

Algebraic Expression Activities Based on Algorithmic Thinking for Students with Learning Disabilities Who Experience Difficulties in Mathematics: A 7E Model Approach

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Abstract: This study aimed to design an unplugged instructional activity based on the algorithmic thinking dimension of CT and structured within the 7E learning model to support sixth-grade students with learning disabilities who experience difficulties in mathematics in learning algebraic expressions. The study employed a design and development research methodology involving analysis, design and pilot implementation phases. The activity was developed to help students structure algebraic reasoning through step-by-step processes, flowchart representation, and algorithmic sequencing. Observations made during the pilot study showed that, in addition to the intuitive and unsystematic problem-solving approach the student initially demonstrated, the student was able to use more structured algorithmic steps during the activity. It was observed that the student was able to list the steps of the process, assign appropriate values to variables, and represent the problem-solving process using flowcharts. It was also observed that the student noticed some errors in the problem-solving process and revised their incorrect solutions by applying the steps of algorithmic thinking. During the pilot implementation, the student was observed to apply algebraic expressions and the algorithmic structure used in the activity to new problem situations. These pilot observations provide preliminary indications regarding the feasibility of integrating algorithmic thinking with the 7E learning model to structure the problem-solving process within the context of the developed activity. The study contributes to the limited literature on CT-based instructional design for students with learning difficulties and offers a pedagogically grounded model adaptable to different mathematical topics and special education contexts.

Keywords: mathematics learning difficulties, computational thinking, algorithmic thinking, 7E learning model

1. Introduction

Computational Thinking (CT) is recognized as a key 21st-century skill that fosters systematic, creative, and solution-oriented thinking (Wing, 2014). Extending beyond computer science, CT is closely associated with mathematical reasoning and problem solving. Research shows that integrating CT into mathematics instruction enhances problem-solving performance (Hanid et al., 2022), supports decomposition and algorithmic reasoning (Csizmadia et al., 2015), and is significantly related to visuospatial skills, logical reasoning, and overall problem-solving ability (Román-González et al., 2019).

CT skills are considered as fundamental as reading, writing, and arithmetic (Wing, 2006), and developing these skills in K–12 education is essential for future-oriented problem solving (Wei et al., 2021). Ensuring equitable access to CT for students with disabilities is therefore critical. International frameworks emphasize equal educational opportunities for all learners (UNESCO, 2017). However, despite increasing CT integration in K–12 education, limited attention has been given to students with disabilities (Bouck & Yadav, 2022). Bouck and Yadav (2022) proposed practical strategies for integrating CT into mathematics instruction to address this gap.

Studies demonstrate that CT-based interventions benefit students with special needs. For example, serious game designs have supported problem-solving development in children with Autism Spectrum Disorder (Menna Elshahawy et al., 2020), while visual programming environments have been shown to reduce barriers for dyslexic programmers (Nadeem et al., 2021). Coding instruction has also improved independence and motivation in students with ASD (Sola Özgüç & Altın, 2022), and programming with robotic tools has enhanced CTS development among students with ASD and intellectual disabilities (Kim et al., 2024). Similarly, game-creation workshops have fostered CTS in adolescents with ASD (Munoz et al., 2018). A recent systematic review confirms that CT applications improve cognitive skills, participation, and autonomy among learners with difficulties (Veiga et al., 2025).

Nevertheless, a significant gap remains. While CT research is expanding, studies targeting specific learning disabilities—particularly dyscalculia—are scarce, and conceptual clarity and assessment approaches remain limited (Veiga et al., 2025; Kert et al., 2022). Addressing this gap requires instructional designs that integrate the algorithmic thinking dimension of CT into mathematical topics that dyscalculic students find challenging, such

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as algebraic expressions. The present study seeks to contribute to this need through the development of a structured instructional material.

1.1. The 7E Learning Model and CT Integration for Students with Dyscalculia

Traditional instruction often relies on repetition and rote strategies, which may further burden memory processes and limit conceptual understanding for students with dyscalculia. Computational Thinking (CT) offers an alternative by structuring problem-solving through step-by-step reasoning and abstraction (Grover & Pea, 2013; Wing, 2006). In particular, the algorithmic thinking dimension supports sequencing, planning, and strategy formation—areas in which dyscalculic students commonly experience difficulty.

In this study, computational thinking (CT) is approached as a higher-order thinking framework that structures the problem-solving process, while algorithmic thinking is considered one of the fundamental components of this framework. Decomposition, abstraction, generalization, and debugging are addressed as problem-solving processes used in interaction with algorithmic thinking within the CT process. The primary focus of the study is algorithmic thinking; within this scope, the student's ability to break down a problem into steps, sequence the steps of the problem-solving process, implement them, and represent them using a flowchart has been evaluated. The other CT processes have been treated as elements that complement the algorithmic thinking process at the relevant stages of the activity.

CT activities are expected to enhance cognitive awareness, support structured problem-solving strategies, and strengthen learning motivation. Unplugged activities are especially advantageous, as they emphasize thinking processes rather than technological tools, enabling the development of algorithmic reasoning without requiring programming knowledge (Brackmann et al., 2017). Thus, CT functions not merely as a technological integration tool but as a cognitive framework that makes problem-solving processes explicit, supports error recognition, and promotes stepwise progression.

Students with dyscalculia face persistent challenges in mathematical conceptualization and problem solving (Kucian & Von Aster, 2015). Addressing these difficulties requires instructional approaches that activate prior knowledge, provide cognitive scaffolding, and facilitate transfer. The 7E learning model developed by Eisenkraft (2003) offers a constructivist framework that structures these processes. As an expanded version of the 5E model (Bybee, 1997), the 7E model introduces the elicit and extend phases to strengthen prior knowledge activation and learning transfer (Eisenkraft, 2003). These refinements ensure that essential elements of learning are systematically addressed (see Figure 1).

