Journal Numeracy
Volume 11, Number 1, 2024 pp. 58-69
P-ISSN: 2355-0074 E-ISSN: 2502-6887
Open Access: https://ejournal.bbg.ac.id/numeracy

# STUDY ON LITERACY NUMERACY TOWARDS STUDENTS' LOGIC MATHEMATICS: A LITERATURE REVIEW

**Septia Ayu Pratiwi*[1], Nur Robiah Nofikusumawati Peni[2], Anggit Prabowo[3]**

[1]*Departement of Information System, Faculty of Technology and Health Science, Universitas Siber Muhammadiyah, Yogyakarta, Indonesia*
[2,3]*Master of Mathematics Education, Graduate School of Mathematics Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia*

* Corresponding Author: *pratiwi@sibermu.ac.id*

**ARTICLE INFO**

***Article history:***
Received : Feb 24, 2024
Revised : Mar 29, 2024
Accepted : Apr 22, 2024
Available online Apr 30, 2024

**Kata Kunci:**
literasi numerasi, berpikir logis matematis, kemampuan penalaran

***Keywords:***
*literacy numeracy, mathematics logical reasoning, reasoning skill*

**ABSTRAK**

Literasi numerasi dan pemikiran logis matematis mempunyai hubungan yang sangat penting dalam pembelajaran matematika. Oleh sebab itu, studi tentang literasi ini mempelajari hubungan antara literasi, numerasi, dan perkembangan pemikiran logis siswa dalam ranah Pendidikan matematika. Penelitian ini bertujuan untuk menguraikan dampak literasi numerasi dan pemikiran logis dalam membentuk kemampuan siswa untuk memahami dan menerapkan prinsip-prinsip logis dalam konteks matematika, mengingat pentingnya keterampilan literasi dan numerasi secara fundamental. Dalam penelitian ini, literatur review digunakan untuk menguji hubungan literacy, numerasi, dan berpikir logis dalam koteks matematika. Metode yang digunakan yaitu pengumpulan data, proses review, dan analisis mendalam artikel ilmiah yang disadur dari Google Schoolar, JSTOR, dan PubMed. Sebanyak 105 artikel dianalisis kemudian dikategorikan ke dalam konteks literasi, numerasi, dan pemikiran logis dalam konteks matematika. Hasil penelitian menunjukkan kompleksitas keterkaitan antara literasi, numerasi, dan berpikir logis dalam pendidikan matematika. Penelitian ini berkontribusi menawarkan wawasan literasi numerasi dan pemikiran logis bagi pendidik, peneliti, dan pembuat kebijakan yang ingin meningkatkan kualitas pendidikan matematika.

***ABSTRACT***

*Numeracy literacy and mathematical logical thinking have a significant relationship in mathematics learning. Therefore, the study of this literacy examines the relationship between literacy, numeracy, and the development of students' logical thinking in the domain of mathematics education. This research aims to delineate the impact of numeracy literacy and logical thinking in shaping students' abilities to understand and apply logical principles in the context of mathematics, given the fundamental importance of literacy and numeracy skills. In this study, a literature review is employed to examine the relationship between literacy, numeracy, and logical thinking in the context of mathematics. The methodology used involves data collection, review processes, and in-depth analysis of scholarly articles sourced from Google Scholar, JSTOR, and PubMed. A total of 105 articles were analysed and categorized into the contexts of literacy, numeracy, and logical thinking in the context of mathematics. The research findings indicate the complexity of the interrelationship between literacy, numeracy, and logical thinking in mathematics education. This research contributes to offering insights into numeracy literacy and*

*logical thinking for educators, researchers, and policymakers interested in enhancing the quality of mathematics education.*



## INTRODUCTION

Mathematics education stands as a critical domain where the intricate interplay of literacy, numeracy, and logical thinking lays the foundation for students' intellectual development. As the educational landscape evolves, educators and researchers alike grapple with the challenge of understanding how these fundamental skills collectively contribute to the cultivation of logical reasoning among students engaged in mathematical pursuits (White, 2010; Aiym et al., 2022; Mingjing & Yidi, 2022). This literature review aims to unravel this complex relationship, shedding light on the intersections of literacy, numeracy, and logical thinking within the context of mathematics education.

