Journal for the Child Development, Exceptionality and Education, 5(1), 59-67, June 2024 e-ISSN: 2757-7554
jcdee.com

Genc Bilge Publishing Ltd.
(Young Wise) © 2024
gencbilgeyayincilik.com

Review Article

Pattern skills and computational thinking in early childhood education

Rumeysa Beyazhancer [1] and Baris Demir[2]*

Kocaeli University, Faculty of Education, Mathematic Education Department, Kocaeli, Turkiye

Article Info

Received: 14 April 2024
Accepted: 28 June 2024
Online: 30 June 2024

Keywords
Computational Thinking (CT)
Early Childhood Education
Pattern skills

Abstract

This article examines the relationship between pattern skills and Computational Thinking (CT) in early childhood education, emphasizing their significance. Pattern skills enable children to recognize repetitive sequences and structures in their environment, laying the foundation for mathematical thinking. Computational Thinking, a strategic approach to problem-solving, consists of four core components: decomposition, pattern recognition, abstraction, and algorithm development. CT supports problem-solving and cognitive flexibility in early childhood. The article highlights the role of digital games and unplugged (non-digital) activities in developing these skills. Tools like ScratchJr enhance children's algorithmic thinking, while physical activities with tangible materials strengthen pattern recognition skills. In conclusion, developing pattern skills and CT together improves children's analytical thinking, problem-solving, and logical reasoning abilities.

To cite this article

Beyazhancer, R., & Demir, B. (2024 Pattern skills and computational thinking in early childhood education. *Journal for the Child Development, Exceptionality and Education, 5*(1), 59-67. DOI: https://doi.org/10.5281/zenodo.13893235

Introduction

The preschool period is a critical phase for children's cognitive, social, and linguistic development. Skills acquired during this time have a significant impact on children's future academic success. Pattern skills, in particular, allow children to recognize repetitive sequences and regularities in their surroundings and develop reasoning abilities based on these sequences. This skill is a cognitive process that forms the foundation for not only mathematical and linguistic development but also problem-solving abilities (Clements & Sarama, 2007; Papadakis et al., 2016).

Pattern recognition is an important component of mathematical thinking and supports the development of advanced mathematical thinking skills in preschool children. Clements and Sarama (2007) found that the ability to recognize and create patterns plays a fundamental role in helping children learn more complex mathematical concepts they will encounter in the future. For example, early mathematical skills such as number sequences, geometric shapes, and rhythmic counting are closely related to the development of pattern skills (Clements & Sarama, 2007).

In recent years, the concept of Computational Thinking (CT) has also gained importance in this process. Wing (2006) defines CT as a thinking skill that integrates problem-solving processes used in computer science into education. The four main components of CT—decomposition, pattern recognition, abstraction, and algorithm development—are particularly closely related to pattern skills in early childhood (Bers, 2018; Wing, 2006). CT skills help children gain cognitive flexibility in their analytical thinking, logical reasoning, and problem-solving processes (Papadakis et al., 2016).

[1] Dr., Math Teacher, Bursa Uludağ University, Faculty of Education, Mathematics Education Department, Bursa, Turkiye. E-mail: rumeysahan@hotmail.com ORCID: 0000-0001-5061-8835

[2] Corresponding Author: Dr., Lecturer, Kocaeli University, Faculty of Education, Mathematics Education Department, Kocaeli, Turkiye. E-mail: baris.demir@kocaeli.edu.tr ORCID: 0000-0001-6997-6413

Research shows that pattern skills and CT can be strengthened in early childhood through digital games, physical materials, and everyday activities (Bers et al., 2014). For example, programming tools such as ScratchJr support children's algorithmic thinking and pattern recognition skills, contributing to both cognitive and creative thinking processes (Bers et al., 2014; Papadakis et al., 2016).

In this study, two closely related and mutually supportive cognitive skills, CT and pattern skills, will be introduced in the context of early childhood education, and strategies and approaches for their development will be discussed.

Definition and importance of pattern skills

Pattern skills are defined as the ability to notice repetitive structures and regularities in the environment, as well as to identify and make sense of similarities in objects and ideas. This skill plays a significant role in children's cognitive development and intensifies particularly during early childhood. The development of pattern recognition skills in preschool helps children understand mathematical concepts. This skill facilitates the comprehension of fundamental mathematical concepts such as number sequences, shapes, and geometric relationships. During early childhood, children perceive the regularities in their environment, which helps improve their problem-solving and mathematical thinking skills (Clements & Sarama, 2007).

