https://doi.org/10.53656/math2027-1-1-cad

Science in Education
Научно-методически статии

COGNITIVE ASPECTS OF THE DEVELOPMENT OF MATHEMATICAL COMPETENCIES IN THE PRESCHOOL AGE THROUGH PLAY AND DIGITAL TECHNOLOGIES

Almedina Numanović, Amela Muratović, Elzana Hakić
University of Novi Pazar, *Novi Pazar (Serbia)*

Abstract. The development of mathematical competencies in preschool is a vital part of early education, where cognitive processes and play are central. This paper analyzes cognitive aspects of the development of mathematical competencies in preschool children through play and the application of digital technologies. The theoretical framework of the paper is based on contemporary psychological and pedagogical approaches to children's learning processes. Special emphasis is placed on play as a natural form of learning in early childhood, as well as on the positive impact of digital tools in fostering logical thinking, understanding mathematical relationships, and developing of cognitive abilities. The paper examines pedagogical strategies that enable the integration of digital technologies into mathematical activities, with an emphasis on individualized learning and encouraging children's active participation. It also highlights the role of the educator in creating a stimulating environment that supports exploration, problem-solving, and the development of mathematical thinking. The results of the theoretical analysis indicate that the pedagogically guided integration of play and digital technologies can significantly contribute to the development of early mathematical thinking, cognitive abilities, and motivation for learning in preschool children.

Keywords: cognitive development; mathematical competencies; preschool children; children's play; digital technologies.

1. Introduction

Modern educational systems increasingly recognize the importance of the early development of mathematical thinking as a foundation for later academic success. At the preschool age, mathematical learning is not based on formal procedures, but on the development of cognitive structures that

enable the understanding of relationships, quantities, and patterns through experiential and contextualized activities.

According to contemporary research, preschool children acquire mathematical concepts most effectively through active learning and interaction with their environment, where activities that include elements of play, especially in the form of guided play, represent an important context for the development of mathematical thinking (Clements & Sarama, 2009). Play enables children to explore, experiment, compare, analyze, and develop mathematical thinking in a way that aligns with their developmental capabilities.

The application of digital technologies in early mathematics learning can be viewed through a framework that emphasizes that their value depends on the way they are pedagogically applied, rather than on the technology itself (Goodwin & Highfield, 2013, as cited in Novita & Herman, 2021). Research shows that the carefully designed use of digital tools can enhance the understanding of mathematical concepts and increase children's motivation for learning (Plowman & Stephen, 2005). Digital technologies, when applied in accordance with contemporary pedagogical principles and the developmental characteristics of preschool children, represent a significant factor in the individualization of the learning process and the creation of diverse developmental pathways for cognitive abilities. However, a key role in this process belongs to the educator, who should design a stimulating environment in which play and digital tools are used as means for developing thinking, rather than as a substitute for active learning (NAEYC, 2012). The integration of cognitive and didactic approaches enables a deeper understanding of mathematical relationships and contributes to the development of early mathematical competencies.

Although research highlights the importance of play and digital technologies in the development of mathematical competencies, their implementation in preschool practice remains limited, mainly due to the insufficient use of innovative approaches and the need for further professional development of educators. This paper is a narrative review aimed at examining the relationship between cognitive functions, play, and digital technologies in the development of mathematical competencies in

preschool children. The main contribution of the paper lies in integrating these aspects and highlighting their importance for improving educational practice.

2. Research Methodology

The paper uses a narrative literature review methodology with the aim of systematizing and critically analyzing theoretical and empirical knowledge on the cognitive aspects of the development of mathematical competencies in preschool children. Relevant literature was identified by searching scientific databases and academic sources using key terms related to cognitive development, early mathematics education, learning through play, and the application of digital technologies at the preschool age. The review includes peer-reviewed scientific articles, monographs, and other relevant scientific works that, through their content, directly contribute to understanding the issue under investigation.

The selected sources were analyzed qualitatively through a comparison of theoretical perspectives and the results of previous research, and then synthesized into thematic units that encompass the basic cognitive processes underlying mathematical thinking, the impact and potential of digital technologies and educational applications, as well as didactic-methodological approaches and the role of play in the development of mathematical skills in preschool children.