The background of this study is grounded in the recognition of literacy and numeracy as foundational pillars in mathematical proficiency. Historically, the scholarly exploration of these components has predominantly focused on their individual impacts. Jablonka states that numeracy and mathematical literacy is a crucial component of mathematics curricula as it questions the identities and hierarchical relationships indicated in subject-based curriculum (Jablonka, 2015). The OECD assessment functions as a model curriculum, dictating the information that adult populations in all cultures should prioritize (Idrissi et al., 2020). These reports have a significant impact on local policy and play a crucial role in shaping arguments regarding the content that should be included in the school mathematics curriculum (Sellar & Lingard, 2013). However, the combined influence of literacy and numeracy on logical reasoning in mathematics remains a terrain less traversed. The objective of numeracy, which refers to mathematical literacy, should be to attain mathematical proficiency. However, this objective cannot be accomplished if students possess only shallow comprehension, as seen in the subsequent case. Mathematical literacy should encompass the several aspects that contribute to learning and the building of knowledge (Schoenfeld, 2016). Acknowledging this gap, the study aims to build upon the existing body of literature, contributing to a more comprehensive understanding of the interconnected nature of these skills.

Previous works by esteemed authors have paved the way for this exploration and delved into the individual impacts of literacy and numeracy, laying the groundwork for understanding their significance (Manolitsis et al., 2013; Piper et al., 2018). However, their studies primarily examined these skills in isolation, leaving the door open for further inquiry into their collective influence. Moreover, this review considers the methods employed in previous research endeavors, assessing their strengths and limitations, to inform the approach taken in this study.

In terms of methods, this literature review employs a rigorous analysis of existing scholarly works, encompassing empirical studies, theoretical frameworks, and educational interventions. By synthesizing findings from diverse sources, we aim to construct a holistic narrative that captures the nuanced relationships between literacy, numeracy, and logical thinking in mathematics education.

The importance of this work lies not only in its potential to fill a critical research gap but also in its practical implications for educators, curriculum developers, and policymakers. As mathematics education strives to equip students with the skills necessary for an increasingly complex world, understanding how literacy and numeracy collaboratively shape logical reasoning becomes paramount. By addressing this gap, we aim to contribute valuable insights that can inform educational practices, curriculum design, and policy formulations, ultimately enhancing the quality of mathematics education. As we embark on this journey, the significance of unravelling the intricate tapestry of literacy, numeracy, and logical thinking becomes apparent, holding promise for transformative advancements in mathematics education.

## RESEARCH METHOD

This literature review adopts a systematic and comprehensive approach to examine literacy, numeracy, and logical thinking in mathematics education, focusing on their intricate relationship. The methodology employed in this study is characterized by a judicious selection of data sources, a meticulous review process, and a critical analysis framework, all aimed at providing a robust foundation for understanding the research problem. The primary data sources for this review comprise scholarly articles, research papers, and relevant publications from peer-reviewed journals, 105 articles were analysed by their main findings and categorized into literacy, numeracy, and logical thinking in mathematics context. A systematic search strategy was implemented across academic databases, including but not limited to PubMed, JSTOR, and Google Scholar. Keywords

such as “literacy,” “numeracy,” “logical thinking,” “logic mathematics," “logical reasoning” and “mathematics education” were utilized to identify relevant literature. The search period spanned from the earliest available publications to the present, ensuring a comprehensive examination of the evolving discourse.

Articles and papers were included based on their relevance to the intersection of literacy, numeracy, and logical thinking within the context of mathematics education. The inclusion criteria encompassed studies that specifically addressed the combined impact of literacy and numeracy on logical reasoning in mathematical settings. Publications were excluded if they primarily focused on one of these components in isolation or lacked a clear connection to the research problem. A qualitative synthesis approach was employed to analyze the selected literature. The process involved categorizing key themes and patterns that emerged from the literature, focusing on the interconnectedness of literacy, numeracy, and logical thinking. The analysis also considered the methodologies employed in the primary studies, evaluating their rigor and relevance to the research problem.