Pattern recognition skills not only form the basis of mathematical thinking but are also strongly related to language development. Rittle-Johnson et al. (2019) state that pattern recognition plays an important role in learning linguistic patterns. Repetitive language structures, such as rhymes, songs, and rhythmic games, are particularly effective in the language learning process. Through these types of structures, children internalize grammatical rules and develop greater linguistic awareness, which in turn helps expand their vocabulary and improve their understanding of grammar (Rittle-Johnson, Zippert, & Boice, 2019; Papadakis et al., 2016). Additionally, pattern recognition is not only limited to cognitive and language development but also contributes to social-emotional growth. Sarama and Clements (2009) note that pattern recognition activities enhance problem-solving and teamwork skills in children. Pattern-making activities encourage collaborative learning, thereby contributing to the development of social skills and supporting children's self-regulation abilities.

In summary, pattern recognition is a fundamental cognitive process acquired during early childhood, supporting both mathematical and linguistic development. According to Papadakis et al. (2016), educational materials provided to children should enable them to identify patterns in order to foster the development of these skills. For example, digital tools and games allow children to experience patterns in a more concrete way, thereby strengthening their cognitive processes. Children’s understanding of patterns follows a developmental trajectory. Table 1 shows the developmental stages of pattern skills (adapted from Sarama & Clements, 2009, as cited in Gök Çolak, 2020).

Table 1. Developmental Stages of Pattern Skills (Sarama & Clements, 2009; adapted from Gök Çolak, 2020)

Age Range	Developmental Progress	Associated Pattern Skills
Around 2 years	Pre-patterning	Indirectly discovers patterns but does not recognize them as such.
3 years	Pattern Identifier	Verbally describes and identifies simple patterns.
4 years	Pattern Repairer/Extender	Completes or extends missing elements in a pattern.
5 years	Pattern Extender	Continues simple repeating patterns.
6 years	Pattern Unit Identifier	Identifies the smallest repeating unit and articulates the pattern rule.
7 years	Number Pattern Identifier	Transforms patterns displayed in different forms into numerical patterns.

Types of Patterns

When the literature is examined, it is seen that there are pattern types such as repetitive patterns, expanding patterns, number-shape patterns, linear patterns (Warren & Cooper, 2006, Blanton & Kaput, 2004, Palabıyık & Akkuş İspir, 2011). Jackman (2005) stated that for preschool children, stringing beads and placing nails according to a special pattern such as blue, red, green and yellow is an example of a visual pattern, and repeating or saying sounds (such as soft, loud, soft, loud, soft) over and over again and then having children repeat this sequence is an example of a verbal pattern. The teacher reading the template using simple words: circle, square, circle, square, circle, square, circle, square or a,b,a,b,a,b,a,b. In parallel with this information, Copley (2002) includes repeating the features of the pattern such as number, color, object, shape and movement in the same order. For this purpose, he stated that activities such as recognizing, defining and extending the pattern according to the rule can be done with children (Kesicioğlu, 2013).

While some researchers divide patterns into two groups as recurrent and changing (Olkun & Toluk-Uçar, 2014: 94), some publications divide them into three groups as recurrent, expanding and relational (Sperry-Smith, 2012). While there is a literature (Sperry-Smith, 2012) that defines repetitive patterns as a single group, there is also a literature that divides them into three as linear, cyclical and hopscotch patterns (Papic, 2007). Changing patterns are defined as a single type of pattern that increases or decreases depending on a certain rule (Olkun & Toluk-Uçar, 2014: 94), as well as studies that divide them into two as increasing and decreasing (Mulligan & Mitchelmore, 2009). In relational patterns, there is a relational regularity. As a result, when the literature was examined, it was seen that there are different definitions of pattern types and that pattern types contain some differences, even if they are inclusive of each other (Gök Çolak, 2020). Examples of some of the pattern types are presented below.