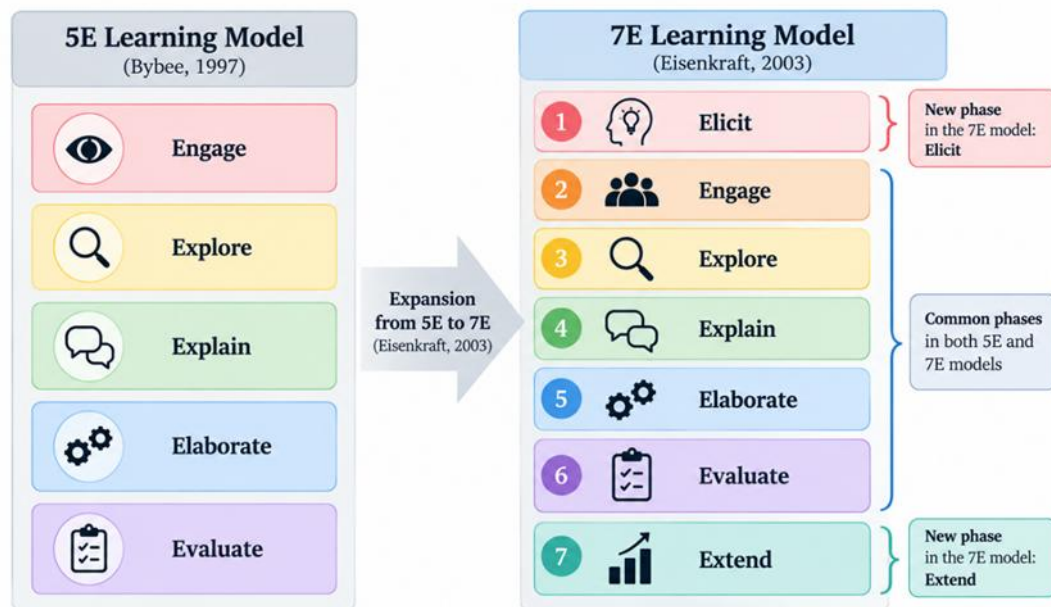


Figure 1. Stages of the 7E Learning Model

The integration of the phases of the 7E learning model for dyscalculic students into CT is explained below:

Elicit: This phase seeks to reveal students' prior understanding of the subject, their conceptual knowledge, and any misconceptions they may have. In dyscalculic students, this involves identifying whether they have prior knowledge or misconceptions regarding number concepts, the operation order, the names of geometric shapes, or the representation of mathematical symbols. The question 'What do you think?' at the beginning of the lesson involves analysing students' thought processes and understanding the problem, which is the first step in the

algorithmic thinking dimension of information processing thinking, and students are made aware that the problem can be broken down into steps for the algorithmic thinking process. At this phase, the aim is not to reach the correct answer or consensus, but to initiate discussion (Eisenkraft, 2003).

Engage: The purpose of the engage phase is to capture students' attention, stimulate motivation, and encourage predictive thinking (Eisenkraft, 2003). For students with dyscalculia, this phase may include gamified scenarios, concrete examples, and everyday contexts to sustain interest. Through these activities, students begin analyzing the problem situation, aligning with the problem-solving processes of computational thinking.

Explore: In this phase, students participate in guided discovery-based learning. Students with dyscalculia engage in unplugged activities requiring step-by-step problem solving, thereby supporting algorithmic thinking. Breaking problems into smaller parts reflects decomposition, while identifying relationships supports pattern recognition within CT. Students systematically analyze components, generate possible solutions, and represent their reasoning visually. The teacher facilitates this process by guiding inquiry, posing probing questions, suggesting strategies, and providing feedback to support understanding (Eisenkraft, 2003).

Explain: In this phase, the teacher evaluates the accuracy of students' conceptual understandings and supports concept development by introducing relevant models and theoretical frameworks (Eisenkraft, 2003). Students are encouraged to articulate their findings using appropriate scientific terminology, thereby refining their conceptual clarity. The algorithmic thinking dimension of CT is emphasized as students explain their solutions step by step, making their reasoning processes explicit. For students with dyscalculia, this phase supports the sequencing of operational steps and the establishment of cause-and-effect relationships within problem-solving processes.

Elaborate: This phase promotes the transfer of learning beyond the classroom context (Hilgard & Bower, 1975). Students apply acquired knowledge to new problem situations (Eisenkraft, 2003). For students with dyscalculia, this involves maintaining a consistent algorithmic structure across different algebraic tasks, thereby supporting the generalization and abstraction dimensions of CT.

Evaluate: Both process and product are assessed in this phase. Beyond obtaining correct results, students are expected to articulate their reasoning and solution strategies. The debugging dimension of CT is emphasized, as students reflect on their use of algorithmic steps, identify errors, and analyze their sources.

Extend: This phase involves the application and transfer of learning to broader contexts (Eisenkraft, 2003). Through algorithmic thinking, students use acquired knowledge across disciplines and in everyday situations. For students with dyscalculia, this transfer supports learning retention and the application of structured reasoning beyond the immediate instructional setting.

Eisenkraft's (2003) 7E model, particularly through its elicit and extend phases, offers a comprehensive learning cycle that is especially supportive for students with dyscalculia. Integrating computational thinking (CT) into this framework enhances students' ability to structure cognitive processes and approach mathematical concepts algorithmically. Within this model, algorithmic thinking is systematically embedded across phases to activate prior knowledge, support structured problem solving, foster conceptual clarification, and promote transfer to new contexts.

Although research on CT in mathematics education has increased, there remains a limited body of instructional materials specifically integrating algorithmic thinking within a constructivist framework for dyscalculic learners. This gap reflects a need for pedagogically grounded models that address both cognitive structuring and conceptual development. Accordingly, the present study aims to contribute to the literature by designing a CT-based instructional activity structured within the 7E learning model to support the learning of algebraic expressions among students with learning disabilities who experience difficulties in mathematics.

1.2. Aim of the Study

The aim of this study is to develop an unplugged teaching activity based on the algorithmic thinking sub-dimension of CT to support sixth-grade students diagnosed with learning disabilities who experience difficulties in mathematics in learning algebraic expressions. The developed activity was structured based on Eisenkraft's (2003) 7E learning model, and all phases of the model were integrated with the cognitive processes of algorithmic thinking. In this regard, the study aims to provide an example of instructional material design for information processing-based mathematics instruction for students with learning disabilities who experience difficulties in mathematics, for which there is limited literature, and to present a theoretical and pedagogical framework on how algorithmic thinking can structure learning processes in the topic of algebraic expressions. The study employed a design and development research methodology to create instructional materials and evaluate their pedagogical suitability.

2. Method

This study employed the design and development research method. The purpose of design and development research is to develop learning environments, generate theories for effective teaching, or create instructional designs (Collins et al., 2004). Design and development research has six components: (a) learners and how they learn, (b) the context in which learning and performance occur, (c) the nature of the content and how it is organised, (d) the teaching strategies and activities used, (e) the media and delivery systems used, and (f) the designers themselves and the processes they use (Richey & Klein, 2007).

The primary objective of design and development research is to develop a product, material, or instructional design tailored to a specific learning need, refine the developed prototype based on expert opinions and pilot studies, and ultimately produce the final product (Reigeluth & Frick, 1999; Şahin, 2023). This research method consists of a three-phase process of (1) analysis, (2) design, (3) development and evaluation, which enables the systematic development of teaching materials applicable in educational settings.

