

Overview of the history of development of theories about metacognition and its implications on educational science in various fields from 1976 to 2022

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Introduction

Certainly, the concept of metacognition has played an important role in a number of scientific fields, but it is particularly important in understanding mechanisms in educational science. The process of understanding and at least partially taking control over our own thought mechanisms provides a foundation for many effective teaching and learning strategies nowadays. It is thus considered one of the most important developments in educational theory over the past few decades.

Recent rapid advancements in A.I. and machine learning are giving us new insights into metacognition and are constantly opening up new possibilities for its application in education. New technologies offer a perspective that helps researchers to analyze and understand learning patterns in a whole new quality. Newer, faster and more precise metrics demonstrate us an array of possibilities. As a result, A.I. has already become a powerful tool for identifying effective metacognitive strategies and personalized educational methodology, and has, of yet, even only begun to unfold its potential.

The reason to embark on this overview at this specific moment is the increasing intersection of A.I. and education. A.I. is rapidly and equally increasingly becoming a fundamental component of educational systems worldwide. There's an urgent need for educators, researchers, and A.I. developers just alike to understand and utilize the invaluable potential of science in metacognition regarding the era of A.I.-enhanced learning.

Given those preliminaries, it is timely to review the history of metacognition and its evolution, with specific regard on its relevance and implications in the current context. As our educational systems continue to evolve, so too will our understanding and ultimately the application of findings on metacognition in the near future. The lessons we have been allowed to learn from decades of research on mechanisms of perception, comprehension and information processing of the human brain will influence the development of next-generation educational technologies, and the optimization of A.I. tools for improved teaching and learning experiences.

Year	Reference	Analysis
1976	Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), <i>The nature of intelligence</i> (pp. 231-236). Erlbaum.	Original introduction of metacognition as the knowledge, understanding and regulation of cognitive processes. He emphasized the importance of understanding our cognitive abilities to enhance learning outcomes. His work is foundational in the field, setting the stage for future research.
1987	Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), <i>Metacognition, motivation, and understanding</i> (pp. 65-116). Lawrence Erlbaum Associates.	Research on metacognition in children, highlighted the importance of self-regulation and strategic knowledge in successful learning. Emphasized the role of metacognition in educational contexts, particularly in how children learn and process information. Foundational findings for teaching and learning strategies.
1994	Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. <i>Contemporary Educational Psychology</i> , 19(4), 460-475.	Developed the Metacognitive Awareness Inventory (MAI) to measure individual metacognitive awareness. Investigated the ability to quantitatively assess metacognitive skills. This has allowed for a more objective understanding of metacognition and has provided a valuable tool for further research.

2002	Pintrich, P. R. (2002). The role of metacognitive knowledge in learning, teaching, and assessing. <i>Theory into Practice</i> , 41(4), 219-225.	Expansion on metacognition in classroom setting, introducing the Metacognitive Self-Regulated Learning Theory. Posing that metacognition can enhance self-regulation in learning, which in turn promotes better academic performance. Influential work for educational practice in classroom learning.
2004	Kuhn, D., & Dean, D. (2004). Metacognition: A bridge between cognitive psychology and educational practice. <i>Theory into Practice</i> , 43(4), 268-273.	Three main components of metacognition: metacognitive knowledge, regulation, and experiences. Important framework with significant implications for teaching and learning strategies and the overall comprehension of the concept of metacognition itself.
2005	Nietfeld, J. L., Cao, L., & Osborne, J. W. (2005). The effect of distributed monitoring exercises and feedback on performance, monitoring accuracy, and self-efficacy. <i>Metacognition and Learning</i> , 1(2), 159-179.	Relationship between metacognition and academic performance. Found that students with high metacognitive awareness tend to perform better in academia. Reinforced the importance of metacognition in academic success and has implications for how educators ought to approach teaching.
2012	Fleming, S. M., & Dolan, R. J. (2012). The neural basis of metacognitive ability. <i>Philosophical Transactions of the Royal Society B: Biological Sciences</i> , 367(1594), 1338-1349.	Identified brain regions associated with metacognitive abilities, offering a biological proof for metacognition. Provided a deeper understanding of the biological underpinnings of the theory, closing the gap between cognitive psychology and neuroscience / biology.
2013	Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. <i>Psychological Science in the Public Interest</i> , 14(1), 4-58.	Review of applied learning techniques, highlighting practice testing and distributed practice as the most effective methods, both strongly related to metacognition.
2013	Zohar, A., & Barzilai, S. (2013). A review of research on metacognition in science education: Current and future directions. <i>Studies in Science Education</i> , 49(2), 121-169.	Found, that explicit instruction in metacognitive strategies can help students improve in various academic areas, including science and reading comprehension. Influential in strategies on how to teach and ultimately apply metacognitive strategies.
2015	Bryce, D., Whitebread, D., & Szűcs, D. (2015). The relationships among executive functions, metacognitive skills and educational achievement in 5 and 7 year-old children. <i>Metacognition and Learning</i> , 10(2), 181-198.	Metacognition within math education - found that a child's metacognitive ability is a strong indicator of mathematical competency.
2015	Karagiannidis, Y., Barkoukis, V., Gourgoulis, V., Kosta, G., & Antoniou, P. (2015). The role of motivation and metacognition on the development of cognitive and affective responses in physical education lessons: A self-determination approach. <i>Motricidade</i> , 11(3), 77-91.	Roles of motivation and metacognition in the formation of cognitive and affective outcomes from participation in physical education lessons within the framework of self-determination theory.