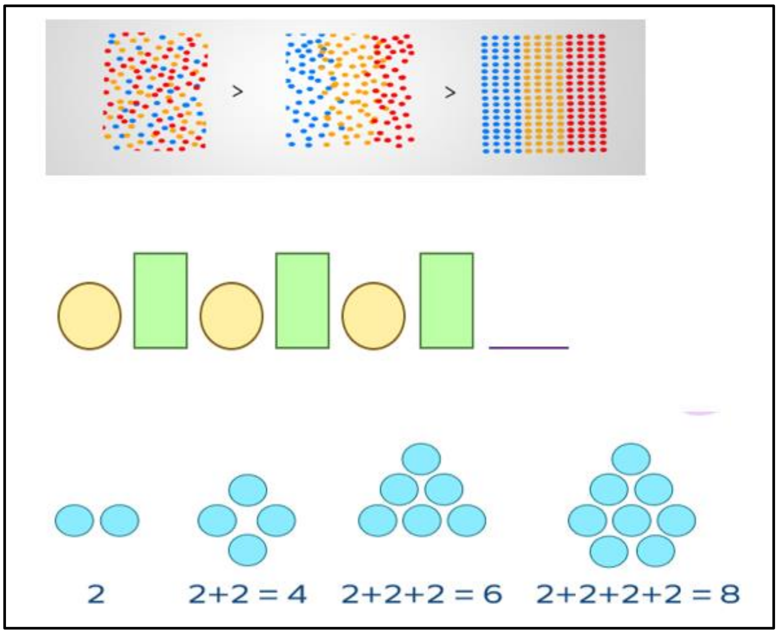

Figure 1. Some examples of pattern types

Computational Thinking

Computational Thinking (CT) is a way of thinking that utilizes problem-solving processes from computer science to develop individuals' ability to break down and solve complex problems. CT is not limited to computer science; it can also be applied to everyday life and across various disciplines. Wing (2006) defined CT as a fundamental approach aimed at enhancing individuals' capacity to think systematically and solve problems. This model consists of four core components that can be applied in different disciplines:

Decomposition: The process of breaking down a complex problem into smaller, more manageable parts. This step helps improve understanding of the problem and facilitates finding a solution. Shute et al. (2017) highlighted that the ability to break down problems is particularly effective in developing problem-solving strategies among young students. Decomposition helps children handle complex information in smaller segments and address each part separately to form an overall solution.

Pattern Recognition: The ability to identify similarities and repetitive structures. Pattern recognition allows children to establish relationships between problems and use previous experiences to tackle new problems. Bers (2018) emphasized that pattern recognition is one of the key components of CT, enabling children to improve their problem-solving abilities by connecting with repeating structures. Pattern recognition helps children solve new situations based on prior experiences. For example, recognizing repeating structures in a math problem can accelerate the problem-solving process (Papadakis et al., 2016).

Abstraction: The ability to focus only on the important aspects of a problem while avoiding unnecessary details. This process involves identifying the most critical information within large data sets or information groups. Lu and Fletcher (2009) noted that abstraction helps students grasp the essence of complex problems. This skill allows students to solve both mathematical and scientific problems more efficiently. Abstraction directs children's focus to the necessary information, making the problem-solving process more effective (Wing, 2006).

Algorithm Development: The process of defining a sequence of steps to solve a specific problem. This step plays a critical role, especially in programming and computer science, but is also highly useful in solving everyday problems. Brennan and Resnick (2012) stated that algorithmic thinking helps children systematize the problem-solving process and achieve more effective results. Algorithms allow children to create a roadmap for solving a problem, and this process is particularly important for mathematical and technical problems.