In the initial analysis phase, the difficulties encountered by students with learning disabilities who experience difficulties in mathematics in learning mathematics were examined; cognitive difficulties experienced in the areas of operation order, sequencing, understanding symbolic representations, and algebraic thinking were identified. These difficulties affect students not only at the arithmetic level but also in higher-order mathematical skills such as algebraic thinking. For this reason, priority has been given to developing teaching materials on algebraic expressions. Another reason for choosing the topic of algebraic expressions is that sixth-grade students will be encountering this topic for the first time. The aim is for students with learning disabilities who experience difficulties in mathematics to participate more positively in the process without being affected by negative learning experiences. The inclusion of algebra learning outcomes for the first time in the 6th grade (Ministry of National Education [MoNE], 2018) also supports this objective pedagogically. In this regard, the learning outcome "M.6.2.1.2, which states "calculates the value of an algebraic expression for different natural number values that the variable can take", has been selected as the focus of the activity. This learning outcome involves calculating the value of an algebraic expression for different natural number values assigned to the variable. Furthermore, the literature suggests that algorithmic thinking, as a component of computational thinking (CT), plays an important role in structuring students' problem-solving processes, sequencing solution steps, and following logical procedures (Grover & Pea, 2013; Wing, 2006). Based on this analysis, it has been concluded that the activity should be designed to enable step-by-step processing, the creation of flowcharts, and the visualisation of the problem-solving process.

In the second phase, the design phase, the first prototype of the activity was developed based on the 7E Learning Model. Eisenkraft's (2003) 7E model provides a framework that aligns with the algorithmic thinking process, as it supports the step-by-step construction of knowledge from a constructivist perspective. During the design process of the activity, a problem scenario was created that students could relate to in their daily lives. Algebraic expressions requiring the concept of variables are structured in a simple and understandable form. Solution areas are provided where students can perform step-by-step calculations. Guidance questions have been prepared for drawing flowcharts. Tasks that support debugging and generalisation skills have been added in line with the algorithmic thinking sub-dimension of CT. After the initial draft of the activity was created, the content was prepared for evaluation in terms of visual simplicity, clarity of instructions, and the needs of students with learning disabilities who experience difficulties in mathematics.

In the third phase, the development and evaluation phase, the activity was presented to two experts in mathematics education and special education who have conducted research on the 7E Learning Model. Experts were asked to provide their views on the cognitive appropriateness of the tasks, the clarity of the instructions, their adaptability for students with learning disabilities who experience difficulties in mathematics, the relationship between CT and algorithmic thinking, and their structural alignment with the 7E model. Based on the feedback received, the activity has been revised to include shorter instructions, spaces allowing the student to separate the steps of the process, and a guiding question to facilitate the drawing of the flowchart.

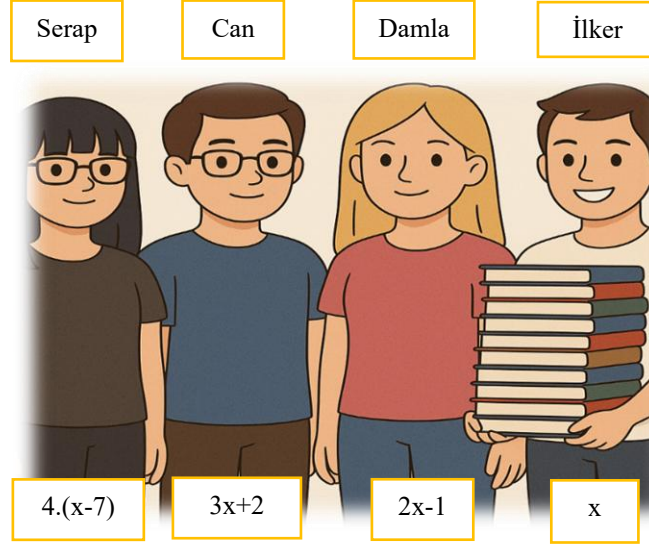
The revised activity was conducted individually with a 12-year-old seventh-grade male student diagnosed with learning difficulties in a state school's support education room as a pilot application. The student was selected following discussions with the head teacher, the school guidance counsellor and the mathematics teacher. The mathematics teacher has reported that the specified student is able to perform basic arithmetic operations, has no problems with reading skills, and that their family emphasizes the importance of education. As part of the pilot study, the student's problem-solving process was observed, their level of following the sequence of steps was recorded, their written answers and flowchart were examined, and their verbal thinking process was noted. The observations obtained during the pilot implementation provide preliminary indications regarding the feasibility of the activity and the student's use of step-by-step problem solving and flowchart representation within the activity. In light of these findings, the final version of the activity was developed and presented in the article. Voluntary consent has been obtained from students and parents for the pilot application

data used in this study. The activity was conducted as an individual exercise and no personal information was recorded in any way. The study was carried out in accordance with ethical principles.

As the unplugged activity developed in this study is aimed at supporting the learning of algebraic expressions among students with learning disabilities who experience difficulties in mathematics, this method was deemed appropriate for explaining the activity design process. The final version of the activity is provided below.

2.1. Activity

The number of novels Damla, Can and Serap read in a month is given in relation to the number of novels İlker read in a month.



It is known that İlker, one of these four friends, read 10 novels in a month.

Accordingly, who is the person who read the fewest novels and who is the person who read the most novels in a month?

What was your first step in solving this problem? Write down your steps for solving the problem.

Did you encounter any difficulties in the process of solving the problem?

Draw a flowchart explaining each step you took to solve this problem and explain why you thought that way. What did you pay attention to when preparing the flowchart?

Check the accuracy of your flowchart. If there is an error, how do you correct it?

2.2. Implementation of the Activity

This section presents the findings regarding the planning and implementation process of the pilot study conducted to assess the feasibility of the finalized activity design. The qualitative data were analyzed using descriptive analysis based on the phases of the 7E Learning Model and algorithmic thinking. The analysis categories were established prior to the study, based on the stages of the 7E learning model and the processes addressed within the scope of algorithmic thinking. The student's statements obtained from audio recordings, along with their written responses and flowchart, were examined together in accordance with these categories.

After learning about algebraic expressions in the school environment, students are planned to be involved in the process through an algorithmic thinking-based activity developed to reinforce this knowledge. It is deemed appropriate to implement the activity, designed to enhance the academic performance of students with learning difficulties in the classroom environment, reduce learning losses, and support both their academic and behavioural development, in the support education room. In these environments, students work at a slower pace of learning, with individualised goals and adapted teaching strategies, unlike in general classroom teaching; thus, their learning processes can be tailored to their cognitive capacities. The fact that support classrooms enable individual or small group-based teaching makes it pedagogically more appropriate for students with learning disabilities who experience difficulties in mathematics to carry out activities in an individualised manner. This approach is also consistent with Cohen's (1988) meta-analysis findings. The research, using a threshold of .80 as a measure of large effect size, revealed that single-subject instructional designs have a meaningful and powerful effect on the academic performance of children and adolescents with learning difficulties. In this context, individualised and structured teaching arrangements can be considered an effective tool in supporting the

progress of students with learning disabilities who experience difficulties in mathematics in their learning process.

As part of the activity, students are presented with a problem that incorporates the specified learning outcome. Students are expected to solve the problem step by step and explain the problem-solving process in detail. Additionally, they are required to create a flowchart that shows each step they take while solving the problem. Flowcharts are a concrete reflection of algorithmic thinking (MoNE, 2018). Because flowcharts enable the process of solving a problem to be expressed in a visual and orderly manner, broken down into steps. Flowcharts help students understand how an algorithm works and remember it for a long time (DoI, 2018). Thus, students gain the ability to both plan the steps of a solution and follow a logical solution path by putting these steps in order (Dumlu & Turanlı, 2024). In short, flowcharts are used as a tool in developing algorithmic thinking skills.

