Al-Ishlah: Jurnal Pendidikan
Vol. 17, 4 (December, 2026), pp. 5744-5754
ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v17i4.8489

Application of Programming Algorithms to Support Computational Thinking in Children with Autism Spectrum Disorder

Zsalzsa Puspa Alivia[1], Jaja Kustija[2], Lala Septem Riza[3], Anne Hafina[4], Munir[5], Wahyudin[6]

1 Universitas Pendidikan Indonesia, Bandung, Indonesia; zsalzsa@upi.edu
2 Universitas Pendidikan Indonesia, Bandung, Indonesia; jajakustija@upi.edu
3 Universitas Pendidikan Indonesia, Bandung, Indonesia; lala.s.riza@upi.edu
4 Universitas Pendidikan Indonesia, Bandung, Indonesia; annehafina@upi.edu
5 Universitas Pendidikan Indonesia, Bandung, Indonesia; munir@upi.edu
6 Universitas Pendidikan Indonesia, Bandung, Indonesia; wahyudin_sanusi@upi.edu

ARTICLE INFO

Keywords:

autism spectrum disorder;
computational thinking;
learning media;
programming algorithms

Article history:

Received 2025-08-18
Revised 2025-08-25
Accepted 2025-10-20

ABSTRACT

Children with Autism Spectrum Disorder (ASD) often experience challenges in logical reasoning and problem-solving, which can hinder their computational thinking (CT) development. This study aimed to examine the effectiveness of programming algorithm-based learning media in enhancing CT skills among children with ASD during Phase C informatics learning. A mixed-method approach combining Design-Based Research (DBR) and Single Subject Research (SSR) was employed. The study involved three children with ASD enrolled at SD BPI Bandung. The DBR process consisted of four stages: needs analysis, media design, development, and implementation. The intervention was conducted through an SSR design with three phases—Baseline 1 (A1), Intervention (B), and Baseline 2 (A2)—to assess changes in CT performance. All participants demonstrated notable improvements in CT skills following the intervention. For example, Participant KA's score increased from 20% to 60%, KZ's from 30% to 60%, and SB's from 20% to 45%. The results indicated consistent upward trends and stable retention during the post-intervention baseline phase, suggesting that the programming algorithm learning media effectively enhanced computational thinking abilities. The findings support the use of structured, technology-assisted learning to promote CT in children with ASD. However, the small sample size limits generalizability, and future studies should include larger, more diverse participants. The study underscores the importance of developing adaptive, inclusive learning media that accommodate individual cognitive and sensory needs.

Corresponding Author:
Zsalzsa Puspa Alivia
Universitas Pendidikan Indonesia, Bandung, Indonesia, Email: zsalzsa@upi.edu

1. INTRODUCTION

Ensuring inclusive and equitable quality education for all learners is a core mandate of Sustainable Development Goal 4 (SDG 4), which highlights the right to education for children with diverse needs, including those with Autism Spectrum Disorder (ASD). In Indonesia, the integration of inclusive education has gained momentum, especially in formal schooling systems that are increasingly accommodating students with neurodevelopmental differences. ASD is characterized by deficits in social interaction, communication, and restricted or repetitive behaviors, often accompanied by challenges in abstract thinking, symbol processing, and executive functioning (Vella et al., 2018). These difficulties can hinder children's development of problem-solving abilities, logical reasoning, and flexible thinking, which are essential in navigating both academic and everyday contexts (Fauziyah et al., 2022; Kim et al., 2024). As educational demands become increasingly technology-oriented, the necessity to equip all students—including those with ASD—with computational thinking (CT) skills becomes more pressing.

Computational thinking refers to a set of cognitive processes involved in formulating problems and expressing their solutions in ways that can be carried out by a computer or algorithmic system (Wing, 2008). It encompasses abstraction, decomposition, algorithmic thinking, pattern recognition, and debugging—skills which are now widely recognized as fundamental for the 21st century, alongside literacy and numeracy (Grover & Pea, 2013). CT is increasingly integrated into primary education curricula worldwide, with countries such as the United States, the United Kingdom, and South Korea embedding it in early years instruction (Hsu et al., 2018). Research shows that CT can and should be introduced from early elementary grades, provided that the pedagogy, tools, and content are developmentally appropriate (Djurdjevic-Pahl et al., 2017; Barr & Stephenson, 2011).