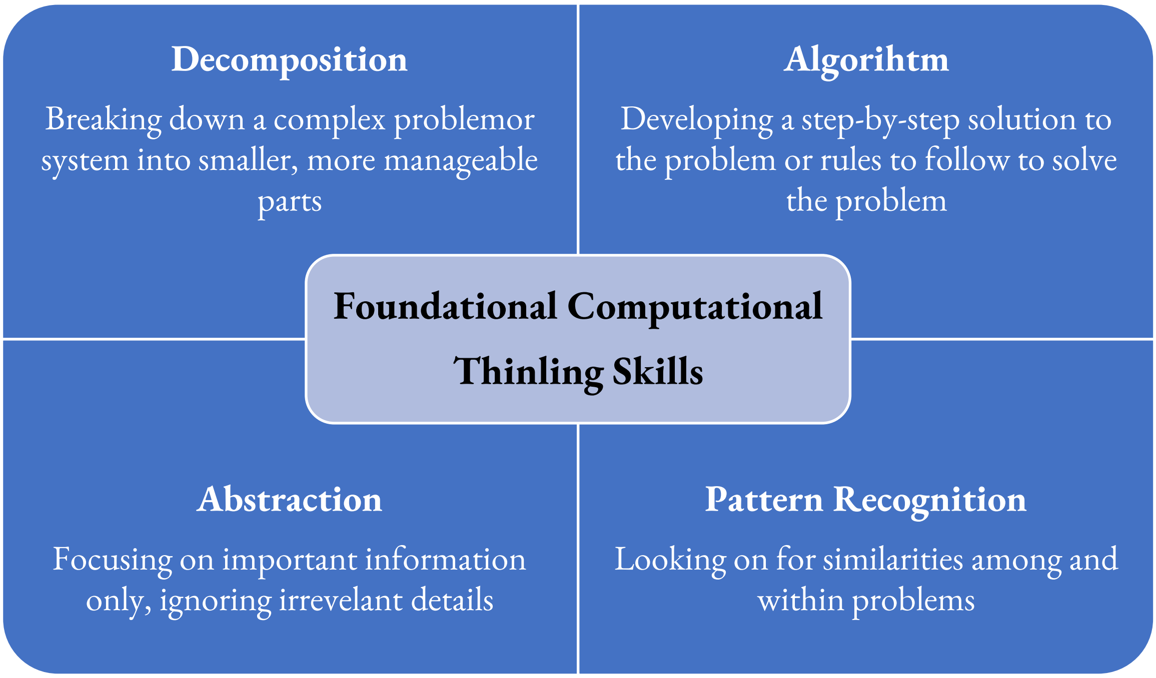

Figure 2. Steps of Computational Thinking (ISTE, 2016)

These four components are critical in developing children's analytical thinking and problem-solving abilities. The components of CT enrich children's cognitive processes and enable them to tackle more complex problems. Since computational thinking helps improve problem-solving and critical thinking skills, it is highly beneficial for children. By following the process of breaking down a problem to create an algorithm, children learn to approach problems logically and systematically. Computational thinking also helps children develop creativity and innovation skills as they are encouraged to think outside the box and come up with creative solutions to problems. Additionally, computational thinking promotes communication and collaboration skills as children work with others to solve problems and share their solutions and ideas.

The components of CT are closely related to pattern skills. Pattern recognition helps children notice repeating structures in the problem-solving process and establish connections between them. Bers (2018) emphasized that pattern recognition is one of the most fundamental components of CT, allowing children to make logical inferences in their cognitive processes. Pattern recognition is particularly noted as an effective tool in the development of algorithms (Wing, 2006). Papadakis et al. (2016) suggested that CT skills can be strengthened in early childhood through digital games and activities. These activities play an important role, especially in supporting algorithm development and pattern recognition skills.

The Relationship Between Computational Thinking (CT) and Pattern Skills in Early Childhood Education

Computational Thinking (CT) and pattern skills are two closely related and mutually supportive cognitive skill sets in early childhood education. During this period, children develop their problem-solving abilities through processes of recognizing and solving patterns. Wing (2006) and Bers (2018) specifically argue that pattern recognition is one of the core components of CT, reinforcing children's cognitive processes such as logical reasoning and problem-solving. Research has shown that developing pattern recognition skills in early childhood contributes to children's success in more complex problem-solving processes in later years.

Pattern recognition skills are not limited to mathematical abilities but are also related to language development and general cognitive processes. Rittle-Johnson and Saylor (2013) state that children learn sentence structures and grammar rules more easily by recognizing linguistic patterns. This demonstrates that pattern recognition contributes to children's broader cognitive development. Repetitive language activities, such as rhymes, songs, and rhythmic games, strengthen children's pattern skills and help them better understand linguistic structures (Papadakis et al., 2016).

Digital programming tools also contribute to the development of these skills. Tools such as ScratchJr teach children problem-solving and algorithmic thinking processes, allowing them to recognize and work with patterns. Brennan and Resnick (2012) highlighted that programming tools like ScratchJr create a multidimensional impact on children's cognitive development, supporting not only mathematical thinking but also analytical and creative thinking skills. Activities related to pattern recognition through digital tools also help children structure their problem-solving processes while supporting their algorithmic thinking skills (Kazakaoff et al., 2013; Bers, 2018).

Unplugged activities, or non-digital activities using physical materials, also play an important role in this process. Papadakis and Zaranis (2016) noted that pattern-creation games with tangible materials strengthen children's cognitive processes and particularly contribute to their mathematical thinking skills. These types of activities help children understand abstract concepts by making them more concrete, allowing for greater flexibility in problem-solving processes. Sorting and patterning games using blocks, shapes, and beads contribute to the development of pattern recognition skills through concrete experiences (Lee et al., 2019).