During the implementation, students' thought processes, the strategies and approaches they use, and their responses in the voice recording and activity sheet after the implementation can be evaluated. The implementation stages of the activity according to the 7E learning model are presented in Table 1.

Table 1. *Implementation Phases According to the 7E Learning Model*

7E Learning Model Phases and Objectives	Implementation Stages
Elicit (Elicit prior knowledge)	What is the first step you take when solving a problem? Can you provide examples of algebraic expressions? Have you heard of flowcharts in the Information Technologies and Software course? Can you create a flowchart?
Engage (Engage students' attention and encourage predictive thinking)	Students are presented with a scenario. Who do you think could have read the most and the least? Can we substitute 1 for x? What would the results be if we did? What would the results be if we substituted 2 for x?
Explore (Recognize and define the problem Execute the operations)	It is noticed that $x=10$. It is requested to determine the person who reads the least and most number of novels. The given expressions are written: $\text{İlker}=x$, $\text{Serap}=4(x-7)$, $\text{Damla}=2x-1$, $\text{Can}=3x+2$. The variable assignment operation is performed ($x=10$).
Explain (Ensure that students clearly and accurately learn the definitions, properties, relationships, and examples of concepts)	Students share their findings. The teacher explains the concept of variables and the algorithmic solution. After the teacher's explanation, students are asked to share their findings again using the concepts/terms. The plan for how to prepare the flowchart together is made.
Elaborate (Apply the learned algorithmic reasoning in another situation)	Examples from daily life are given: If an athlete runs x minutes every day, how much will they run in a week? If a baby sleeps a hours every day, how many hours will they sleep in a month?
Evaluate (Evaluate the process and the product)	Students write down the solution step by step, draw a flowchart, and indicate the step they find difficult.
Extend (Transfer learned knowledge to a new problem)	A new problem is solved: $\text{Enes} = x$, $\text{Berrin} = 3x - 12$, $\text{Deniz} = x + 4$, $\text{Demir} = 3x$. The calculation is performed for $x=8$.

2.3. Pilot Implementation

The pilot study was conducted with a male student in the 7th grade. It was determined through parent meetings that the student's family had a supportive attitude towards the educational process. The student's parents were informed about the study and approved their child's participation. The participant has been formally diagnosed with a learning disability by a specialist physician at a fully equipped hospital and registered with the Guidance and Research Center (Rehberlik ve Araştırma Merkezi [RAM]) under the learning disability category. Following the educational assessment conducted by the RAM, it was recommended that the student receive supplementary instruction in mathematics as part of a support education program. This recommendation was considered educational evidence that the student required additional support in mathematics. In addition, the opinions of the school administration, the school guidance counsellor, and the mathematics teacher were taken into account in evaluating the student's mathematics learning difficulties and selecting the participant. Based on the RAM educational assessment and the views of the school staff, the student was identified as experiencing difficulties in learning mathematics and was receiving mathematics instruction in the support education room. However, the participant had not received a separate formal diagnosis of dyscalculia. Therefore, throughout the

study, a distinction was maintained between the participant's formal diagnosis of a learning disability and the mathematics learning difficulties identified through the RAM educational assessment and school-based observations.

The study was conducted with a single participant in order to examine the participant's individual cognitive processes and interaction with the developed material in depth.

Although the activity was designed based on the learning objectives for algebraic expressions at the 6th-grade level, the pilot implementation was conducted with a 7th-grade student. Factors influencing the selection of this student included a diagnosis of a learning disability, a recommendation by the RAM for supplementary mathematics instruction, documented difficulties in learning mathematics, and current participation in mathematics instruction within a support education room. Furthermore, the aim of the pilot implementation was not to evaluate the activity's effectiveness for the target group, but rather to examine the feasibility of the developed activity, the clarity of the instructions, and the interaction between the student and the activity. Consequently, the student was deemed a suitable participant for the pilot implementation based on the assessments of the school administration, the guidance service, and the mathematics teacher.

The pilot programme was conducted within an individualised timeframe to ensure a focus on the student's cognitive processes; therefore, no time constraints were imposed on the student. The procedure took a total of 34 minutes. The data collection process was supported by two primary data sources: the activity log, in which the student drew a flowchart, and the audio recording. The audio recording was taken for the think-aloud protocol, which is recorded to reveal the strategies the student uses while explaining their problem-solving process, the difficulties they encounter, and their logical flow. These methods have enabled the collection of qualitative data regarding the applicability of the activity and the level at which the student utilises their algorithmic thinking skills. The pilot programme was conducted to assess the pedagogical suitability and feasibility of the developed activity and did not aim to evaluate its effectiveness.

To ensure the reliability of the analyses, a faculty member specializing in mathematics education listened to the audio recordings, reviewed the written transcripts of the recordings, and examined the analyses that were conducted. The researcher's and the faculty member's evaluations were compared; differences were discussed until a consensus was reached, and the final interpretations were reported in accordance with this consensus.

In line with the phases of the 7E learning model, the student's prior knowledge regarding the problem-solving process, their conceptual understanding of algebraic expressions, and their perceptions of algorithmic thinking were examined through a semi-structured interview conducted with audio recording. The findings from the interview are presented below:

2.3.1. Findings regarding the elicit phase

The data obtained indicate that the student intuitively managed the problem-solving process and experienced some conceptual uncertainties.

The student stated that when starting to solve a problem, they first focused on understanding the question; however, when they could not understand the question, they resorted to rereading and trying again rather than using a systematic strategy. They explained this situation as follows:

"First, I read the question and try to understand it. If I understand it, I try to solve the question based on what I have learned before. If I don't understand it, I read it again."

This statement indicates that the student possesses a fundamental awareness of the problem-solving process; however, this awareness has not yet been transformed into a structured problem-solving strategy.

Upon examining prior knowledge of algebraic expressions, it was observed that the student confused algebraic expressions with equations. When asked to give an example of an algebraic expression, the student used the expression ' $3x=30$ ', clearly demonstrating this confusion. Following the researcher's guidance, the student used the following expression:

"It can only be $5x$."

This excerpt demonstrates that the student is familiar with the concept of variables but is unable to clearly distinguish between algebraic expressions and equations.

When examining preconceptions about algorithmic thinking, it was observed that the student defined the algorithm through examples from daily life and perceived this process as a highly detailed structure. The student explained the algorithm with the following example:

"For example, if you say 'just take out the pan and crack the eggs' in a recipe for eggs with sausage, you're doing it wrong. You need to explain everything in detail from start to finish."