Interestingly, several cognitive characteristics commonly found in individuals with ASD—such as attention to detail, preference for rule-based systems, and structured problem-solving—may align with CT competencies. Structured learning tasks such as algorithmic programming can potentially enhance these students' strengths while supporting areas of need (Deng et al., 2020; Lodi et al., 2021). Techniques such as decomposition, for instance, allow learners to break down complex problems into smaller, more manageable parts—an approach particularly beneficial for children with ASD who may struggle with cognitive overload. Likewise, pattern recognition and algorithmic reasoning can offer predictable and repeatable processes that reduce anxiety and promote engagement.

Despite this alignment, empirical research specifically addressing CT education for children with ASD remains limited, especially in non-Western contexts. In Indonesia, where curriculum implementation of informatics learning is still evolving, very few studies have examined how programming and algorithm-based learning media can support neurodiverse learners. International studies have demonstrated positive outcomes from the use of interactive, visual, and game-based tools to promote CT in children with ASD (Kim et al., 2024; Hsu & Chen, 2022). However, these findings are often drawn from small samples or highly structured settings, and many have yet to explore how such media can be adapted to fit culturally diverse learning environments or mainstream school curricula. Furthermore, while technology is frequently cited as a motivator for learners with ASD, its effectiveness varies depending on the learner's sensory sensitivities, familiarity with digital tools, and the degree of scaffolding provided (Knight et al., 2019; Vidal-Hall et al., 2020). Without careful customization, technology can be either overstimulating or under-engaging.

Effective CT instruction for children with ASD, therefore, requires learning environments that are not only technologically enriched but also pedagogically sound and individualized. Learning media that incorporate visual clarity, minimal sensory distractions, and structured interaction have been shown to be particularly effective for this group (Wang, 2022). Algorithm-based media—especially those designed to present clear sequences, contrasting visuals, and paced learning—can serve as scaffolds that support learners' executive function and attention control (Israel et al., 2020). At the same time, such tools should allow for adaptability, enabling learners to proceed at their own pace and revisit content as needed. This highlights the importance of iterative instructional design processes, where the media are tested and refined based on user feedback and performance outcomes.

In light of these needs, this study employs a Design-Based Research (DBR) methodology, which is particularly well-suited to complex educational interventions involving special populations. DBR supports iterative development and theory-informed refinement of instructional practices within real-world settings (McKenney & Reeves, 2012). Its application here allows for the co-evolution of practical teaching tools and educational theory, especially as it pertains to inclusive technology integration. Coupled with a Single Subject Research (SSR) design, the study provides both developmental insights and individual-level analysis of effectiveness, capturing nuanced variations in learner progress over time.

Despite promising international developments, the Indonesian context presents a significant gap in understanding how algorithm-based media can be implemented effectively for learners with ASD. Past research in similar domains has largely focused on general primary school populations or used media not tailored to the sensory and cognitive profiles of neurodiverse learners. Moreover, previous studies have seldom addressed how such interventions align with the newly implemented Phase C of the national informatics curriculum, which emphasizes algorithmic thinking and problem-solving. There is also limited guidance for teachers on how to select or adapt educational technologies for inclusive classrooms.

This study seeks to fill that gap by investigating the implementation of algorithm and programming-based learning media in Phase C informatics instruction, specifically aimed at enhancing computational thinking skills in children with Autism Spectrum Disorder. The research addresses the following question: How does the implementation of algorithm-based programming media affect the development of computational thinking skills in children with ASD during Phase C informatics learning?

Through this investigation, the study aims to contribute both practical insights for classroom implementation and theoretical advancements in the design of inclusive educational technologies. By grounding the development process in DBR and focusing on real learners in real contexts, the study not only evaluates effectiveness but also provides a scalable model for inclusive CT instruction. The outcomes are expected to inform future curriculum development, teacher training, and technology design that supports the diverse cognitive and learning profiles of children with ASD—both in Indonesia and internationally.