More broadly, Brennan and Resnick (2012) emphasized the multidimensional impact of programming education on children's cognitive development. Such educational approaches not only support children's algorithmic thinking skills but also strengthen their pattern recognition and problem-solving processes. Research shows that introducing these skills in early childhood enhances children's mathematical and scientific thinking abilities in later years (Papadakis et al., 2016).

Pattern recognition is entirely dependent on a child's ability to analyze objects and images. A child can recognize what is the same and what is different. This ability significantly influences a child's capacity to combine different patterns and predict the next outcome. Pattern recognition greatly assists in making specific decisions, making it easier to handle different situations.

Strategies for Developing Pattern Skills and Computational Thinking

Developing Computational Thinking (CT) and pattern skills in early childhood significantly contributes to children's analytical thinking, problem-solving, and cognitive flexibility. These skills can be supported through digital and physical tools, various games, and activities, promoting both cognitive and socio-emotional development. Below are some strategies that contribute to the development of these skills:

Digital Games and Programming Activities

Digital games and programming activities are highly effective in developing CT and pattern skills in young children. Programming tools like ScratchJr provide children with opportunities to develop algorithmic thinking and pattern recognition skills. ScratchJr enables children to identify repeating sequences and create algorithms based on these sequences. Papadakis et al., (2016) emphasized that ScratchJr greatly contributes to children's cognitive development, enhancing their creative thinking and problem-solving skills. Additionally, the use of digital programming tools allows children to create algorithms and make their problem-solving processes more systematic (Bers et al., 2014).

Figure 3. An example from the ScratchJr program

Not only do digital games promote cognitive development, but they also make learning enjoyable for children. As Brennan and Resnick (2012) pointed out, introducing programming to children at an early age lays a strong foundation for developing their algorithmic thinking abilities. During this process, children gain the skills to recognize repeating patterns and manipulate these patterns. Kazakaoff et al., (2013) noted that digital game-based programming tools are effective in helping children develop cognitive flexibility.

Unplugged (Non-Digital) Activities

In addition to digital tools, unplugged activities—games and activities using physical materials—are also effective in developing CT and pattern skills. These activities support children's cognitive processes by engaging them in games with tangible materials. Lee et al. (2019) emphasized that sorting and pattern-making games using colorful blocks, shapes, and beads help children learn abstract concepts through concrete experiences. Tangible materials allow children to recognize patterns, create algorithms, and apply these algorithms in a hands-on way.

Figure 4. Unplugged Activities example pattern generation

Shute et al. (2017) found that children's problem-solving skills are enhanced through non-digital activities, improving their cognitive flexibility and creative thinking capacities. These activities also encourage collaboration and problem-solving through social interaction, especially in group settings.

Rhythmic Activities and Songs

Rhythmic activities and songs play a key role in children's linguistic and cognitive development. Clements and Sarama (2007) noted that rhythmic patterns not only improve children's language skills but also support their pattern recognition and mathematical thinking abilities. Rhymes, songs, and clapping games help children notice repeating structures and reflect on them. Rittle-Johnson and Saylor (2013) emphasized that learning linguistic patterns helps children better grasp grammar and sentence structures.