Based on this statement, it is understood that the student perceives algorithmic thinking as an overly detailed and cognitively demanding process; consequently, they express hesitation regarding its applicability in mathematical problems. Indeed, when asked whether algorithmic thinking is useful in solving mathematical problems, the student responded as follows:

"I have no idea, as I've never tried it before."

This finding indicates that the student does not display a negative attitude towards algorithmic thinking, but has not yet acquired the experience and cognitive schema necessary to understand how to apply this approach in a mathematical context.

2.3.2. Findings regarding the engage phase

The findings obtained in this phase indicate that student evaluated algebraic expressions based on their surface features before generating solutions and developed intuitive judgments based on coefficient size.

When asked to estimate the person who read the least and the most novels before solving the problem, the student directly associated the value of the variable with the information provided and used the following statement:

"İlker reads the least. X equals 10 because."

This statement indicates that the student has noticed the information given in the problem but still tends to compare without performing algebraic operations. Regarding their prediction about the person who reads the most novels, they made the following explanation based on the magnitude of the coefficient:

"Serap reads the most. The number in front of her is much higher than the others."

When the researcher drew attention to the expression ' -7 ' in brackets, the student responded as follows, thinking that this term would not significantly affect the result:

"O -7 doesn't change much."

This expression indicates that the student focuses solely on the coefficient and disregards the effect of the constant term, rather than evaluating algebraic expressions as a holistic structure.

During the engage phase, the student's way of thinking about the concept of variables was deepened through the question, 'Can different values be written in place of x ?' The student expressed that the variable could not take on a different value in the problem where the number of novels İlker read was given, stating:

"No, we can't write it down. Because it's known that İlker reads 10 novels in a month. So without knowing what İlker has read, I can't find any of the others."

This explanation demonstrates that the student has reasoned logically based on the given condition and has realised that the variable cannot be considered independently of the context. However, in a hypothetical situation where the number of novels İlker has read is not given, it has been stated that 1 could be written in place of x ; but in this case, the result would not be certain.

Upon the researcher's request to calculate the number of novels read by Damla and Serap under the assumption that $x=1$, the student stated that this value could not be valid, citing the negative result obtained as justification:

"4 minus 7 doesn't work. Because when you take 7 away from 4, you get -3 . You can't have -3 , can you? We can't write 1."

This finding indicates that the student can interpret mathematical results in a real-life context and recognises that negative values are inconsistent with the context. It can also be said that the student questions the values that the variable can take based on the problem context, and that this creates a cognitive dissonance, thereby increasing their readiness to learn.

2.3.3. Findings regarding the explore phase

During the explore phase, the student calculated the values of algebraic expressions using the variable value given in the problem; they structured the problem-solving process through written operations and verbal explanations. In this phase, students' processes of substituting values for variables, sequencing operational steps, and evaluating algebraic expressions were analyzed based on audio recordings and students' written work.

The student determined that the number of novels İlker read in a month was given as 10 in the problem and, relating this to the value of the variable, reached the result $x=10$. He expressed this situation with the following words:

"It is known that İlker, one of four friends, read 10 novels in a month. I also realized that x could be 10."

Following this conclusion, the student performed calculations by substituting the value 10 for the variable in all algebraic expressions. The student explained the process step by step and specifically noted that they correctly applied the coefficient-variable multiplication:

"If x is 10, I can write 10. For $2x - 1$, I multiplied 2 by 10, which gave me 20; I subtracted 1, which gave me 19. I did the same for the others."

The student's explanation demonstrates the use of step-by-step execution, one of the fundamental components of algorithmic thinking. However, upon examining the student's written problem-solving process, it was determined that the student incorrectly applied the distributive property in Serap's algebraic expression. It was observed that the student expressed the expression $4(x-7)$ as $4x-7$. This error indicates that the student failed to apply the distributive property correctly because they did not distribute the multiplication to both terms inside the parentheses. The student's written answer is presented in Figure 2.

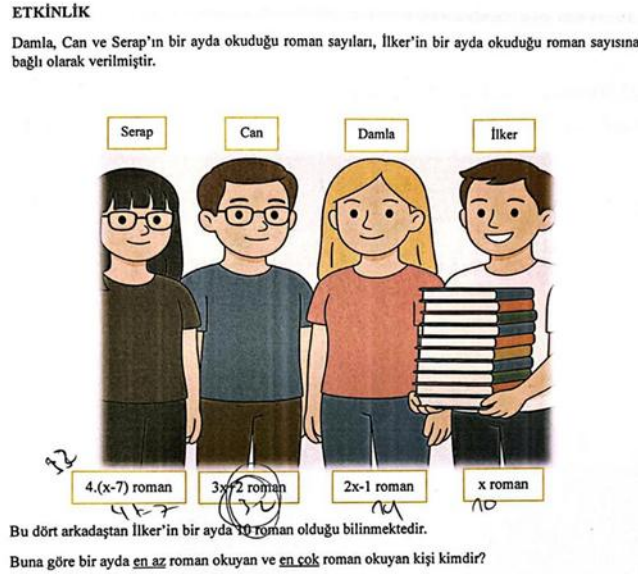


Figure 2. Student's Written Response

Upon examining Figure 2, it is evident that the student did not distribute the multiplication in the expression $4(x-7)$ to both terms inside the parentheses and, therefore, did not correctly apply the distributive property. This indicates a difficulty in correctly interpreting the structure of the algebraic expression. When the researcher asked how Serap calculated the number of novels she had read, the student realized their mistake and explained:

"I usually combine these, but I didn't subtract 7 from 10. I made a mistake here. So Serap read 12 books."

This explanation shows that the student has entered the debugging process and is able to question their own solution. After noticing their mistake, the student reevaluated the results and expressed the final comparison as follows:

"İlker reads the least of all, while Can reads the most. I made a terrible mistake."

This observation provides a preliminary indication of how error recognition and debugging may emerge during the Explore phase within the structured activity. The student's recognition of their mistake and subsequent restructuring of their solution aligns with the objectives of the exploration phase of the 7E learning model and the debugging dimension of algorithmic thinking.

2.3.4. Findings regarding the explain phase

During the explain phase, the student's problem-solving process was revisited with teacher guidance; fundamental concepts regarding the order of operations and evaluating algebraic expressions were reviewed. In this phase, the student was asked to explain the problem-solving process step by step in their own words, and their level of conceptual understanding was assessed through audio recordings and student explanations.

The student explained the problem-solving process in a structured and comprehensive manner. Upon examining the student's explanations, it was observed that they were able to organise the problem-solving

process into specific steps and express these steps consciously. The student summarised the problem-solving process as follows:

“The first step was to understand the question. Secondly, as I realised I couldn't solve the question without any values, I used the information provided here and found that x was 10. I wrote 10 in the places where I saw x . Then, using the value of x , I found the value of each one individually.”

It was observed that the student listed the steps of the process in their explanations and described the process of assigning values to variables in a specific order. However, since these statements emerged during the “Explain” phase, which involved teacher guidance, they were evaluated not as an indication of independent development in the student’s algorithmic thinking skills, but rather as an observation that the student was able to describe the solution steps in an algorithmic order with structured support.