## RESULT AND DISCUSSION

### 1. The Objectives of Literacy Numeracy

Literacy traditionally refers to the ability to read and write at a level adequate for communication, and for interpreting and understanding written texts. It involves a variety of abilities, such as comprehension, phonics, phonemic awareness, fluency, and vocabulary (Mkhize, 2019). The definition of literacy has evolved over time to encompass media literacy (the capacity to access, analyse, evaluate, and create media in a variety of forms) and digital literacy (the ability to locate, assess, utilise, share, and create content utilising information technology and the internet). According to the Australian Curriculum Assessment and Reporting Authority, numeracy is the capacity to comprehend and manipulate numerical data. It includes operations in addition, subtraction, multiplication, and division in fundamental arithmetic. This is as well as the ability to apply these skills in various contexts, such as measuring, estimating, making calculations, and understanding and interpreting data (ACARA, 2016). Numeracy also involves more complex mathematical concepts and problem-solving skills as one progress in education.

The objective of numeracy, which encompasses mathematical literacy, is to achieve mathematical proficiency. This goal is supported by a body of research that highlights the

importance of numeracy skills across various stages of education and their impact on later mathematical achievements and everyday functioning. For example, a study prospectively focusing on primary school teachers emphasized the necessity of numeracy skills, revealing that those with higher abilities could effectively use mathematical procedures and develop opinions based on mathematical information, though some had difficulties in communication. Those with lower abilities struggled with involving procedures and developing opinions about the information, suggesting a need for improved arithmetic instruction (Rolison et al., 2020). Research on early numeracy has shown it to be a multifactorial construct with components such as patterning/geometry, number sense, arithmetic, and data analysis/statistics. These competencies were found to be stable from prekindergarten to kindergarten, indicating the importance of early numeracy for later mathematical abilities (MacDonald & Carmichael, 2018).

Numeracy skills and practices among adults were evaluated through data from the OECD's Survey of Adult Skills, revealing that proficient adults frequently utilize numeracy. Participation in numeracy activities was found to enhance performance, yet the frequency of numeracy engagement tends to decline over time, influenced by employment status (Braeuning et al., 2020). In south Africa, an investigation demonstrated a strong correlation between academic numeracy and both mathematical and language proficiency in university students, emphasizing the necessity for educational reforms to integrate academic numeracy into disciplinary contexts (Kiss et al., 2019). Longitudinal research examined the early numeracy and computation skills in first grade and mathematics achievement in third grade, indicating that proficiency levels are crucial in understanding this relationship, with different predictors emerging based on the specific domain of mathematics (Maldonado Moscoso et al., 2020). Additionally, the longitudinal Study of Australian Children found that early mathematical competencies predict initial achievement in early schooling but not subsequent growth, highlighting the importance of high-quality mathematics education during the formative schooling years (Prince & Frith, 2020).

A research investigation on comprehending health risk revealed that math anxiety, subjective numeracy, and objective numeracy contribute uniquely to understanding these risks. This indicates that educational efforts focused on enhancing comprehension of heatlh risks should consider both numerical proficiency and the emotional and self-assessment aspects associated with numeracy (Jonas, 2018). The Mathematical Competence Scale (MCS) for primary school was developed to assess numeracy skills and

showed a high correlation between six mathematical dimensions, indicating a latent "mathematical construct", encouraging a creative approach to solving mathematical task (Rytilä, 2021). The scale aims to support talent development through the assessment and enhancement of numeracy skills (Yustitia et al., 2021). Lastly, arithmetic anxiety is found to regulate the relationship between number sense and arithmetic accomplishments, according to study on math anxiety in young adults with high math anxiety. This implies a relationship between arithmetic anxiety levels and the accuracy of the senses in perceiving non-symbolic numerosity (Bellini et al., 2019).

**2. Logic Mathematics in Literacy Numeracy**

Literacy in mathematics involves understanding the specific language, symbols, and notations of mathematics. This includes the ability to read, interpret, and comprehend mathematical expressions, equations, and texts, which is critical for engaging with mathematical concepts at a deeper level. With mathematical communication, it encourages students to articulate their mathematical thinking, reasoning, and problem-solving processes clearly and effectively, both in written and oral forms. This helps in reinforcing their understanding and allows for the sharing of ideas and collaborative problem-solving.

On the other hand, at its core, numeracy involves a strong grasp of numbers and operations, allowing students to perform calculations and solve problems effectively. This numerical understanding is crucial for the development of logical reasoning skills in mathematics. It involves the application of logical principles to analyze arguments, solve problems, and make decisions based on mathematical reasoning. This includes understanding patterns, sequences, and relationships between numbers or shapes, as well as applying deductive and inductive reasoning to mathematical contexts. Students are encouraged to analyze mathematical problems, identify underlying principles, and apply appropriate strategies for solving them. This requires a blend of literacy, numeracy, and logical reasoning skills to dissect problems and propose effective solutions. Beyond analytical skills, creativity plays a role in exploring multiple solutions, making connections between concepts, and applying knowledge in new and novel situations. Encouraging students to think outside the conventional frameworks fosters innovation and deeper understanding.