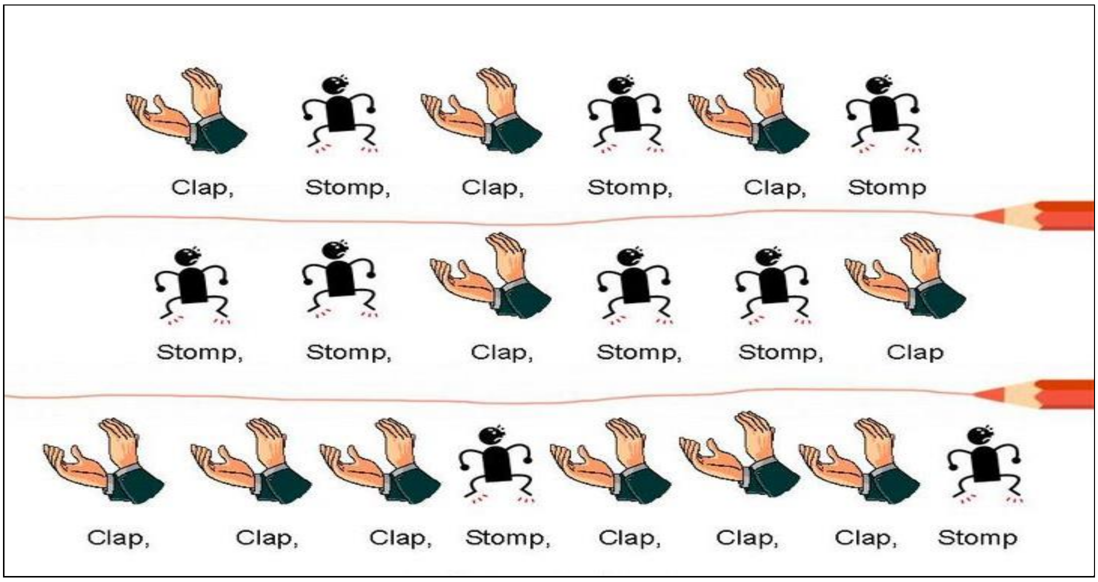

Figure 5. Rhythmic activities and songs pattern example

Rhythmic activities not only strengthen linguistic awareness but also enhance children's cognitive processes. For example, by identifying repeating sound patterns through songs and rhymes, children improve their understanding of both language and mathematical concepts. These activities develop children's ability to recognize patterns and make inferences based on those patterns.

Educational Policies and Curriculum Development

Integrating CT and pattern skills into early childhood education is a critical step in supporting children's cognitive, social, and academic development. Introducing these skills early allows students to develop problem-solving, analytical thinking, and logical reasoning abilities at a young age (Wing, 2006). Education policies and curricula should be structured to support the development of these skills, as this will directly impact future academic success.

CT should be integrated into curricula as an interdisciplinary approach, not just limited to computer science. Brennan and Resnick (2012) argued that integrating CT with other disciplines enhances students' ability to think multidimensionally and that introducing this skill as part of the curriculum at an early age is crucial. Similarly, Papadakis and Zaranis (2016b) highlighted that integrating CT into education through digital tools strengthens children's pattern recognition skills. Therefore, educational policies should be designed to place special emphasis on these areas.

The curriculum should be enriched with both digital tools and physical materials. Shute et al. (2017) found that enriching curricula with digital technologies encourages students to collaborate both in individual and group activities. Therefore, developing policies that increase access to digital programs and technology in schools is important for ensuring equal educational opportunities.

Supporting curricula with unplugged (non-digital) methods is also recommended. Lee et al. (2019) found that unplugged activities help children develop pattern and algorithmic skills with tangible materials, allowing them to build cognitive processes that succeed even in non-digital environments. Integrating such activities into the curriculum would enable the spread of CT even in regions with limited access to digital technologies. Increasing professional development opportunities for educators to contribute to the development of these skills is essential. Bers et al. (2014) pointed out that teachers' familiarity with digital tools supporting CT and pattern skills enhances the success of classroom applications. In this regard, curriculum developers should create policies that support teacher education and the integration of technological tools.

Finally, incorporating CT and pattern skills into education from an early age plays a critical role in helping children acquire 21st-century skills. The studies of Papadakis and Zaranis (2016) show that these skills improve children's collaboration, creative thinking, and problem-solving abilities in both individual learning and group-based activities.

Conclusion

Pattern skills and Computational Thinking (CT) are two critical skills that support children's cognitive, social, and academic development during the preschool period. These skills strengthen children's problem-solving, logical thinking, and algorithmic thinking processes. Specifically, Clements and Sarama (2007) emphasized the impact of pattern skills on mathematical and language development, while Wing (2006) and Brennan and Resnick (2012) presented important findings on how CT enhances children's interdisciplinary thinking abilities.

Educators planning activities that encourage these skills through both digital and physical tools will make significant contributions to children's future academic success. Papadakis et al. (2016) noted that programming activities supported by digital tools help children develop both pattern recognition skills and algorithmic thinking abilities. Meanwhile, Lee et al. (2019) demonstrated that unplugged activities can be successfully implemented even in regions with limited access to digital tools.

In conclusion, CT and pattern skills are two important cognitive processes that complement and develop together during early childhood. Activities supported by digital tools and tangible materials contribute to the development of these skills, strengthening children's problem-solving, analytical thinking, and logical reasoning abilities. These processes also support children's cognitive as well as socio-emotional development (Bers, 2018).