The student also explained the order in which they performed the operations during the problem-solving process and provided their reasoning. In particular, their mention of first calculating Serap’s algebraic expression indicates that they prioritised intuition during the solution process:

“Since Serap caught my attention the most, I calculated her first.”

This statement shows that the student used both intuitive and logical thinking in the problem-solving process. After calculating all the expressions, the student explained that they reached the conclusion by comparing the values obtained and completed the solution process with the following words:

“I found the correct answer by comparing the values. Then the question ended.”

In this phase, the solution process was explained to the student step by step, and the order of operations was reinforced. The student was again asked to explain the solution. The student's written answer is presented in Figure 3.

Bu problemi çözerken ilk adımınız ne oldu? Problemin çözümü için işlemler

1) Sorunu anlamak
2) Her bir değer verildikten sonra bulduğum bilgileri kullanarak diğerleri buldum
3) İlk önce Serap'ın değerini buldum
4) Bu değerleri kullanarak diğerleri buldum

1) Understanding the problem

2) Since the value of x could not be determined without given information, I used the information indicating that İlker read 10 novels.

3) I substituted 10 for x in the algebraic expressions.

4) First, I calculated Serap's value, followed by İlker's and the others in sequence.

5) I compared these values to determine the correct result.

Figure 3. The Student's Steps in the Problem-Solving Process

The student explanations presented in Figure 3 show that, after the teacher explained the problem-solving process step by step and reinforced the sequence of operations, the student was able to verbally structure the problem-solving process and express the procedural steps in a logical sequence. For this reason, these behaviors were evaluated as behaviors exhibited by the student following teacher support rather than as independent performance. In this phase, the creation of a flowchart was also addressed within the framework of teacher–student interaction as a means of systematizing and visualizing the steps of the student’s problem-solving process and concretizing the algorithmic thinking process.

2.3.5. Findings regarding the elaborate phase

During the elaboration phase, the student's ability to transfer the knowledge gained about algebraic expressions and the algorithmically structured problem-solving process was examined. To this end, the student was presented with two different everyday life problems requiring algebraic thinking. The student's responses were analysed through audio recordings and written products.

In the first problem, the question asked was, ‘If an athlete runs for x minutes every day, how much will they run in a week?’ The student generalised correctly using the concept of variables and expressed their solution as follows:

"One day he ran x , in seven days he runs $7x$. He runs for $7x$ minutes."

This statement demonstrates that the student has used the skill of generalisation, one of the fundamental components of algebraic thinking, and has been able to transfer the quantity represented by the variable to different time intervals. The student has assigned a value to the variable in order to concretise their solution and has made the following additional explanation:

"In fact, if they run for 30 minutes a day, they run for 210 minutes a week."

This explanation demonstrates that the student has grasped the meaning of the algebraic expression and can relate the symbolic representation to numerical values.

In the second problem, the question 'If a baby sleeps a hours every day, how many hours does it sleep in a month?' was posed. The student attempted to understand the problem by repeating the question and produced a solution by considering the unit of time. In this process, it was observed that the student treated the concept of a month as 30 days and generalised using multiplication. The student expressed their solution as follows:

"If you sleep a hours a day... a month has 30 days. Multiply by 30, it becomes $30a$."

This finding demonstrates that the student can transfer quantities expressed by variables to different contexts and relate algebraic expressions to real-life situations. The student's written response is presented in Figure 4.

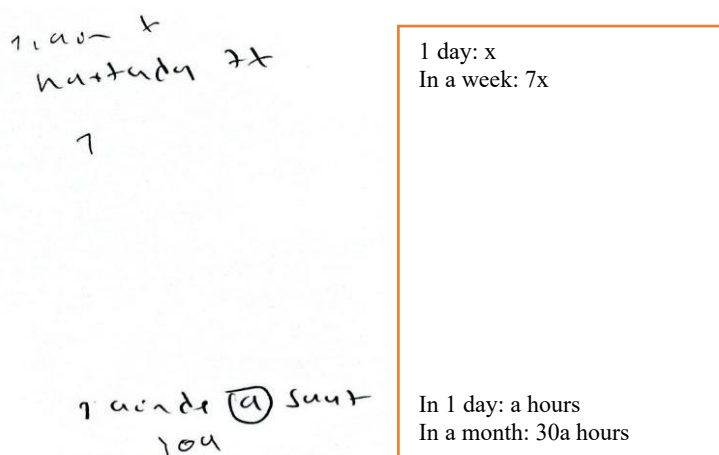


Figure 4. The Student's Written Responses to the Elaborate Phase

The student responses presented in Figure 4 demonstrate that the student's algebraic thinking process is not limited to the given problem; rather, they are able to adapt the algorithmic solution logic they have learned to new problem situations.

The findings obtained during the elaborate phase indicate that the student's ability to generalise and transfer algorithmic thinking processes has been supported, and that their level of proficiency in using algebraic expressions in different contexts has improved. This situation aligns with the objectives of the elaborate phase of the 7E learning model and the abstraction and generalisation dimensions of algorithmic thinking.

2.3.6. Findings regarding the evaluation phase

During the evaluate phase, the student's problem-solving process was examined in terms of structuring, visualising algorithmic thinking steps, and questioning their own solution. Within this scope, the student was asked to create a flowchart representing the problem-solving process; the student's process of creating the flowchart, the geometric shapes they used, and their method of evaluating the solution were analysed through audio recordings and student products.

Before starting to draw the flowchart, the student was asked about their knowledge of the geometric shapes used in flowcharts. The student stated that they knew the visual representations of some shapes but could not remember their names, explaining this situation as follows:

"I know what they look like in my mind, but I don't know their names."

The student attempted to draw the shapes they remembered; it was observed that during the drawing process, they could not clearly state the names of the shapes and used representations that were not formally correct. With the researcher's guidance, they discussed the deltoid and parallelogram shapes; the student indicated that they had hesitated in recognising the shapes but had remembered them with visual cues. This situation shows that the

student focused more on functional use than conceptual knowledge in drawing the flowchart. The student's written answer is presented in Figure 5.