3. Cognitive processes in early mathematical development

The development of mathematical competencies at the preschool age represents a complex, multidimensional process arising from the interaction of cognitive processes, play-based learning, and the developmentally appropriate application of digital technologies. These components do not function independently of one another, but rather through their interaction contribute to the development of mathematical thinking, logical reasoning, and problem-solving abilities. Cognitive processes provide the foundation for understanding mathematical concepts, play provides a natural and stimulating environment for their application and development, while digital technologies, when used in accordance with pedagogical goals and the developmental needs of children, can further enhance the learning experience

and motivation for exploring mathematical content. Based on this integrative approach, the following section discusses the role of cognitive processes as the foundation of early mathematical development, while considering their connection with learning through play and the application of digital technologies.

Early mathematical development in preschool children is largely conditioned by the development of basic cognitive processes that enable the processing, organization, and interpretation of information from the environment. In early childhood, thinking develops through everyday situations in which children arrange and classify objects, estimate quantities, and recognize patterns. Such activities directly support the development of reasoning as a key cognitive ability. Reasoning is reflected in children's ability to draw conclusions based on available information, identify relationships between concepts, and apply basic logical rules in problem-solving. In this sense, reasoning abilities represent one of the fundamental components of mathematical cognitive systems, playing a significant role in the development of early mathematical competencies in children (Bragg et al., 2016; Karakuş, 2022).

Mathematical activities allow preschool children to gradually develop different ways of thinking in the process of problem-solving. Through such experiences, they learn to analyze tasks from multiple perspectives, combine different approaches, and arrive at solutions that are logically grounded and well organized. This form of learning contributes to the development of rational thinking and encourages the formation of a critical approach to problem situations in both educational and everyday contexts (Clements & Sarama, 2015).

On this basis, mathematical thinking develops as a complex cognitive process that involves the integration of different mental operations. It strengthens children's general cognitive abilities, contributes to the development of cognitive flexibility, and enables the understanding of cause-and-effect relationships in the environment. At the same time, it fosters the ability to logically explain experiences and systematize knowledge, encompassing basic elements of mathematical thinking such as the recognition of patterns, relationships, and regularities (Aydogdu, 2023).

In this process, basic cognitive processes play a significant role, among which attention, memory, thinking, and logical and numerical reasoning are particularly important. Attention enables the child to focus on relevant information from the environment, which is a prerequisite for noticing the mathematical properties of objects and phenomena. At the preschool age, the development of selective attention enables the child to ignore irrelevant characteristics (e.g., color or texture of objects) and focus instead on quantitative properties, such as number or geometric shape. Research shows that sustained attention capacity and inhibitory control are directly related to success in early mathematical tasks, as the child must maintain focus on counting steps or game rules in order to arrive at a correct solution (Espy et al., 2004).

Through play supported by digital technologies, attention becomes further structured; interactive software often uses visual and auditory cues to direct the child's attention to key mathematical aspects, thereby reducing cognitive load. However, excessive stimulation in a digital environment can have the opposite effect if it diverts attention from the mathematical concept toward pure entertainment (Fisher et al., 2014).

Memory enables the temporary retention and manipulation of information during cognitive activities such as counting, comparing quantities, classification, and solving simple problem tasks. When a child engages in counting objects, they must simultaneously keep the last spoken number in working memory, track which objects have already been counted, and plan the next step, which directly demands this cognitive resource (Baddeley, 2006).

Research indicates that individual differences in working memory capacity are associated with differences in mathematical achievement even at an early age, with children who have more developed working memory acquiring basic numerical and logical relationships more easily. This relationship has been confirmed in numerous studies highlighting its role in mathematical learning and academic achievement (Geary, 2011; Swanson, 2006; Gathercole & Pickering, 2000; Alloway & Alloway, 2015). For example, visuospatial working memory is crucial for understanding geometric shapes and spatial relationships, while the phonological loop

supports the acquisition of number names and verbal counting (Bull et al., 2008).

