

Visualizing Learning: A Meta-Analysis on the Use of Associative Cognitive Networks in Science and Mathematics Education



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Network Analysis

Knowledge Graphs

Neurocognition



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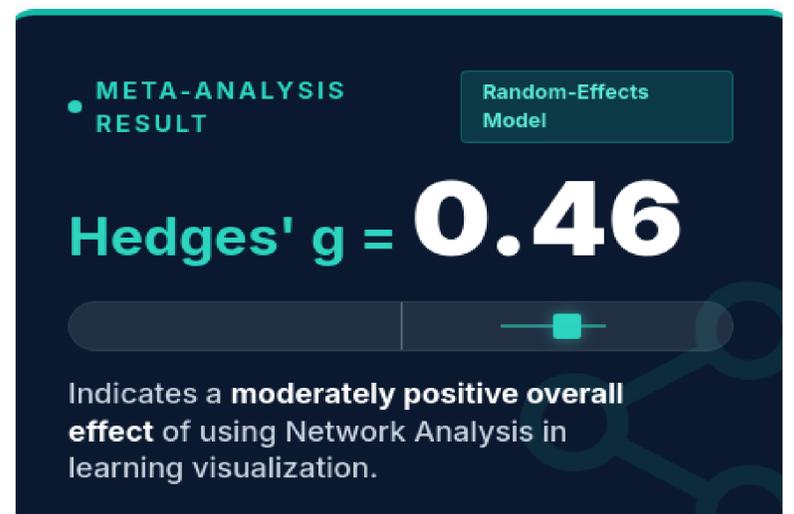
INTRODUCTION & AIM

Recent advances in Neuroeducation and Cognitive Neuroscience have positioned Knowledge Networks (KNs) as powerful tools for organizing and representing information in Science and Mathematics education. Grounded in graph theory and Network Science, these structures model conceptual interconnections while mirroring the neural circuits underlying learning and memory.

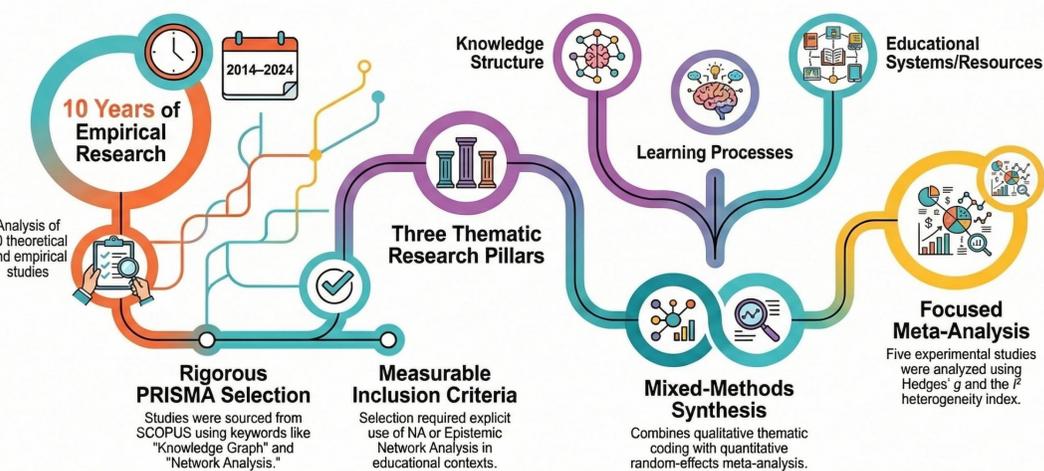
This study investigates the impact and application domains of this methodology within science and mathematics education through a mixed-methods systematic review.

Qualitative analysis of 30 studies identified three core applications of Network Analysis (NA): Knowledge Structure Analysis, Learning Process Modeling via ENA, and Evaluation of Educational Systems and Resources. Across all categories, NA revealed relational patterns — conceptual bottlenecks, expert-novice differences, and pedagogical strategies — that traditional methods fail to capture.

B. Quantitative Results: Impact of Network Analysis on Learning

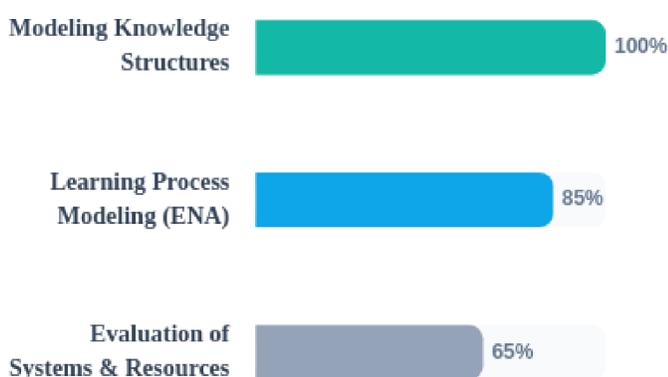


METHOD



RESULTS & DISCUSSION

A. Qualitative Results: Domains of Application of Knowledge Network Analysis in Science and Mathematics



CONCLUSION

Network Analysis (NA) demonstrates transformative potential in science and mathematics education by enabling the dynamic visualization of conceptual relationships, revealing patterns such as expert-novice differences and epistemic bottlenecks, yielding a moderate but significant overall effect on learning outcomes, fostering complex cognitive skills including argumentation, synthesis, and metacognition, and underscoring the need for future experimental and longitudinal research exploring moderating variables such as educational context, student level, and content type.

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