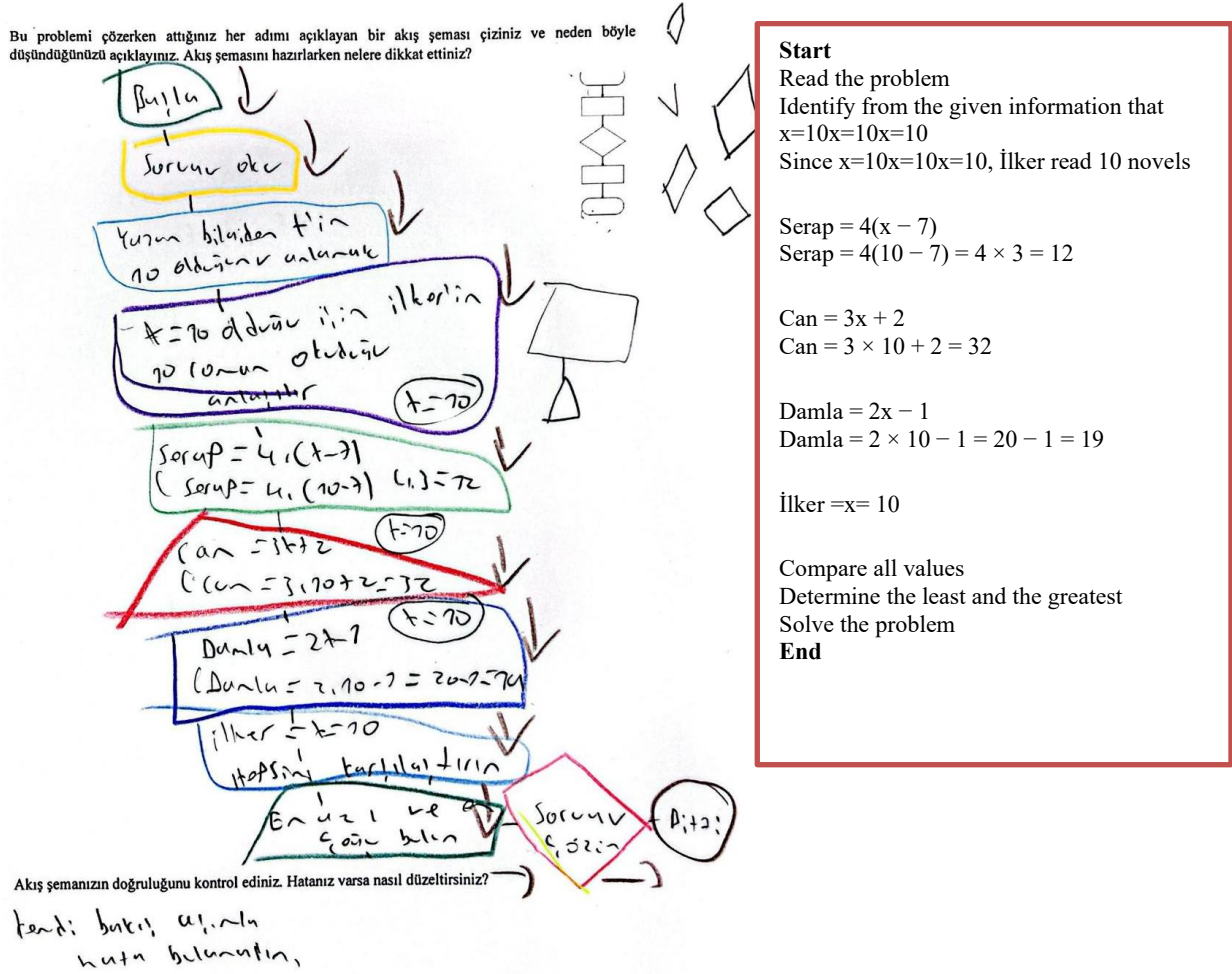


Figure 5. Flowchart Created by the Student

Before starting to create the flowchart presented in Figure 5, the student emphasised that the drawing must be understandable not only to themselves but also to others, and stated that they planned the problem-solving process as follows:

"Someone else needs to understand this; it won't do if we write something only we can understand. Let's write the instructions first."

This statement indicates that the student views the problem-solving process not merely as an individual activity, but as a communicative and shareable process. After completing the written instructions, the student began drawing geometric shapes, predominantly favouring rectangles. However, they also sought to use different shapes such as triangles, parallelograms, deltoids, and circles. It was observed that the formal accuracy of the geometric shapes in the drawings was not fully achieved; the corners were not clear and some shapes were left open (Figure 5).

After completing the flowchart, the student was asked to compare their writing with the problem-solving process. In their initial assessment, the student stated that they did not notice any errors in their solution and gave the following response:

"I couldn't find any fault with it from my own perspective."

This situation indicates that the student has limited awareness of evaluating the problem-solving process. However, when asked whether they struggled with the problem-solving process under the researcher's guidance, the student admitted to making a mistake and clearly stated the source of the error. The student's written response is presented in Figure 6.

Problemi çözme sürecinde zorlandınız mı?

7 İtuta uşftın, ama zorlanmadım,
hata = ille önceliğine dikkat etmemek.

"I made a mistake, but I didn't struggle. My mistake was not paying attention to the order of operations."

Figure 6. The Student's Evaluation of the Problem-solving Process

Upon examining the student's explanation presented in Figure 6, it is evident that the student was unable to independently identify the error in their solution during the initial assessment; however, following the researcher's guiding questions, the student recognized the error and attributed its source to not paying attention to the order of operations. Therefore, this finding was interpreted not as an independent development in the student's metacognitive awareness, but rather as a behavior demonstrating that, following the researcher's guidance, the student was able to reflect on the problem-solving process and articulate the source of the error.

Findings related to the evaluate phase indicate that the student can visualise the problem-solving process through a flowchart; however, they require support in the conceptual naming and formal accuracy of geometric shapes. The fact that the student can question the problem-solving process and identify the source of the error following researcher-guided instruction demonstrates that debugging behaviors can emerge under structured support during the evaluation phase.

2.3.7. Findings Regarding the 'Extend' Phase

In the extend phase, the student's ability to transfer the problem-solving process they have constructed based on algebraic expressions and algorithmic thinking to a new problem situation was examined. To this end, a new problem requiring the use of the learned knowledge in a different context, as shown in Table 1, was presented to the student, and the student's problem-solving process was analysed through audio recordings and written products.

In this study, the Elaborate and Extend phases have been structured to serve different purposes. The Elaborate phase aims to help students deepen their existing understanding by applying algebraic expressions to various real-life examples. In the Extend phase, the goal is for students to transfer the algorithmic solution structure they used in previous phases to a new problem situation involving different variables, algebraic expressions, and numerical values. Therefore, the Elaborate phase focuses on making sense of and deepening the learned structure through different examples, while the Extend phase focuses on transferring this structure to a new problem situation.

The student calculated the values of the algebraic expressions using the variable value given in the new problem and determined the results obtained for each person step by step. During the problem-solving process, it was observed that the student performed the calculations using their fingers and expressed the results verbally. The student's calculations proceeded as follows:

"Berrin: 8 times 3 is 24 pages, subtract 12 from 24 and you get 12. Deniz: Eight plus four is twelve. Demir: If it's 3x, then 3 times eight is 24."

These statements demonstrate that the student correctly applied the operations of assigning values to variables, multiplication and subtraction, and systematically carried out the problem-solving process. After calculating all the values, the student re-examined what the problem was asking and clarified the solution objective:

"Right, now what is the question asking for; the least or the most?"

