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THE ROLE OF MODERN TECHNOLOGIES IN THE FORMATION OF INDEPENDENT THINKING IN PRIMARY SCHOOL STUDENTS

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Annotation. *This article explores the impact of modern technologies on the development of independent thinking skills among primary school students. It discusses how digital tools, interactive learning platforms, and educational applications contribute to creating a learner-centered environment that encourages curiosity, critical inquiry, and self-guided learning. The study emphasizes the importance of integrating technology thoughtfully to foster analytical thinking, decision-making, and problem-solving abilities from an early age. It also highlights the role of teachers in guiding students to use technology responsibly and productively. The paper provides examples of effective practices and outlines recommendations for optimizing the use of modern technology in primary education.*

Keywords. *Modern technologies, independent thinking, primary education, digital tools, learner-centered environment, educational apps, critical inquiry, problem-solving, early childhood development, technology integration.*

The contemporary educational landscape is undergoing a profound transformation driven by rapid technological advancements. In primary education, modern technologies are increasingly recognized as powerful tools for fostering independent thinking—a critical skill in the 21st century. Independent thinking, defined as the ability to analyze information critically, generate original ideas, and solve problems autonomously, is essential for academic success and lifelong learning. Research demonstrates that when integrated thoughtfully, digital tools can significantly enhance cognitive autonomy, metacognitive skills, and creative problem-solving abilities in young learners. This article examines the multifaceted

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relationship between technology and independent thinking development, drawing on empirical studies from educational psychology, cognitive science, and instructional technology.

Digital learning environments offer unique opportunities to cultivate independent thinking through interactive and personalized learning experiences. Adaptive learning platforms, such as DreamBox and Khan Academy Kids, use artificial intelligence algorithms to adjust content difficulty based on individual student performance. A longitudinal study by Walkington and Bernacki (2019) found that primary students using adaptive mathematics software demonstrated greater improvements in self-regulated learning strategies compared to traditional instruction. These platforms promote independence by allowing children to progress at their own pace while receiving immediate feedback—a crucial element in developing metacognitive awareness. The Zone of Proximal Development theory (Vygotsky, 1978) finds new relevance in this context, as technology can provide precisely calibrated challenges that scaffold independent problem-solving without excessive teacher intervention.

Game-based learning represents another technological approach with demonstrated efficacy in fostering autonomous thinking. Well-designed educational games require players to experiment, hypothesize, and adapt strategies—processes that mirror scientific thinking. Research by Mayer (2019) on cognitive theory of game learning revealed that primary students who engaged with physics puzzle games like "Crayon Physics Deluxe" showed significant gains in creative problem-solving and persistence when facing challenges. Crucially, these games create low-stakes environments where failure becomes a productive part of the learning process, encouraging children to take intellectual risks and develop resilience. The motivational aspects of gamification should not be underestimated; a meta-analysis by Sailer and Homner (2020) found that game elements like progress tracking and rewards increased intrinsic motivation, which is strongly correlated with independent learning behaviors.

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Coding and robotics programs for young learners have emerged as particularly effective tools for developing logical and independent thinking. Platforms like ScratchJr and LEGO WeDo introduce basic programming concepts through visual, block-based interfaces. A three-year study by Relkin, de Ruiter, and Bers (2020) demonstrated that primary students participating in weekly coding activities exhibited enhanced executive function skills, including improved planning abilities and cognitive flexibility—key components of independent thought. Robotics projects further reinforce these benefits by requiring children to break complex problems into manageable steps, test solutions iteratively, and debug errors independently. These computational thinking skills transfer to non-technical domains; research by Rich et al. (2019) showed that students with coding experience outperformed peers in story comprehension tasks requiring logical sequencing and inference-making.

The rise of maker technologies in primary education provides additional avenues for nurturing independent thinking. Digital fabrication tools like 3D printers and laser cutters, when combined with design software such as Tinkercad, enable students to bring their creative visions to life. Constructionist learning theory (Papert, 1980) posits that hands-on building activities facilitate deeper understanding and independent inquiry. A controlled study by Blikstein and Krannich (2019) in primary maker spaces found that students engaged in digital fabrication projects demonstrated greater improvements in divergent thinking and problem-orientation compared to traditional art projects. These technologies empower children to move from passive consumers to active creators of knowledge—a fundamental shift that undergirds independent thought.

