design incorporates visual supports, clear sequencing, and immediate feedback. Such features align with the cognitive and sensory strengths of students on the spectrum, who benefit from well-structured environments that reduce ambiguity and allow for self-paced exploration. The combination of consistent feedback and gamified challenges proved particularly effective in maintaining motivation and reinforcing understanding of basic programming logic.

The results are consistent with prior research emphasizing the benefits of technology-enhanced learning for students with special educational needs. Tlili [55] highlighted that game-based learning promotes engagement and learning outcomes among students with disabilities, while Gallud *et al.* [47] emphasized the role of interactive and multimodal technologies in supporting inclusive education. The present study extends these findings by demonstrating that distance learning platforms such as Code.org, when used with appropriate scaffolding and visual cues, can effectively facilitate algorithmic thinking in learners with ASD.

The observed improvement in algorithmic reasoning also corresponds with studies on the assessment and development of these skills in children. Adorni [69] found that structured problem-solving tasks, such as the Cross Array Task, enhance algorithmic thinking in school-aged learners, underscoring the pedagogical value of guided digital exercises. Similarly, Kurnaz [70] demonstrated that video-based instructional strategies improve coding performance in children with autism spectrum disorder, confirming the effectiveness of visually supported and repetitive learning processes that parallel the structure of the current intervention.

Despite these positive results, some challenges were noted. Maintaining long-term engagement proved difficult for a subset of participants, reflecting limitations frequently discussed in the literature regarding sustained motivation in digital environments [71]. This suggests that ongoing teacher mediation, adaptive pacing, and personalized encouragement remain important for maximizing the effectiveness of distance learning for ASD students. Overall, this study contributes to the growing body of evidence that inclusive, accessible digital environments can successfully support Computer Science education for children with ASD. By situating the findings within existing research, it becomes clear that distance learning when designed with clear structure, visual organization, and continuous feedback—can enhance both cognitive and motivational outcomes.

VI. Conclusion

This study examined the effectiveness of distance learning

in Computer Science (CS) for children with Autism Spectrum Disorder (ASD) in an inclusive education context. The findings confirm that with appropriate digital platforms, individualized support, and adaptive pedagogical strategies, students with ASD can actively participate in CS learning and demonstrate measurable progress in computational thinking and problem-solving. Interactive, visually guided, and gamified tools such as the Code.org platform proved effective in leveraging the cognitive strengths of these learners, particularly their logical reasoning and preference for structured tasks, while also reducing social and sensory stressors.

From a theoretical standpoint, the study extends research on inclusive and technology-mediated instruction by demonstrating that CS learning can bridge cognitive and engagement gaps for students with special educational needs. The results align with international findings emphasizing multimodal and individualized learning environments for children with ASD. Moreover, the research highlights that when instructional design incorporates visual structure, immediate feedback, and accessible navigation, children on the autism spectrum are able to learn abstract programming concepts more effectively, even in remote settings.

While the intervention was effective, several barriers were observed, including limited teacher readiness, insufficient training in inclusive pedagogy, and challenges in maintaining consistent individualized support during distance learning. Addressing these issues is crucial for the sustainable implementation of this initiative.

To overcome these barriers, the study proposes several actionable interventions. First, teacher training modules should be developed to strengthen digital and inclusive pedagogical competencies. Such professional development programs must integrate practical sessions on using visual programming platforms and adaptive instructional tools for learners with ASD. Second, schools and teacher education institutions should establish peer mentoring and professional learning communities, enabling educators to exchange inclusive teaching strategies and collaborate with special educators. Third, policymakers should support the creation of localized repositories of digital learning materials aligned with national curricula and designed according to Universal Design for Learning (UDL) principles featuring subtitles, simplified interfaces, and bilingual accessibility. Finally, systematic inclusion of digital pedagogy into pre-service and in-service teacher education programs is recommended to ensure long-term preparedness for inclusive online instruction.

Distance learning platforms, when adapted to sensory and cognitive profiles, offer significant advantages for learners with ASD. By providing structure, flexibility, and reduced environmental stress, they can enhance not only academic performance but also social and self-regulation skills. However, it is equally important to ensure that teachers and parents receive adequate guidance and training to support learners effectively in home-based environments.

While the findings offer meaningful insights, they are based on a single case study and should therefore be viewed as illustrative rather than generalizable. Future research with larger, more diverse samples and longitudinal observation is needed to validate and extend these results.

In conclusion, this study demonstrates that inclusive, adaptive CS education can promote both cognitive and social development in children with ASD. By linking empirical findings with practical recommendations, it offers a model for implementing effective distance learning programs and guiding teacher training and policy development in inclusive, technology-supported education.

Ethical Statement

This study was approved by the Kazakh National Women's Teacher Training University Ethics Committee (Protocol No.5, from 08.09.2023).

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Gulnaz Salgarayeva conceptualized, designed, and supervised the research, wrote original draft, review and editing; Botakoz Sabit carried out the study, gathered and analyzed the data, wrote paper, review and editing; All authors had approved the final version.

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