2. METHODS

This study adopted a Design-Based Research (DBR) methodology integrated with a Single Subject Research (SSR) design to explore the impact of algorithm-based programming learning media on the development of computational thinking (CT) in children with Autism Spectrum Disorder (ASD). The use of DBR was appropriate for addressing the dual objectives of this study: developing a practical educational solution tailored to learners with ASD and systematically evaluating its effectiveness in a real classroom setting. DBR enabled iterative refinement of the media and instructional design based on field implementation, while SSR allowed for detailed observation of individual progress, offering robust insights into the causal effects of the intervention.

2.1 Design-Based Research (DBR) and SSR Alignment

The DBR process was conducted in four interconnected phases: (1) Analysis of practical problems, (2) Design of instructional solutions, (3) Development and validation of the learning media, and (4) Implementation and reflection. These stages were strategically aligned with the SSR experimental framework, which followed an A1–B–A2 design consisting of Baseline 1 (A1), Intervention (B), and Baseline 2 (A2) phases. Specifically, the media developed during the DBR design and development stages were implemented and tested in the SSR phase, providing empirical evidence of their effectiveness across individual learning trajectories.

2.2 Participants and Context

The study involved three children with ASD enrolled in Phase C (equivalent to grades 4–5) at SD BPI Bandung, a private inclusive elementary school in West Java, Indonesia. All participants had formal ASD diagnoses verified by professional clinical assessments and were identified as having mild to moderate support needs. The participants were selected through purposive sampling in coordination with the school's special education coordinator to ensure they met the criteria for informatics instruction and could follow basic classroom routines with support.

a. Participant KA: Male, 10 years old, exhibited strengths in visual learning but had difficulty with sequencing and attention span.
b. Participant KZ: Male, 11 years old, demonstrated good memory retention and verbal expression but struggled with abstract reasoning.
c. Participant SB: Female, 10 years old, showed consistent participation but required frequent repetition to retain concepts.

All participants were receiving regular academic instruction with individualized supports as part of the school's inclusive education model. Prior to the study, none had received formal instruction in algorithmic thinking or computer-based programming.

2.3 Ethical Considerations

This study received ethical clearance from the Research Ethics Committee of Universitas Pendidikan Indonesia. Participation was voluntary, and informed consent was obtained from the parents or legal guardians of each child. In addition, assent was obtained from each participant in an age-appropriate manner. Participants' names were anonymized using initials (KA, KZ, and SB), and all data were treated confidentially. During the intervention, care was taken to avoid overstimulation by adjusting screen time, visual complexity, and sound levels to suit each child's sensory profile.

2.4 Assessment Tools and Procedures

To measure the development of computational thinking, the researchers designed an assessment rubric based on core CT components adapted from Wing (2008) and Grover and Pea (2013), with modifications to suit the cognitive profiles of children with ASD. The assessment focused on the following indicators:

a. Decomposition – Ability to break down a problem into smaller parts
b. Pattern Recognition – Ability to identify repeating structures
c. Algorithmic Thinking – Ability to arrange steps logically to solve a task
d. Sequencing – Ability to follow and construct step-by-step processes

Each indicator was rated using a 4-point Likert scale ranging from 1 (emerging) to 4 (mastery), with a total maximum score of 16. The raw score was then converted into a percentage-based score to represent the learner's CT proficiency. The same test instrument was used during all SSR phases (A1, B, A2) to allow for comparability and to assess improvement over time.

Each SSR phase included multiple sessions:

a. Baseline 1 (A1): Pre-intervention phase with three assessments to establish stability of initial skills.
b. Intervention (B): Exposure to the algorithm-based learning media across seven sessions, each including instruction and a post-session CT assessment.
c. Baseline 2 (A2): Post-intervention phase with three assessments to confirm stability and retention of newly acquired skills.

Data were analyzed both visually and descriptively. Graphs were used to illustrate individual performance trends across phases. Increases in scores from A1 to B and sustained performance during

A2 were interpreted as evidence of a functional relationship between the intervention and CT improvement.