References

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education, 72*, 145-157. https://doi.org/10.1016/j.compedu.2013.10.020

Bers, M. U. (2018). *Coding as a playground: Programming and computational thinking in the early childhood classroom*. Routledge. https://doi.org/10.4324/9781315398924

Blanton, M ., &Kaput, J. (2004). Elementary grades students' capacity for functional thinking. In M. Jonsen Hoines ve A. Fuglestad (Eds), *Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education.* Vol. 2, s. 135–142). Oslo.

Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. In *Proceedings of the 2012 annual meeting of the American Educational Research Association, Vancouver, Canada*.

Clements, D. H., & Sarama, J. (2007). Early childhood mathematics learning. In F. K. Lester (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (Vol. 1, pp. 461-555). Information Age Publishing.

Clements, D. H., & Sarama, J. (2007). Effects of a preschool mathematics curriculum: Summative research on the Building Blocks project. *Journal for Research in Mathematics Education, 38*(2), 136-163.

Çolak, F. G. (2020). Erken çocukluk döneminde matematik eğitimi kaynak kitaplarında örüntü becerisinin ve örüntüleme süreçlerinin incelenmesi. *Ulakbilge Sosyal Bilimler Dergisi*, *8*(52), 983-994.

ISTE (2016), ISTE Standarts for Students Web: http://www.iste.org/docs/StandardsResources

Jackman, H. 2005. " Intuitions and Psychological Theory."Manuscript, York University.

Kazakoff, E. R., Sullivan, A., & Bers, M. U. (2013). The effect of a classroom-based intensive robotics and programming workshop on sequencing ability in early childhood. *Early Childhood Education Journal, 41*(4), 245-255.

Kesicioglu, O.S. (2013). Okul Öncesi Dönem Çocuklarının Matematiksel Örüntü Becerilerinin İncelenmesi. *Akdeniz Eğitim Araştırmaları Dergisi, 7*(13), 19-26.

Lee, I., Grover, S., Martin, F., Pillai, S., & Malyn-Smith, J. (2019). Computational thinking from a disciplinary perspective: Integrating computational thinking in K-12 science, technology, engineering, and mathematics education. *Journal of Science Education and Technology, 29*, 1–8. https://doi.org/10.1007/s10956-019-09803-w

Lee, J., & Lee, J. (2019). Unplugged coding activities in early childhood education. *International Journal of Child-Computer Interaction, 21*, 50-57. https://doi.org/10.1016/j.ijcci.2019.07.003

Mulligan, J., & Mitchelmore, M. (2009) Awareness of pattern and structure in early mathematical development. *Mathematics Education Research Journal*, 21(2), 33-49.

Olkun, S., & Toluk-Uçar, Z. (2014). *İlköğretim etkinlik temelli matematik öğretimi (6. Baskı).* Ankara: Eğiten.

Palabıyık, U., Akkuş İspir, O. (2011). Örüntü temelli cebir öğretiminin öğrencilerin cebirsel düşünme becerileri ve matematiğe karşı tutumlarına etkisi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, 30, 111-123.

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2016a). Developing fundamental programming concepts and computational thinking with ScratchJr in preschool education: A case study. *International Journal of Mbile Learning and Organisation, 10*(3), 187-202. https://doi.org/10.1504/IJMLO.2016.077867

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2016b). Teaching mathematics with mobile devices and the Realistic Mathematics Education (RME) approach in kindergarten. *Early Childhood Education Journal, 45*, 419-431. https://doi.org/10.1007/s10643-015-0742-3

Papic, M. (2008). Promoting repeating patterns with young children-More than just alternating colours!. *Australian Primary Mathematics Classroom*, 12(3), 8-13.

Piaget, J. (1957). *Construction of reality in the child*. Routledge & Kegan Paul.

Rittle-Johnson, B., & Saylor, M. (2013). Promoting transfer of learning through analogical reasoning. *Journal of Educational Psychology, 105*(4), 881-894.

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review, 22*, 142-158. https://doi.org/10.1016/j.edurev.2017.09.003

Sperry-Smith, S. (2012). *Early Childhood Mathematics (5th Ed.)* Boston, MA, United States: Pearson,

Warren, E. ve Cooper, T. (2006). Using repeating patterns to explore functional thinking. *Australian Primary Mathematics Classroom, 11*(1), 9-14.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM, 49*(3), 33-35. https://doi.org/10.1145/1118178.1118215