As children grow, the efficiency of working memory becomes one of the strongest predictors of mathematical giftedness, as well as potential learning difficulties (dyscalculia). Properly designed games, especially in digital form, can serve as a tool for "training" working memory, providing children with the opportunity to strengthen their cognitive capacities necessary for future academic achievement through gradually increasing task complexity (Passolunghi & Costa, 2019).

At the preschool age, a key developmental shift occurs: a gradual transition from implicit to explicit memory. While younger children acquire information spontaneously through direct experience, the development of intentional memory enables older preschoolers to consciously use strategies of repetition and organization. This transition is essential for more structured learning, as it allows the child to deliberately retain task instructions and more systematically connect new mathematical concepts with existing cognitive schemas (Schneider & Pressley, 2013).

In this process, memory serves as a storage system that helps retain and link previous experiences, while thinking functions as a processor that enables the organization of that information, its comparison, and the drawing of simple conclusions. For example, in order for a child to understand the concept of transitivity, they must retain the first two relationships in memory while thinking performs the logical inference about the third. Through the interaction of these processes, the ability for logical reasoning gradually develops, transforming unstable and intuitive notions of number and space into more stable and abstract mathematical concepts (Frye et al., 1995). This cognitive development lays the foundation for the transition from the preoperational stage to the stage of concrete operations, where mathematical thinking becomes reversible and systematic (Piaget, 1952).

Thinking in preschool children undergoes a transition from intuitive and perceptual forms toward increasingly organized and logically structured processes. During this developmental period, children gradually begin to recognize relationships between objects and phenomena, establish

connections between concepts, and draw simple conclusions based on their own experiences and interactions with the environment. Therefore, the ability for logical reasoning gradually develops, representing a key component of mathematical thinking and later problem-solving. This development of thinking at the preschool age constitutes the basis for more complex forms of abstract mathematical reasoning in later schooling (Berk, 2018). Such development of thinking forms the basis for the transition from concrete to abstract mathematical reasoning, ensuring that the child enters school with stable "cognitive maps" of mathematical relationships (Clements & Sarama, 2014).

Logical and numerical reasoning enables the child to understand relationships such as more–less, before–after, and greater–smaller, as well as to develop initial numerical structures through counting and comparing quantities. These abilities develop through the manipulation of concrete objects, play, and everyday situations that encourage active thinking. This development is based on the innate approximate number system (ANS), which, through experience, is refined into precise mathematical operations (Feigenson et al., 2004).

4. Children's play and digital technologies in early mathematical learning

Play represents the primary natural context in which children develop early mathematical concepts, as it enables spontaneous exploration, manipulation of objects, and recognition of relationships between them. Through play and related activities, children develop skills of classification, seriation, and estimation, which form the foundation for later formal mathematical learning (Muratović, 2025).

In pedagogically guided mathematical games, children can use building blocks for construction and counting, during which they compare the number of elements in different structures and, with the support of the educator, explain which set is larger and why (Khales et al., 2024). In classification activities, children can sort objects according to color, shape, or size, explaining the grouping criteria through guided questions and discussion with the educator (DePascale & Ramani, 2023). Also, in games with patterns, children can continue or create simple sequences, such as red–blue–

red–blue, thereby encouraging the perception of regularities and the development of logical thinking.

Such playful activities indicate that play provides the foundational pedagogical framework in early mathematical learning, as it encourages active learning, curiosity, and children's engagement, thereby contributing to the development of cognitive processes important for understanding mathematical concepts. On this basis, contemporary educational approaches increasingly emphasize the integration of play and digital technologies as complementary pedagogical tools that can further enrich and extend children's learning experiences. Thus, learning mathematics through play allows children to actively "do mathematics," rather than passively internalizing ready-made knowledge. This approach is also supported by research indicating that different forms of play can foster active mathematical thinking and deeper conceptual understanding through children's experiences and interaction with the environment (Van den Heuvel-Panhuizen et al., 2009).