Upon the researcher confirming the purpose of the question, the student reached a conclusion by comparing the results obtained and provided the following answer:

$x=8$
 $3,8=24-12=12$
 $8+4=12$
 $3,8=24$
 Enes $1x-12$ $1x$
 Berin $1+4$ $1x$
 Deniz $1x$
 Demir $1x$
 Enes $8x+1$
 Berin 12
 Deniz 12
 Demir 24
 En 12 $6-1$
 En 12 12

"Enes reads the least, Demir reads the most."

Figure 7. The Student's Written Response in the Extend Phase

An analysis of the student's responses presented in Figure 7 reveals that the student continued to use the algorithmic structure employed in the previous activity when faced with the new problem. The student performed a significant portion of the steps independently; when the student re-examined what the problem required, the student reached a solution by comparing the results obtained after receiving confirmation from the researcher. Therefore, the observed behaviors were interpreted not as evidence of independent development in the student's transfer and generalization skills, but rather as observations indicating that the student was able to apply the previously used algorithmic structure to a new problem situation with limited researcher support.

The student behaviors observed during the pilot study provided findings regarding the applicability of the activity—designed on the basis of algorithmic thinking—in the process of teaching algebraic expressions. It was observed that the student was able to carry out the solution steps independently at some stages, while at other stages, the student required guidance from the researcher/teacher. These findings were treated not as evidence of the activity's effectiveness, but as pilot observations aimed at evaluating the activity's feasibility and student-activity interaction.

3. Discussion and Conclusion

In this study, an unplugged activity based on the algorithmic thinking sub-dimension of CT skills was designed to contribute to the learning of sixth-grade students diagnosed with learning disabilities who experience difficulties in mathematics in the subject of algebraic expressions. The activity is structured according to Eisenkraft's (2003) 7E learning model, and all phases are integrated with the content of algorithmic thinking. The study is a design and development research focusing on instructional material design rather than evaluating instructional effectiveness. In this respect, the study offers a theoretical perspective on how a cognitive processing-based teaching approach focused on the learning dynamics of students with learning disabilities who experience difficulties in mathematics can be structured. A review of the literature reveals that there are a limited number of studies associated with students with special needs that include the sub-dimensions of CTS (Bouck and Yadav, 2022). This indicates a gap at the intersection of special education and mathematics education. The activity designed in this study serves as an example aimed at filling this gap. Furthermore, the view that unplugged activities can be an effective tool for concretising students' algorithmic thinking skills forms one of the theoretical foundations of this design (Brackmann et al., 2017). Preliminary observations provide limited findings regarding the feasibility of this instructional design for the use of CT in the contexts of mathematics and special education. In this regard, the study presents a unique interdisciplinary example rarely seen in the literature in terms of instructional design. The adaptability of similar activity designs to other types of learning difficulties, such as dyslexia and dysgraphia, could also be investigated.

Preliminary observations suggest that the developed activity could serve as a practical resource for teaching mathematics to students with learning disabilities who experience difficulties in mathematics and for incorporating algorithmic thinking into the instructional process. It is recommended that CT-based activities adapted to different mathematical topics (e.g., fractions, ratios and proportions, geometric thinking) be developed. There appears to be limited research on mathematical activities and materials incorporating different dimensions of CT for students with dyscalculia. It is recommended that such studies be conducted to address this deficiency. Considering the constructivist nature of the 7E model, the integration of sample materials that include the dimensions of CTS into teaching programmes should be supported. Materials designed for students

with learning disabilities who experience difficulties in mathematics should be simple, visually supported, and structured in a step-by-step manner to facilitate their engagement in the learning process. Such materials may contribute to students' problem-solving processes. In a study conducted by Mastropieri et al. (2005), the chemistry lessons of two different tenth-grade classes, including students with disabilities, were compared. The findings showed that students in the class where science materials were used in the teaching process demonstrated significantly higher academic performance than their peers in the class where only traditional teaching approaches were applied. This result indicates that constructivist teaching processes supported by concrete materials have positive effects on learning outcomes even in heterogeneous student groups.

The activity was designed in alignment with the algebraic expressions learning outcomes of the MoNE (2018) Mathematics Curriculum and was refined based on expert opinions. These revisions were made to enhance the cognitive and pedagogical appropriateness of the activity. Although the study includes qualitative empirical data obtained from the pilot implementation, no empirical evidence regarding the instructional effectiveness of the activity developed can be presented, as the pilot implementation was conducted with only one student and was not designed to evaluate its effectiveness. This is considered one of the study's main limitations. Another limitation of the study is that, although the activity was designed for 6th-grade students, the pilot implementation was conducted with a 7th-grade student. While the aim of the pilot implementation was to examine feasibility and student-activity interaction rather than to evaluate the activity's effectiveness, this discrepancy between the participant's grade level and the activity's target grade level should be taken into account. Therefore, observations derived from the pilot implementation should not be considered direct evidence regarding the activity's suitability or effectiveness for 6th-grade students. Future studies should implement the activity with the intended target group—6th-grade students—and examine its suitability with larger participant groups.

Kert et al. (2022) found in their research that students diagnosed with learning difficulties experienced difficulties in situations such as sequencing, planning procedural steps and understanding symbolic representations. In this context, integrating the phases of the 7E model with algorithmic thinking offers a possible framework for structuring the instructional process. In particular, the elicit and explore phases of the model are designed to provide opportunities for students with learning disabilities who experience difficulties in mathematics to use their existing cognitive schemas and gradually arrive at the solution to the problem. It is anticipated that the difficulties experienced by students with learning disabilities who experience difficulties in mathematics when learning algebraic expressions may be addressed through strategies such as step-by-step thinking, determining the order of operations, and visualising problem-solving processes. From this perspective, the use of CT activities to structure problem-solving processes is consistent with the theoretical framework described by Grover and Pea (2013).

Kert et al. (2022) found that developing CTS in students with special needs increases their motivation to learn. In the pilot study, it was observed that the flowchart made the student's solution steps visible and allowed the student to evaluate their mistake following the researcher's guidance. The pilot implementation provides a preliminary example of how the activity may be used as an individualized instructional approach for students with learning disabilities who experience difficulties in mathematics. In this context, the constructivist nature of the 7E learning model focuses the learning process not only on knowledge transfer but also on cognitive awareness and strategy development processes. Görecek Baybars and Küçüközer (2018) used the 7E learning model in their research and determined that the activities included in the 7E learning model were effective in terms of conceptual understanding. Researchers conducting studies on teacher candidates have found that teacher candidates possess greater scientific understanding after instruction using the 7E learning model. Although learning difficulties were not specifically addressed in this study, it demonstrated the positive effect of 7E for groups experiencing conceptual difficulties.

As a result, the observations obtained from the single-participant pilot study indicate that an activity integrating the 7E model with algorithmic thinking could be a viable instructional design for teaching algebraic expressions. These observations should not be interpreted as evidence of the activity's effectiveness and should not be generalized to larger groups of students. Future studies involving longer-term implementations could examine the retention and transfer of algorithmic thinking skills.

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