2017	Makarova, E., Aeschlimann, B., & Herzog, W. (2017). The importance of the teacher–student relationship in classrooms of students with different levels of self-regulation and motivation. <i>Educational Psychology, 37</i> (5), 603-620.	Relationship between visualization and metacognition. Demonstrated, how visualizing the very process of learning can help self-assessing it, and how the use of schemes in education can be used to better understand the process of learning and skills acquired.
2017	Ozturk, N. (2017). Assessing Metacognition: Theory and Practices. <i>International Journal of Assessment Tools in Education, 4</i> (2), 134-148.	Metacognition, its assessment, and limitations of assessment measures and procedures. Pattern of metacognition assessment based on ten current studies revealed, that the latest metacognition assessment studies tended to utilize domain-specific or real-life tasks.
2017	Sobocan, A. M. (2017). Metacognitive strategies in reading comprehension of majors in education. <i>Center for Educational Policy Studies Journal, 7</i> (1), 137-157.	Role of metacognition in second language acquisition. Underscored, that enhancing metacognitive awareness can improve language learning outcomes in SLA.
2020	Wanderley, S., & Barros, A. (2020). The Alliance for Progress, modernization theory, and the history of management education: The case of CEPAL in Brazil. <i>Management Learning, 51</i> (5), 545-563.	Investigated the Economic Commission for Latin America in Brazil to discuss how modernization theory was mobilized to influence management education. Provides a historical perspective on the influence of modernization theory on management education, with implications for how to better understand the development of educational theories in general.
2022	Loksa, D., Ko, A. J., Jernigan, W., Oleson, A., Mendez, C. J., & Burnett, M. M. (2022). Metacognition and Self-Regulation in Programming Education: Theories and Exemplars of Use. <i>ACM Transactions on Computing Education (TOCE), 22</i> (1), 1-34.	Presented a systematic review of metacognition and self-regulation work in the context of computer programming. They also discussed several prominent metacognitive and self-regulation theories from the literature outside of computing education.
2022	Brenner, C. (2022). Self-regulated learning, self-determination theory and teacher candidates' development of competency-based teaching practices. <i>Smart Learning Environments, 9</i> (1), 1-18.	Described self-regulated learning practices and how motivational supports for teacher candidates' self-determined motivation creates contextual conditions that support development of these practices in prospect teachers. This research has implications for education of educators and how we ought to approach teaching competency-based practices.
2022	Rivas, S. F., Cadenas, M., & Sanz, J. (2022). Metacognitive Strategies and Development of Critical Thinking in Higher Education. <i>Frontiers in Psychology, 13</i> , 913219.	Intervention proposal to develop critical thinking and meta knowledge skills. Showed, that critical thinking improves with the use of metacognition. Particular implications for higher education and how educators can pass on critical thinking skills to their students.