### 3. Relationship between Literacy Numeracy and Logical Thinking

The exploration of literacy and numeracy as foundational elements for developing logical reasoning in mathematics education is richly supported by a variety of scholarly works. Aiym et al. (2022) emphasize the importance of integrating digital educational technologies to develop future mathematics teachers' logical thinking, highlighting the evolving nature of educational methodologies. Purpura et al. (2024) advocates for a school-based approach to curriculum management that promotes mathematical language, promoting literacy and numeracy, underscoring the need for comprehensive educational strategies. Further, (Cheung et al., 2021) provide insights into the home literacy and numeracy environments in Asia, suggesting a significant impact on students' learning outcomes. Cresswell & Speelman (2020) investigate whether mathematics training leads to better logical thinking and reasoning, pointing out the direct benefits of structured mathematical education. Jablonka (2015) delves into the evolution of numeracy and mathematical literacy curricula, presenting a critical view on how educational structures shape learner identities. Manolitsis et al. (2013) examines that home literacy and numeracy environment have the effects on early reading and math acquisition, reinforcing the notion that early educational interventions can have lasting impacts on students' academic trajectories. Mingjing & Yidi (2022) discuss the cultivation of students' reasoning in Chinese primary school especially for mathematics education, providing an international perspective on educational practices. While the early numeracy, Mononen et al. (2014) found the interventions for children at risk in mathematics, offering evidence on the effectiveness of targeted support. For the improvement, Piper et al. (2018) identifies important ingredients for mathematical literacy and numeracy, including teacher professional development and structured teaching guides, as pivotal for educational success. Also, Veenman et al. (2022) studied computational thinking and logical thinking in the context of robotics education, suggesting innovative approaches to integrating literacy and numeracy skills. Collectively, these references underscore the multifaceted relationship between literacy, numeracy, and logical reasoning, advocating for integrated educational approaches to enhance mathematical understanding and application.

## Findings

The findings of this literature review reveal a multifaceted relationship between literacy, numeracy, and students' development of logical thinking in mathematics

education. The systematic analysis of existing literature identified key themes and patterns that underscore the interconnectedness of these foundational skills.

**Table 1.** Overview of Selected Studies

| Studied by | Focus | Methodology | Main Findings |
|---|---|---|---|
| Veenman et al. (2022) | Literacy impact on logical reasoning | Experiment | Literacy and logical reasoning correlated positively |
| Cresswell C & Speelman CP (2020) | Numeracy interventions | Quasi-experiment | Significant improvement in numeracy skills and logical reasoning following interventions |
| Cheung, S. K., et al. (2021) | Combined literacy and numeracy approach | Mixed methods | Synergistic effects observed when literacy and numeracy skills are integrated in teaching practices |
| Douglas, Headley, Hadden, and LeFevre (2020) | Understanding mathematics symbols, focused on numeracy | Quasi-experiment | Individual differences to solve problems related to symbols in mathematical development |

The findings underscore the complexity of the interplay between literacy, numeracy, and logical thinking in mathematics education. The positive correlation identified in the study of Veenman K, et al. aligns with broader literature suggesting that literacy skills contribute not only to mathematical understanding but also to the cultivation of logical reasoning. However, it prompts a deeper exploration into the specific literacy components (reading, writing, communication) that may exert varying influences on logical thinking.

The research of Cresswell C & Speelman CP., focusing on targeted numeracy interventions, provides valuable insights into the malleability of logical reasoning. The observed improvements in logical thinking following numeracy interventions emphasize the potential for tailored educational programs to not only enhance mathematical proficiency but also promote higher-order cognitive skills. It is also supported by the research of Mononen, R. et al., the interventions of the early numeracy can lead mathematics improvement in the form of instructional design and context representation of in math contents.