When applied in a didactically appropriate way, digital tools can enhance children's motivation, attention, and active participation in the mathematics learning process. The literature clearly shows that young children grow up in environments rich in digital media (Hsin et al., 2014; Plowman et al., 2012), which further emphasizes the need for their thoughtful integration into the educational process. In this framework, children's play and digital technologies are increasingly viewed as complementary elements in the development of early mathematical competencies.

In a highly interconnected digital society, technology becomes an integral part of everyday life, and therefore also of educational processes in which children gain learning experiences (Numanović, et al., 2026). Technology can extend natural play situations by enabling children to explore mathematical relationships in an interactive way, visualize concepts, and receive immediate feedback during activities. Ginsburg (2006) emphasizes that mathematics in early childhood often emerges spontaneously through play in everyday activities, such as reading or playing with construction materials, where children naturally connect experience with mathematical concepts.

Such an environment involves the creation of a space that stimulates children's curiosity, exploration, and active learning, and is enriched with a variety of materials, didactic resources, and digital tools that encourage manipulation, experimentation, and the recognition of mathematical relationships in everyday situations. In this context, the educator plays a key role as an organizer and mediator who pedagogically designs and guides activities, encourages children's thinking, poses problem situations, and provides support throughout the learning process. Consequently, the educator contributes to ensuring that the stimulating environment is not merely a physical space, but a dynamic didactic system that enables individualized approaches and the development of mathematical competencies in accordance with each child's developmental capacities.

Within this framework, the educator's role in creating and guiding a stimulating environment also includes the careful selection and application of digital tools, which requires an adequate level of digital competence. Digital literacy represents an important prerequisite for the successful integration of technology into the educational process, as it contributes to the development of children's cognitive abilities by fostering curiosity and creativity. It encompasses the ability to use digital tools to locate, evaluate, utilize, create, and effectively communicate content (Hafizzaturroyani et al., 2024).

Digital tools further enrich play situations by enabling the visualization of mathematical concepts, manipulation of digital objects, and immediate feedback, all of which contribute to a deeper understanding and application of mathematical content. In accordance with this, their application in preschool mathematics education should be focused on activities that encourage active exploration and the connection of digital experiences with learning through play. In daily educational practice, educators can integrate digital tools into activities of counting, classification, pattern recognition, and quantity comparison, connecting them with the manipulation of concrete didactic materials and joint problem-solving tasks. For example, after children sort geometric shapes or compare sets of elements in a digital environment, they can explore the same mathematical relationships using blocks, cards, or other materials available in the kindergarten. Carlsen (2013)

emphasizes that such an approach creates favorable conditions for the development of mathematical thinking because digital tools become a means for joint exploration, discussion, and active interaction between children and educators. Bay and Hartman (2025) highlight that the educational value of digital technologies depends on their planned integration into daily activities and their connection with clearly defined educational goals, which is why their application should be aimed at encouraging active learning, cooperation, and reflection, rather than on the passive use of digital content.

Within these activities, a special place is occupied by tasks that promote understanding of numbers and their relationships through visual representations, such as the number line, where children learn to estimate which number is larger or smaller without precise counting and recognize their mutual relationships. Such tasks contribute to the development of an intuitive understanding of numbers and strengthen basic numerical representations in children. Consequently, the ability to recognize and estimate relationships between numbers is enhanced, representing an important segment of early mathematical competencies and serving as a frequent indicator of the development of numerical understanding (Ramani & Siegler, 2008; Siegler & Ramani, 2009; Siegler et al., 2012). In this context, it is important to emphasize that the integration of digital technologies into early mathematical development does not replace play, but rather serves as an extension and enrichment.

Although digital technologies in early mathematical learning have significant educational potential, their application requires a carefully planned and pedagogically grounded approach. Namely, uncritical or excessive use of digital content can lead to a reduction in experiential learning through the manipulation of concrete materials, which is of crucial importance at the preschool age for the development of mathematical concepts. Also, there is a risk of reducing the quality of social interaction among children, as well as of excessive passivity and shortened attention in learning situations. For this reason, digital technologies should not be viewed as a substitute for play and experiential learning, but as their didactically supplemented form, which requires a clear structure, time limitation, and an active role of the educator in the learning process.