3. FINDINGS AND DISCUSSION

This section presents the outcomes of the Single Subject Research (SSR) design implemented to evaluate the effectiveness of algorithm-based programming learning media in developing computational thinking (CT) skills among children with Autism Spectrum Disorder (ASD). The analysis focused on three participants—KA, KZ, and SB—whose progress was tracked across three phases: Baseline 1 (A1), Intervention (B), and Baseline 2 (A2). Data were interpreted using visual analysis, including trend observation and level change, a commonly used method in SSR to examine individual patterns over time (Gast & Ledford, 2018). The consistency of pre- and post-intervention data was used to determine the functional relationship between the intervention and observed learning outcomes.

The first stage in the Design-Based Research (DBR) method is the analysis of practical problems. During this stage, a field study was conducted with students with Autism-Spectrum Disorder (ASD) at SD BPI Bandung, which involved assessing both basic and advanced cognitive skills. The results indicated deficiencies in skills such as conservation, analysis, correspondence, and seriation. Following this, interviews and observations with teachers were carried out to determine the most suitable materials and types of media for use. Based on these interviews and observations, it was concluded that programming algorithm material was appropriate, and that interactive learning media featuring engaging images would help maintain student interest and prevent boredom during lessons.

In the second stage, known as development design, a design is created for learning media related to algorithms and programming. This includes designing the content, flowcharts, and storyboards. The subsequent stage is development, which involves creating and testing the programming algorithm learning media. During this development phase, Unity software is used, along with additional applications such as Adobe Illustrator for creating the necessary assets. The process includes black box testing to ensure that the inputs and outputs meet expectations, followed by validation by media experts.

After the learning media is validated by media experts as feasible, the next step is the testing and refinement stage using an SSR experimental design. This stage consists of several phases: Baseline 1 (A1), Intervention (B), and Baseline 2 (A2). Initially, students undergo Baseline 1 (A1), which involves a pre-test to assess their initial computational thinking abilities. During Baseline 1 (A1), students are tested three times to ensure that their ability levels are stable. Next, the students proceed to the Intervention stage (B), where they engage with the programming algorithm learning media through materials and simulations conducted seven times. During this phase, data is collected from test results at each session. Finally, Baseline 2 (A2) involves a post-test administered three times to confirm the stability of the students' ability levels after the intervention.