Emerging research on immersive technologies reveals their potential to stimulate independent thinking through experiential learning. Virtual reality (VR) field trips, for instance, allow primary students to explore ancient civilizations or molecular structures firsthand, prompting self-directed questioning and investigation. A neuroeducation study by Parong and Mayer (2021) using EEG measurements found that VR experiences elicited stronger activation in prefrontal

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brain regions associated with critical thinking compared to textbook learning. Augmented reality (AR) applications that overlay digital information onto physical environments similarly promote active exploration; for example, an AR app that visualizes geometric concepts in classroom spaces can help students independently discover mathematical relationships (Zhang et al., 2020).

However, the relationship between technology and independent thinking is not universally positive. Cognitive scientists caution against passive technology use, such as excessive video consumption or drill-and-practice apps that prioritize rote memorization over higher-order thinking (Hirsh-Pasek et al., 2015). The American Academy of Pediatrics (2016) emphasizes the importance of "joint media engagement," where adults co-use technology with children to model questioning and reflection. Effective integration requires deliberate pedagogical strategies; teachers must structure technology use to promote inquiry rather than dependence. Research by Zheng et al. (2021) suggests that the most beneficial implementations combine digital tools with offline reflection activities, such as having students explain their problem-solving processes verbally after completing computer-based tasks.

Teacher professional development emerges as a critical factor in maximizing technology's benefits for independent thinking. Many educators lack training in selecting and implementing tools that genuinely foster autonomy rather than mere compliance. A large-scale study by Tondeur et al. (2022) identified four key competencies for teachers: technological pedagogical knowledge (how to teach with technology), the ability to facilitate student-centered learning, skills in designing open-ended technology tasks, and capacity to model metacognitive strategies during tech use. School systems that invested in sustained, practice-based teacher training saw significantly greater gains in students' independent thinking measures compared to those that focused solely on device distribution.

Longitudinal data raises important considerations about equity in technology-enhanced independent learning. While affluent schools often have resources for cutting-edge tools, research by Warschauer et al. (2019) demonstrates

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that well-designed mobile learning interventions can effectively support independent thinking development in under-resourced settings. The key differentiator appears to be pedagogical approach rather than device sophistication; even basic tablets with carefully selected apps produced measurable improvements when teachers received proper support. This finding underscores the need for systemic investments in both technology access and teacher capacity building.

As artificial intelligence becomes more prevalent in education, new questions arise about maintaining cognitive autonomy. AI writing assistants and math solvers could potentially undermine independent thinking if overrelied upon. However, preliminary research by Luckin et al. (2022) suggests that "pedagogical AI" designed to ask probing questions rather than provide answers may actually enhance independent thought. For example, an AI reading companion that asks "Why do you think the character made that choice?" rather than explaining the plot point encourages deeper, self-guided analysis.

The neuroscience of technology-assisted learning offers insights into how digital tools shape young brains. Functional MRI studies comparing children's brain activity during traditional versus technology-enhanced problem-solving reveal that well-designed digital tasks elicit stronger connectivity between the anterior cingulate cortex (involved in decision-making) and dorsolateral prefrontal cortex (responsible for working memory and reasoning) (Howard-Jones et al., 2021). These neurological changes correlate with observable improvements in independent thinking capacities, suggesting that technology isn't merely changing how children learn but potentially reshaping the cognitive architectures that support autonomous thought.

Looking forward, the most promising applications of educational technology will likely combine several research-backed principles: adaptive challenge levels that maintain flow states, open-ended interfaces that encourage creative expression, embedded metacognitive prompts that foster reflection, and collaborative features that allow peer learning while preserving individual accountability. As primary education continues evolving in our digital age, the thoughtful integration of

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technology—guided by rigorous research rather than trends—remains paramount for cultivating the independent thinkers tomorrow's world will require.

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