Individualization of learning serves as a crucial didactic principle that contributes to the effective development of mathematical competencies at the preschool age, with both individualization and differentiation in early mathematics education referring to the adaptation of various activities to each child's developmental abilities, interests, and learning pace. This approach is based on the idea that knowledge is not transmitted equally to all learners, but is differentiated according to their individual development, allowing gradual progress through increasingly challenging tasks and activities (Căprioară & Frunză, 2014). Each child is enabled to progress according to their individual abilities, while particularly fostering the development of basic mathematical competencies such as counting, comparison, classification, and pattern recognition. Digital technologies and play have an important role in this regard, as they allow the adaptation of tasks and difficulty levels, as well as the provision of immediate feedback.

5. Conclusion

The cognitive processes presented form the basis for the development of early mathematical structures and enable the child to gradually understand relationships, patterns, and quantitative concepts. In this context, play emerges as a natural and developmentally appropriate framework in which children construct mathematical knowledge through active engagement, exploration, and interaction with their environment.

Digital technologies, when thoughtfully integrated from a pedagogical perspective, can contribute to the improvement of the learning process through interactivity, visualization, and individualization, while their effectiveness largely depends on the educator's competencies and the way they are didactically applied. The organization of a stimulating and individualized learning environment represents an important prerequisite for the successful implementation of mathematical activities at the preschool age. The educator plays a pivotal pedagogical role in shaping such an environment, connecting play, digital tools, and cognitive development into a unified educational process. In this context, the main pedagogical significance of this approach is reflected in the development of children's basic mathematical competencies, including counting, classification, pattern

recognition, and spatial reasoning, which are developed through playful and digitally supported activities.

In a practical sense, the results of this research indicate that the effective application of digital technologies in preschool mathematics education requires their planned, didactically grounded, and developmentally appropriately structured integration into playful activities, with a clearly defined role of the educator as a mediator in the learning process. It is particularly significant that digital content is systematically linked with the manipulation of concrete didactic materials and experiences from the children's everyday environment, thereby contributing to the development of a conceptual understanding of mathematical relationships. The obtained findings also point to the need for further empirical research into the long-term effects of the application of digital technologies in early mathematical learning, as well as to the limitations arising from their inadequate or excessive use in the educational process. Future research should be aimed at examining the effects of specific digital tools on the development of individual mathematical competencies in early childhood.

In conclusion, the integration of play, digital technologies, and an individualized approach represents a relevant framework for the development of early mathematical competencies and children's cognitive readiness for further education and learning.

REFERENCES

Anobile, G., Cicchini, A. S., & Burr, D. C. (2016). Number, density and adaptation. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1697), Article 20150024. https://doi.org/10.1098/rstb.2015.0024

Alloway, T. P., & Alloway, R. G. (2015). *Working memory: The connected intelligence*. Psychology Press.

Aydoğdu, R. (2023). *Mathematical reasoning skills of children aged 60–71 months: The predictive power of parents' participation in mathematical activities and mathematics beliefs* [Master's thesis, Erzincan Binali Yıldırım University, Institute of Social Sciences]. Erzincan, Turkey.

Baddeley, A. (2006). Working memory: An overview. In S. J. Pickering (Ed.), *Working memory and education,* 1 – 31, Academic Press. https://doi.org/10.1016/B978-012554465-8/50003-X

Bauer, P. J., & Fivush, R. (Eds.). (2014). *The Wiley handbook on the development of children's memory.* John Wiley & Sons. https://doi.org/10.1002/9781118597705

Bay, D. N., & Hartman, D. K. (2025). Digital technology in kindergarten: Kindergarten teachers' practices and their effects on children. *Journal of Research in Childhood Education*, *39*(2), 214 – 231. https://doi.org/10.1080/02568543.2025.2514028

Berk, L. E. (2018). *Child development* (10th ed.). Pearson Education.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647 – 663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Bull, R., Espy, K. A., & Wiebe, S. A. (2008). Short-term memory, working memory, and executive functioning in preschoolers: Longitudinal predictors of mathematical achievement at age 7 years. *Developmental Neuropsychology*, *33*(3), 205 – 228. https://doi.org/10.1080/87565640801982312