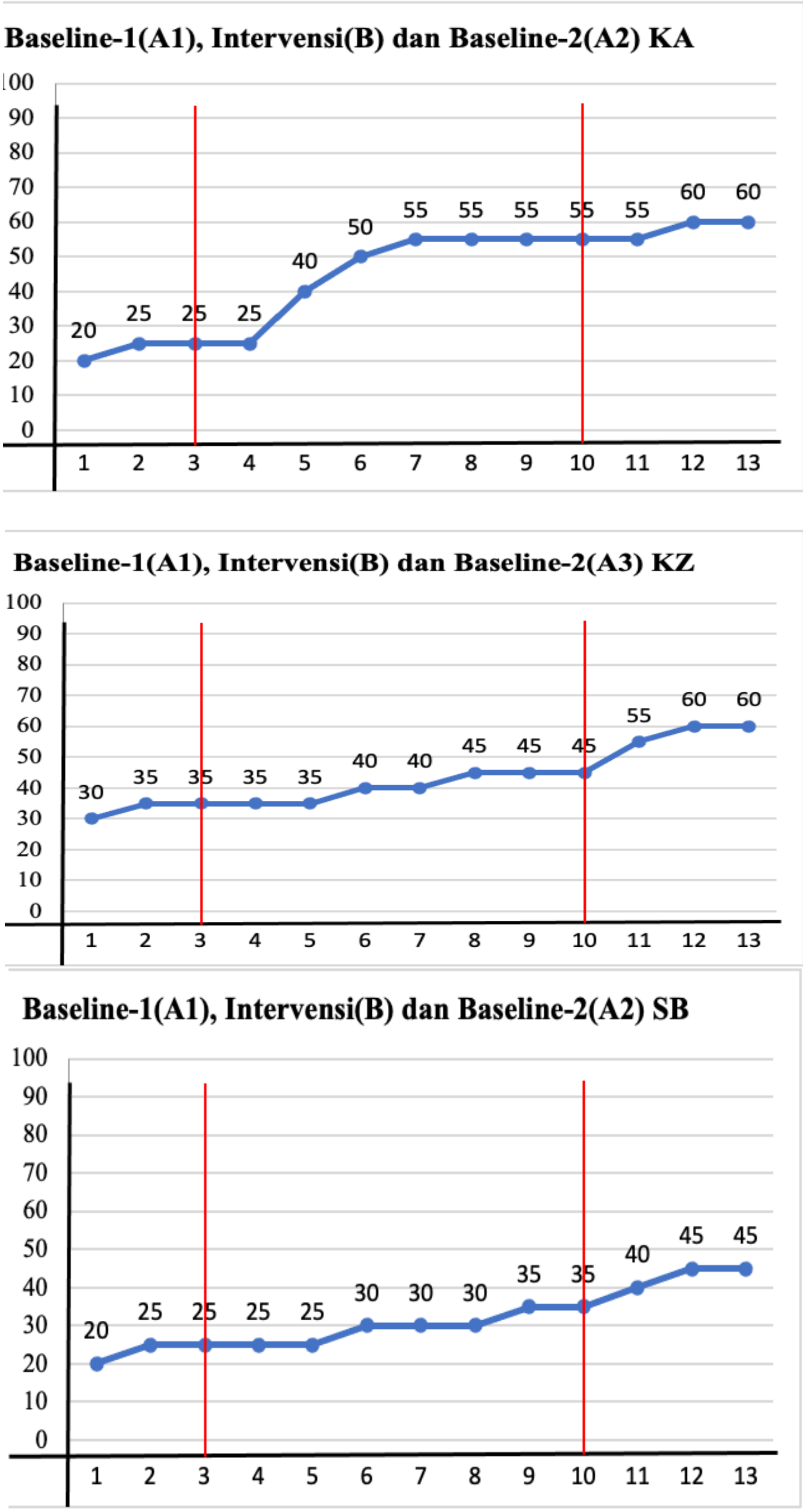

Figure 1. The results of Each Participant's Computational Thinking Abilities

3.1 Participant KA

KA began the study with a CT score of 4 (20%) in the first A1 session. Over three baseline sessions, his scores increased modestly, stabilizing at 5 (25%) in the second and third assessments. During the Intervention phase (B), a marked upward trend was observed: from 5 (25%) in the first session to 10

(50%) in the third session. Scores stabilized at 11 (55%) across sessions 4–7. In Baseline 2 (A2), scores increased slightly again to 12 (60%), with consistent performance across all three sessions.

The visual trend indicates a clear level change between A1 and B phases, with skills maintained or slightly improving in A2. This reflects KA's increasing ability to break down problems, apply algorithmic logic, and sequence steps—core components of CT. These improvements suggest that the learning media successfully engaged KA's cognitive strengths, particularly his visual learning preference.

This aligns with findings from Kim et al. (2024), who observed improvements in logical structuring and sequencing among students with ASD exposed to structured robot programming tasks. The structured, interactive format of the media likely supported KA's need for predictability and clear feedback, as suggested by Knight et al. (2019), who emphasized the role of visual scaffolding in supporting learners with ASD.

3.2 Participant KZ

KZ showed slightly higher initial performance, starting with a score of **6 (30%)** in A1-1, progressing to 7 (35%) in A1-2 and A1-3. During the Intervention phase (B), his scores remained at 7 for the first two sessions, increased to 8 (40%) in sessions 3–4, and plateaued at 9 (45%) from sessions 5–7. Notably, in the A2 phase, his scores jumped to 11 (55%) in session 1 and stabilized at 12 (60%) in sessions 2 and 3.

While the growth during the intervention phase was moderate, the post-intervention gains in A2 suggest a delayed learning effect. This pattern is consistent with the findings of Deng et al. (2020), who reported that children with ASD may require repeated exposure and post-instruction consolidation before demonstrating skill mastery.

KZ's trajectory reflects a gradual internalization of CT concepts, possibly due to his reliance on verbal reasoning and slower processing of abstract tasks. The delayed gains support the value of repetition and reinforcement, as emphasized by Grover and Pea (2013), in enabling learners with ASD to transition from surface-level understanding to application.