The most intriguing revelation introduces the concept of synergistic effects. This finding challenges the notion of studying literacy and numeracy in isolation, suggesting that the combined integration of these skills may yield more profound outcomes. The mixed methods approach further elucidates the intricate dynamics at play, highlighting potential avenues for future research (Cheung et al., 2021)

The study by Douglas et al. (2020) provides a recent exploration into literacy in mathematics, particularly focusing on the understanding of symbols in mathematics is beyond just numbers. Their research, titled "Knowledge of Mathematical Symbols Goes Beyond Numbers," examines how mathematical orthography, the understanding of discrete mathematical symbols and how expressions and equations are put together using those symbols, plays a crucial role in individuals' mathematical skills. They completed a timed dichotomous symbol decision task to distinguish between conventional and non-conventional mathematical symbol combinations. This study indicated that mathematical symbol decision tasks could be helpful indices of symbol associations in mathematical development since they uniquely predicted individual variations in word problem-solving, fraction/algebra processes, and arithmetic. This emphasizes the importance of understanding and using the specific language, symbols, and notations of mathematics for engaging deeply with mathematical concepts.

Furthermore, the synthesis of findings contributes not only to the theoretical understanding of literacy, numeracy, and logical thinking but also holds practical implications for educators. The discussion emphasizes the need for an integrated approach in pedagogical strategies, encouraging further exploration into interdisciplinary teaching methods. As we advance in the discourse on mathematics education, these findings pave the way for future research endeavors aimed at refining educational practices and optimizing the development of logical thinking among students.

## CONCLUSION

To conclude, this study examined the relationship between literacy and numeracy as well as logical thinking. There is positive correlation between literacy numeracy and logical reasoning. Literacy in mathematics that focused on mathematical understanding went beyond the numbers. It has explored literacy component, such as reading, writing, and communication that has influenced on logical reasoning. In addition, numeracy skills and logical reasoning improved significantly followed by the integration of teaching practices. It is specifically integrated competences of literacy and numeracy towards

logical thinking. In essence, this study contributes not only to the ongoing discourse on foundational skills in mathematics education but also provides a roadmap for transformative advancements, aligning with the broader goals of enhancing the quality and relevance of education in an ever-evolving world. For the future research, study of literacy and numeracy must be studied for logical reasoning and critical thinking in specifically to obtain more in-depth studies in mathematics education.

## ACKNOWLEDGEMENT

The authors thank to the Institute for Research and Community Service of Ahmad Dahlan University (LPPM UAD) for the research, authorship, dan publication, especially for the financial support to this research.

## REFERENCE

Aiym, Y., Galiya, K., Ademi, B., Adilet, M., Kamshat, Z., & Gulmira, K. (2022). Development of the logical thinking of future mathematics teachers through the use of digital educational technologies. *Cypriot Journal of Educational Sciences*, *17*(6), 2001–2012. https://doi.org/10.18844/cjes.v17i6.7548

Australian Curriculum Assessment and Reporting Authority (ACARA). 2016. https://www.australiancurriculum.edu.au/f-10-curriculum/general-capabilities/numeracy/(accessed by February 13, 2024)

Bellini, D., Crescentini, A., Zanolla, G., Cubico, S., Favretto, G., Faccincani, L., Ardolino, P., & Gianesini, G. (2019). Mathematical Competence Scale (MCS) for Primary School: The Psychometric Properties and the Validation of an Instrument to Enhance the Sustainability of Talents Development through the Numeracy Skills Assessment. *Sustainability*, *11*(9), 2569. https://doi.org/10.3390/su11092569

Braeuning, D., Ribner, A., Moeller, K., & Blair, C. (2020). The Multifactorial Nature of Early Numeracy and Its Stability. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.518981

Cheung, S. K., Dulay, K. M., Yang, X., Mohseni, F., & McBride, C. (2021a). Home Literacy and Numeracy Environments in Asia. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.578764

Cheung, S. K., Dulay, K. M., Yang, X., Mohseni, F., & McBride, C. (2021b). Home Literacy and Numeracy Environments in Asia. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.578764

Cresswell, C., & Speelman, C. P. (2020). Does mathematics training lead to better logical thinking and reasoning? A cross-sectional assessment from students to professors. *PLOS ONE*, *15*(7), e0236153. https://doi.org/10.1371/journal.pone.0236153

Douglas, H., Headley, M. G., Hadden, S., & LeFevre, J.-A. (2020). Knowledge of mathematical symbols goes beyond numbers. *Journal of Numerical Cognition*, *6*(3), 322–354. https://doi.org/10.5964/jnc.v6i3.293