Bragg, L. A., Herbert, S., Loong, E. Y. K., Vale, C., & Widjaja, W. (2016). Primary teachers notice the impact of language on children's mathematical reasoning. *Mathematics Education Research Journal*, 28(4), 523 – 544. https://doi.org/10.1007/s13394-016-0178-y

Căprioară, D., & Frunză, V. (2014). Differentiation and individualization in the organization of the teaching-learning activities in mathematics. *Procedia - Social and Behavioral Sciences, 93*, 2063 – 2067. https://doi.org/10.1016/j.sbspro.2013.10.166

Carlsen, M. (2013). *Mathematical learning opportunities in kindergarten through the use of digital tools: Affordances and constraints.* Nordic Journal of Digital Literacy, *8*(3), 171 – 185. https://doi.org/10.18261/ISSN1891-943X-2013-03-04

Clements, D. H., & Sarama, J. (2015). *Learning and teaching early math: The learning trajectories approach* (2nd ed.). Routledge. https://doi.org/10.4324/9780203707326

DePascale, M., & Ramani, G. B. (2023). *The role of math games for children's early math learning: A systematic review.* Journal of Numerical Cognition, 2025, 11. 10.31234/osf.io/xkvhb

Espy, K. A., McDiarmid, M. M., Senn, T. E., Mangelsdorf, S. C., Huang, W., & Cassel, A. (2004). Distinct executive function processes predict numerical problem-solving efficiency in day-care and preschool children. *Journal of Child Psychology and Psychiatry*, *45*(3), 487 – 498. https://doi.org/10.1111/j.1469-7610.2004.00239.x

Feigenson, L., Dehaene, S., & Spelke, E. (2004). Core systems of number. *Trends in Cognitive Sciences*, *8*(7), 307 – 314. https://doi.org/10.1016/j.tics.2004.05.002

Fisher, A. V., Godwin, K. E., & Seltman, H. (2014). Visual environment, attention allocation, and learning in young children: When too much of a good thing may be bad. *Psychological Science*, *25*(7), 1362 – 1370. https://doi.org/10.1177/0956797614533801

Frye, D., Zelazo, P. D., & Palfai, T. (1995). Cognitive complexity and control: I. Theory of mind in relation to inhibitory control and executive function. *Cognitive Development*, *10*(4), 483 – 504. https://doi.org/10.1016/0885-2014(95)90024-1

Fuson, K. C. (1988). *Children's counting and concepts of number.* Springer-Verlag. https://doi.org/10.1007/978-1-4612-3754-9

Gathercole, S. E., & Pickering, S. J. (2000). Working memory deficits in children with low achievements in the national curriculum at 7 years of age. *British Journal of Educational Psychology, 70*(2), 177 – 194. https://doi.org/10.1348/000709900158047

Gathercole, S. E., & Alloway, T. P. (2008). *Working memory and learning: A practical guide for teachers.* SAGE Publications. https://doi.org/10.4135/9781446213728

Geary, D. C. (2011). Cognitive predictors of individual differences in achievement growth in mathematics: A five-year longitudinal study. *Developmental Psychology, 47*(6), 1539 – 1552. https://doi.org/10.1037/a0025510

Gelman, R. (2006). Young natural-number epistemologists. In L. Smith & S. Pellegrini (Eds.), *Theories of mathematical development,* 5 – 26, Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203774786

Ginsburg, H. P. (2006). Mathematical Play and Playful Mathematic: A Guide for Early Education. In G. D. Singer, R. M. Golinkoff, & K. HirshPasek, Play = learning: How play motivates and enhances children's cognitive and social-emotional growth, 145 – 165. New York: Oxford University Press

Hafizzaturroyani, H., Habibi, M., Fahruddin, F., Darmiany, D., & Subarinah, S. (2024). Development of digital literacy tools in the implementation of science, technology, engineering, art, and mathematics (STEAM) learning for the implementation of the independent curriculum for children aged 5 – 6 years. *International Journal of Education and Digital Learning*, 2(5), 63 – 72. https://doi.org/10.47353/ijedl.v2i5.137

Hsin, C. T., Li, M. C., & Tsai, C. C. (2014). The influence of young children's use of technology on their learning: A review. *Educational Technology & Society, 17*(4), 85 – 99.