3.3 Participant SB

SB began with a CT score of 4 (20%) in A1-1 and progressed to 5 (25%) in A1-2 and A1-3. Her scores remained at 5 in the first two Intervention sessions, then increased to 6 (30%) in sessions 3–5 and 7 (35%) in sessions 6 and 7. In A2, her scores improved to 8 (40%) and finally stabilized at 9 (45%) in the final two sessions.

Although SB showed slower gains compared to KA and KZ, her steady progress indicates meaningful improvement. SB's learning profile, which required repetition and simplified instructions, may explain her slower progression. Nonetheless, the improvement from 20% to 45% reflects increased task familiarity and skill acquisition.

Similar patterns were reported by Wang (2022), who noted that algorithm-based learning tools with clear visual support improved task persistence and cognitive flexibility in children with ASD. SB's response reinforces the importance of personalizing instructional pacing, as learners with ASD often exhibit variability in how quickly they respond to technological interventions (Vidal-Hall et al., 2020).

3.4 Comparative Analysis

Across all three participants, there was a consistent pattern of growth in CT scores following the intervention phase, with score increases ranging from 20% to 35% over the course of the study. The A2 phase confirmed that these improvements were sustained over time, indicating not only skill acquisition but retention. Although the rate and magnitude of improvement varied, all learners demonstrated enhanced competencies in at least three CT components: sequencing, pattern recognition, and algorithmic reasoning.

This finding supports prior literature asserting that technology-based instructional tools can be effective for CT development in neurodiverse learners. For example, Hsu and Chen (2022) found that tangible programming tools paired with board games improved engagement and CT outcomes among children with special educational needs. Similarly, Israel et al. (2020) highlighted that the integration of multimedia in computer science education promoted greater participation and collaboration among students with ASD.

Importantly, this study's visual analysis approach enables a more nuanced interpretation than statistical significance alone. According to Ledford and Gast (2018), SSR allows for "practical significance" to be established through observable and stable behavior changes across phases. In this study, the level changes from A1 to B, and the stable trends in A2 provide evidence of a functional relationship between the intervention and observed learning outcomes.

3.5 Interpretation in Light of Pedagogical Design

The intervention's success can be partially attributed to the design principles grounded in the Design-Based Research (DBR) approach, which emphasized iterative refinement based on user needs. The media incorporated several Universal Design for Learning (UDL) principles, including multiple means of representation (visuals, animation), engagement (interactive challenges), and action/expression (hands-on sequencing tasks). This aligns with recommendations from Lodi and Martini (2021), who emphasize the importance of embedding CT within inclusive pedagogical frameworks.

The study also confirms the importance of structure, repetition, and feedback, which are considered best practices in teaching students with ASD (Munir et al., 2018). The algorithm-based design—featuring visual flowcharts, sequenced instruction, and simulation-based problem solving—enabled learners to scaffold their understanding and gradually progress from guided to independent tasks.

Moreover, the integration of visual narratives and minimal sensory distractions was intentional, based on prior findings that children with ASD often perform better in low-arousal, visually rich learning environments (Knight et al., 2019; Khoirunnisa et al., 2023). These design choices helped maintain attention and reduce cognitive overload, factors that are critical in promoting learning persistence in ASD populations.

3.6 Limitations and Future Directions

Despite its promising outcomes, this study has limitations that warrant consideration. First, the sample size was limited to three participants, which restricts the generalizability of the findings. While SSR offers in-depth insights into individual learning trajectories, broader studies with larger, more diverse samples are needed to confirm replicability.

Second, the absence of formal statistical effect size calculations is a limitation. Although visual analysis provides valuable interpretive data, future research could incorporate nonparametric effect size measures such as Percentage of Non-Overlapping Data (PND) or Tau-U, commonly used in SSR to strengthen validity (Parker et al., 2011).

Third, while the learning media proved effective for this group, its applicability to learners with higher or lower cognitive functioning, or different ASD profiles, remains to be tested. Adaptations may be necessary to accommodate learners with limited verbal ability or greater sensory sensitivities.

Finally, long-term outcomes were not assessed. Although skills were retained over the short term, future studies could include delayed post-tests or follow-up observations to examine whether improvements are sustained beyond the intervention period.

