



Benefits of Cognitive Offloading Tools in Mathematics Education

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Mathematical problem-solving places a heavy burden on children's working memory (WM) resources, with WM capacity predicting mathematical achievement throughout the school years. Cognitive offloading, the act of outsourcing mental demands to external resources, is an effective method of reducing WM demands and improving task performance. While children can benefit from offloading, they often struggle to strategically utilise offloading strategies in non-educational contexts (Armitage & Gilbert, 2024). This review discusses when and how children may use and benefit from embodied (e.g., finger counting) and external (e.g., artefacts or manipulatives) offloading tools in mathematics education.

Finger counting is an embodied cognition strategy that allows children to offload WM demands by externalising numerical knowledge and computations. Despite some negative perceptions, extensive evidence supports the utility of finger counting in mastering early arithmetic skills (Thevenot et al., 2025). Between the ages of 5 and 6, children begin to adaptively utilise finger counting strategies that align with their ability to manage problem complexity in WM. As mental calculation becomes more automatic with practice, children recognise the inefficiency of finger counting, generally abandoning it by age 8. However, finger counting remains beneficial for children with lower ability or when problem demands exceed internal calculation ability beyond middle primary school.

External artefacts allow children to offload information in WM by serving as physical referents for numerical information. Contrary to early developmental theories, manipulatives are helpful beyond early childhood (Holmes, 2013). While research exploring external tools from an offloading perspective is limited, research suggests that children with stronger cognitive resources and mathematics ability use manipulatives more strategically, while those with lower ability likely require explicit instruction to apply and benefit from them. Which manipulatives best support learning at different ages or proficiency levels remains unexplored.

This review suggests that embodied and external resources are effective cognitive offloading tools in mathematics. Current evidence indicates that children with higher WM are more likely to use embodied and external cognitive offloading strategically, while those with lower WM and mathematical skills may use offloading less effectively without explicit instruction. Understanding these individual differences is essential to fostering an adaptive use of offloading strategies and improving mathematical problem-solving across development.

References

- Armitage, K. L., & Gilbert, S. J. (2024). The nature and development of cognitive offloading in children. *Child Development Perspectives*. <https://doi.org/10.1111/cdep.12532>
- Holmes, A. B. (2013). *Effects of manipulative use on PK-12 mathematics achievement: A meta-analysis*. Society for Research on Educational Effectiveness (SREE). <https://eric.ed.gov/?id=ED563072>
- Thevenot, C., Krenger, M., & Poletti, C. (2025). Finger counting as a key tool for the development of children's numerical skills. *Journal of Experimental Child Psychology*, 252, 106156. <https://doi.org/10.1016/j.jecp.2024.106156>

For more information, please refer to the following paper presented at the 47th Annual Conference of MERGA in July 2025.
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