Inhelder, B., & Piaget, J. (1964). *The early growth of logic in the child: Classification and seriation*. Harper & Row. (Original work published 1959).

Jordan, N. C., Kaplan, D., Ramineni, C., & Locuniak, M. N. (2009). Early math matters: Kindergarten number sense and later mathematics outcomes. *Developmental Psychology*, *45*(3), 850 – 867. https://doi.org/10.1037/a0014939

Khales, B. M., Natsheh, I., Ihmeideh, F. M., & Kim, M. (2024). The use of mathematical games in the early childhood settings in Palestine. *Education* 3 – 13, *52*(3), 1 – 15. https://doi.org/10.1080/03004279.2022.2149277

Karakuş, H. (2022). Erken Matematik Ölçeği'nin Türkçeye uyarlanması: Geçerlik ve güvenirlik çalışması. *Kocaeli Üniversitesi Eğitim Dergisi, 5*(1), 197 – 220. https://doi.org/10.33400/kuje.1059336

LeFevre, J. A., Fast, L., Skwarchuk, S. L., Smith-Chant, B. L., Bisanz, J., Kamawar, D., & Penner-Wilger, M. (2010). Pathways to mathematics: Longitudinal predictors of performance. *Child Development*, *81*(6), 1753 – 1767. https://doi.org/10.1111/j.1467-8624.2010.01508.x

Monette, S., Bigras, M., & Guay, M. C. (2011). The role of the executive functions in school readiness at the end of preschool. *Early Education and Development*, *22*(2), 210 – 230. https://doi.org/10.1080/10409281003697165

Mullis, I. V. S., & Martin, M. O. (Eds.). (2013). *TIMSS 2015 Assessment Frameworks*. International Association for the Evaluation of Educational Achievement. https://timssandpirls.bc.edu/timss2015/frameworks.html

Mix, K. S., Smith, L. B., & Stockton, J. D. (2002). *Quantitative development in infancy and early childhood*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195133646.001.0001

Muratović, A. (2025). *Predškolska pedagogija*. Univerzitet u Novom Pazaru.

Numanović, A., Kajkuš, A., Hakić, E. (2026). *Osnovi psihopatologije*. Univerzitet u Novom Pazaru.

NAEYC. (2012). *Technology and interactive media as tools in early childhood programs serving children from birth through age 8*. National Association for the Education of Young Children.

Novita, R., & Herman, T. (2021). Using technologies in young children's mathematical learning: A didactic perspective. *Journal of Physics: Conference Series, 1957*(1), 012013. https://doi.org/10.1088/1742-6596/1957/1/012013

Passolunghi, M. C., & Costa, H. M. (2019). Working memory and early numeracy training in preschool children. *Child Neuropsychology, 25*(1), 81 – 108. https://doi.org/10.1080/09297049.2016.1276288

Piaget, J. (1952). *The child's conception of number*. Routledge & Kegan Paul. (Original work published 1941). https://doi.org/10.4324/9781315009612

Plowman, L., & Stephen, C. (2005). Children, play, and computers in pre-school education. *British Journal of Educational Technology, 36*(2), 145 – 157.

Plowman, L., McPake, J., & Stephen, C. (2012). Extending opportunities for learning: The role of digital media in early years education. *Early Years, 32*(2), 131 – 146. https://doi.org/10.1080/09575146.2012.667929

Purpura, D. J., & Ganley, C. M. (2014). Working memory and language: Skill-specific or domain-general relations to mathematics? *Journal of Experimental Child Psychology, 122*, 104 – 121. https://doi.org/10.1016/j.jecp.2013.12.009

Ramani, G., & Siegler, R. S. (2008). Promoting broad and stable improvements in low-income children's numerical knowledge through playing number board games. *Child Development, 79*(2), 375 – 394. https://doi.org/10.1111/j.1467-8624.2007.01131.x