3.7 Implications for Practice

The findings of this study offer practical implications for educators, curriculum developers, and technology designers. First, it highlights the potential of algorithm-based programming media as a tool to teach CT to learners with ASD, particularly when such tools are adapted to learners' cognitive styles. Second, the study reinforces the importance of individualized instructional design, as participants showed varying rates of improvement. Finally, the integration of DBR and SSR offers a powerful framework for developing, testing, and refining inclusive educational interventions that are both evidence-based and responsive to learner needs.

This study provides preliminary evidence that algorithm-based programming media can enhance computational thinking skills in children with Autism Spectrum Disorder. While the effects varied across individuals, all participants demonstrated measurable growth and skill retention over time. The results affirm the value of structured, visually supported, and developmentally appropriate interventions in inclusive informatics instruction. Future work should build on these findings through expanded studies, long-term evaluation, and continued refinement of technology-enhanced learning environments for neurodiverse learners.

4. CONCLUSION

This study found that algorithm-based programming learning media, when designed with the cognitive and sensory needs of children with Autism Spectrum Disorder (ASD) in mind, can effectively enhance their computational thinking skills. All three participants demonstrated measurable improvements following the intervention, indicating the potential of structured, visually supported digital tools to support informatics learning in inclusive settings. However, the study is limited by its small sample size and reliance on single-subject analysis, which restricts the generalizability of the findings. Future research should involve larger and more diverse participant groups to explore the scalability of these results. Additionally, there is a need to investigate how such media can be integrated with differentiated teaching strategies and broader curricular goals to support sustained learning and engagement for children with varying ASD profiles. These efforts will contribute to the development of more inclusive, effective, and evidence-based practices in computational thinking education.

REFERENCES

Alsaade, F. W., & Alzahrani, M. S. (2022). [Retracted] Classification and detection of autism spectrum disorder based on deep learning algorithms. *Computational Intelligence and Neuroscience, 2022*(1), 8709145. https://onlinelibrary.wiley.com/doi/abs/10.1155/2022/8709145

Apandi, A. R, Munir, M., & Riza, L. S. (2024). Implementation of multimedia interactive learning through a STEM approach based on computational thinking to improve student learning outcomes. *Cendekia: Media Jurnal Ilmiah Pendidikan, 14*(4), 437–447. https://doi.org/10.31004/cendekia.v14i4.12345

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K–12. *ACM Inroads, 2*(1), 48–54. https://doi.org/10.1145/1929887.1929905

Bouck, E. C., Sands, P., Long, H., & Yadav, A. (2021). Preparing special education preservice teachers to teach computational thinking and computer science in mathematics. *Teacher Education and Special Education, 44*(3), 221–238. https://doi.org/10.1177/0888406420968056

Deng, W., Pi, Z., Lei, W., Zhou, Q., & Zhang, W. (2020). Pencil Code improves learners' computational thinking and computer learning attitude. *Computer Applications in Engineering Education, 28*(1), 90–104. https://doi.org/10.1002/cae.22188

Djurdjevic-Pahl, A., Pahl, C., Fronza, I., & El Ioini, N. (2017). A pathway into computational thinking in primary schools. In *2017 International Conference on Computer Supported Education* (pp. 165–175). https://doi.org/10.5220/0006379001650175

Elshahawy, M., Bakhaty, M., & Sharaf, N. (2020). Developing computational thinking for children with autism using a serious game. In *2020 24th International Conference Information Visualisation (IV)* (pp.

761–766). IEEE. https://doi.org/10.1109/IV51561.2020.00138

Fauziyah, N., Budayasa, I. K., & Juniati, D. (2022). Cognition processes of ASD students: Recommendations for mathematics teaching and learning process. *International Journal of Instruction, 15*(3), 805–830. https://doi.org/10.29333/iji.2022.15344a

Grover, S., & Pea, R. (2013). Computational thinking in K–12: A review of the state of the field. *Educational Researcher, 42*(1), 38–43. https://doi.org/10.3102/0013189X12463051

Hsu, T. C., Chang, S. C., & Hung, Y. T. (2018). How to learn and how to teach computational thinking: Suggestions based on a review of the literature. *Computers & Education, 126*, 296–310. https://doi.org/10.1016/j.compedu.2018.07.004

Hsu, T. C., & Chen, M. S. (2022). The engagement of students when learning to use a personal audio classifier to control robot cars in a computational thinking board game. *Research and Practice in Technology Enhanced Learning, 17*(1), 1–15. https://doi.org/10.1186/s41039-022-00195-y

Israel, M., Chung, M. Y., Wherfel, Q. M., & Shehab, S. (2020). A descriptive analysis of academic engagement and collaboration of students with autism during elementary computer science. *Computer Science Education, 30*(4), 444–468. https://doi.org/10.1080/08993408.2020.1759760

Kim, M., Kim, J. K., & Lee, W. (2024). Enhancing computational thinking in students with autism spectrum disorder and intellectual disabilities: A robot programming approach. *International Journal of Developmental Disabilities, 0*(0), 1–16. https://doi.org/10.1080/20473869.2024.2394735

Khoirunnisa, A. N., Munir, M., & Dewi, L. (2023). Design and prototype development of augmented reality in reading learning for autism. *Computers, 12*(3), 65. https://doi.org/10.3390/computers12030065

Khoirunnisa, A. N., Munir, M., Shahbodin, F., & Dewi, L. (2024). Augmented reality-based personalized learning in autism spectrum disorder reading skills. *Journal of Special Education Technology.* Advance online publication. https://doi.org/10.1177/01626434241234567

Knight, V. F., Wright, J., & DeFreese, A. (2019). Teaching robotics coding to a student with ASD and severe problem behavior. *Journal of Autism and Developmental Disorders, 49*(6), 2632–2636. https://doi.org/10.1007/s10803-019-03954-5

Lodi, M., & Martini, S. (2021). Computational thinking, between Papert and Wing. *Science & Education, 30*(4), 883–908. https://doi.org/10.1007/s11191-021-00201-4

Munir, M., Setiawan, W., Nugroho, E. P., Kusnendar, J., & Wibawa, A. P. (2018). The effectiveness of Multimedia in Education for Special Education (MESE) to improve reading ability and memorizing for children with intellectual disability. *International Journal of Emerging Technologies in Learning, 13*(8), 254–263. https://doi.org/10.3991/ijet.v13i08.8291

Muñoz, R., Morales, C., Villarroel, R., Quezada, A., & De Albuquerque, V. H. C. (2019). Developing a software that supports the improvement of the theory of mind in children with autism spectrum disorder. *IEEE Access, 7*, 7948–7956. https://doi.org/10.1109/ACCESS.2018.2889431

Muñoz, R., Villarroel, R., Barcelos, T. S., Riquelme, F., Quezada, A., & Bustos-Valenzuela, P. (2018). Developing computational thinking skills in adolescents with autism spectrum disorder through digital game programming. *IEEE Access, 6*, 63880–63889. https://doi.org/10.1109/ACCESS.2018.2876425

Rodríguez del Rey, Y. A., Cawanga Cambinda, I. N., Deco, C., Bender, C., Avello-Martínez, R., & Villalba-Condori, K. O. (2021). Developing computational thinking with a module of solved problems. *Computer Applications in Engineering Education, 29*(3), 506–516. https://doi.org/10.1002/cae.22389

Vella, L., Ring, H. A., Aitken, M. R., Watson, P. C., Presland, A., & Clare, I. C. H. (2018). Understanding self-reported difficulties in decision-making by people with autism spectrum disorders. *Autism, 22*(5), 549–559. https://doi.org/10.1177/1362361316687988

Vidal-Hall, C., Flewitt, R., & Wyse, D. (2020). Early childhood practitioner beliefs about digital media: Integrating technology into a child-centred classroom environment. *European Early Childhood Education Research Journal, 28*(2), 167–181. https://doi.org/10.1080/1350293X.2020.1724937

Wang, H. (2022). The application of interactive artificial intelligence in the intelligent integration of infants playing teaching aids. In *2022 International Conference on Applied Artificial Intelligence and Computing (ICAAIC)* (pp. 30–33). IEEE. https://doi.org/10.1109/ICAAIC53929.2022.9792789

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366*(1881), 3717–3725. https://doi.org/10.1098/rsta.2008.0118