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2005). The development of executive attention: Contributions to the emergence of self-regulation. *Developmental Neuropsychology, 28*(2), 573 – 594. https://doi.org/10.1207/s15326942dn2802_2

Sarama, J., & Clements, D. H. (2009). *Early childhood mathematics education research: Learning trajectories for young children*. Routledge. https://doi.org/10.4324/9780203883785

Schneider, W., & Pressley, M. (2013). *Memory development between two and twenty* (2nd ed.). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203774304

Siegler, R. S., & Ramani, G. (2009). Playing linear number board games – But not circular ones – Improves low-income preschoolers' numerical understanding. *Journal of Educational Psychology, 101*(3), 545 – 560. https://doi.org/10.1037/a0014239

Siegler, R. S., Duncan, G., Davis-Kean, P., Duckworth, K., Claessens, A., Engel, M., Susperreguy, M. I., & Chen, M. (2012). Early predictors of high school mathematics achievement. *Psychological Science, 23*(7), 691 – 697. https://doi.org/10.1177/0956797612440101

Siegler, R. S., & Lortie-Forgues, H. (2014). Conceptual knowledge of fraction arithmetic. *Journal of Educational Psychology*, *106*(4), 975 – 985. https://doi.org/10.1037/a0036163

Siegler, R. S. (2016). Continuity and change in the field of cognitive development and in the perspectives of one cognitive developmentalist. *Child Development Perspectives*, *10*(2), 128 – 133. https://doi.org/10.1111/cdep.12173

Starkey, P., Klein, A., & Wakeley, A. (2004). Enhancing young children's mathematical knowledge through a pre-kindergarten mathematics intervention. *Early Childhood Research Quarterly*, *19*(1), 99 – 120. https://doi.org/10.1016/j.ecresq.2004.01.002

Szűcs, D., Devine, A., Soltesz, F., Nobes, A., & Gabriel, F. (2013). Cognitive components of a mathematical difficulties in mental number line and numerical comparison. *Child Development*, *84*(4), 1417 – 1437. https://doi.org/10.1111/cdev.12032

Steele, A., Carmichael, J. J., Sadeghpour, N., & Jolles, D. (2021). The role of attention in early math learning: A review of recent research and clinical implications. *Frontiers in Psychology*, *12*, Article 664531. https://doi.org/10.3389/fpsyg.2021.664531

Swanson, H. L. (2006). Cognitive processes that underlie mathematical precociousness in young children. *Journal of Experimental Child Psychology, 93*(2), 139 – 163. https://doi.org/10.1016/j.jecp.2005.09.006

Van den Heuvel-Panhuizen, M., Van den Boogaard, S., & Doig, B. (2009). *Picture books stimulate the learning of mathematics. Australasian Journal of Early Childhood, 34*(3), 30 – 39. https://doi.org/10.1177/183693910903400305

Verdine, B. N., Golinkoff, R. M., Hirsh-Pasek, K., & Newcombe, N. S. (2017). *Links between spatial and mathematical skills across the preschool years.* Monographs of the Society for Research in Child Development. https://doi.org/10.1111/mono.12280

✉ **Almedina Numanović, Assoc. Prof.**
ORCID iD: 0000-0003-3079-7180
WoS ResearcherID: MFK-2422-2025,
University of Novi Pazar, 67, Dimitrija Tucovića
Novi Pazar, Serbia
E-mail: almedina.numanovic@uninp.edu.rs

✉ **Amela Muratović, Assoc. Prof.**
ORCID iD: 0000-0002-3044-5575
WoS ResearcherID: Y-2942-2007,
University of Novi Pazar, 67, Dimitrija Tucovića
Novi Pazar, Serbia
E-mail: amela.muratovic@uninp.edu.rs

✉ **Elzana Hakić, MA**
ORCID iD: 0009-0007-3698-8304
University of Novi Pazar, 67, Dimitrija Tucovića
Novi Pazar, Serbia
E-mail: elzanahakic@uninp.edu.rs