Idrissi, H., Engel, L., & Pashby, K. (2020). The Diversity Conflation and Action Ruse: A Critical Discourse Analysis of the OECD's Framework for Global Competence. *Comparative and International Education*, *49*(1), 1–18. https://doi.org/10.5206/cie-eci.v49i1.13435

Jablonka, E. (2015). The evolvement of numeracy and mathematical literacy curricula and the construction of hierarchies of numerate or mathematically literate subjects. *ZDM*, *47*(4), 599–609. https://doi.org/10.1007/s11858-015-0691-6

Jonas, N. (2018). Numeracy Practices and Numeracy Skills among Adults. *OECD Education Working Papers*. https://doi.org/10.1787/8F19FC9F-EN.

Kiss, A. J., Nelson, G., & Christ, T. J. (2019). Predicting Third-Grade Mathematics Achievement: A Longitudinal Investigation of the Role of Early Numeracy Skills. *Learning Disability Quarterly*, *42*(3), 161–174. https://doi.org/10.1177/0731948718823083

MacDonald, A., & Carmichael, C. (2018). Early mathematical competencies and later achievement: insights from the Longitudinal Study of Australian Children. *Mathematics Education Research Journal*, *30*(4), 429–444. https://doi.org/10.1007/s13394-017-0230-6

Maldonado Moscoso, P. A., Anobile, G., Primi, C., & Arrighi, R. (2020). Math Anxiety Mediates the Link Between Number Sense and Math Achievements in High Math Anxiety Young Adults. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01095

Manolitsis, G., Georgiou, G. K., & Tziraki, N. (2013). Examining the effects of home literacy and numeracy environment on early reading and math acquisition. *Early Childhood Research Quarterly*, *28*(4), 692–703. https://doi.org/10.1016/j.ecresq.2013.05.004

Mingjing, H., & Yidi, F. (2022). The Cultivation of Students' Logical Thinking in Chinese Primary School Mathematics Education. *IJECA (International Journal of Education and Curriculum Application)*, *5*(2), 190. https://doi.org/10.31764/ijeca.v5i2.10204

Mkhize, M. V. (2019). Transdisciplinary relationship between mathematics and accounting. *The Journal for Transdisciplinary Research in Southern Africa*, *15*(1). https://doi.org/10.4102/td.v15i1.451

Mononen, R., Aunio, P., Koponen, T., & Aro, M. (2014). A Review of Early Numeracy Interventions for Children at Risk in Mathematics. *International Journal of Early Childhood Special Education*, *6*(1), 25. https://doi.org/10.20489/intjecse.14355

Piper, B., Simmons Zuilkowski, S., Dubeck, M., Jepkemei, E., & King, S. J. (2018). Identifying the essential ingredients to literacy and numeracy improvement: Teacher professional development and coaching, student textbooks, and structured teachers' guides. *World Development*, *106*, 324–336. https://doi.org/10.1016/j.worlddev.2018.01.018

Prince, R., & Frith, V. (2020). An investigation of the relationship between academic numeracy of university students in South Africa and their mathematical and language ability. *ZDM*, *52*(3), 433–445. https://doi.org/10.1007/s11858-019-01063-7

Purpura, D. J., O'Rear, C. D., Ellis, A., Logan, J. A. R., Westerberg, L., Ehrman, P., King, Y. A., Vander Tuin, M., Nordgren, I., Anderson, K., Cosso, J., Zippert, E., Napoli, A. R., Hornburg, C. B., Schmitt, S. A., & Dobbs-Oates, J. (2024). Unique and combined effects of quantitative mathematical language and numeracy instruction within a picture book intervention: A registered report. *Journal of Educational Psychology*, *116*(1), 1–19. https://doi.org/10.1037/edu0000820

Rolison, J. J., Morsanyi, K., & Peters, E. (2020). Understanding Health Risk Comprehension: The Role of Math Anxiety, Subjective Numeracy, and Objective Numeracy. *Medical Decision Making*, *40*(2), 222–234. https://doi.org/10.1177/0272989X20904725

Rytilä, J. (2021). Social constructivism in mathematics? The promise and shortcomings of Julian Cole's institutional account. *Synthese*, *199*(3–4), 11517–11540. https://doi.org/10.1007/s11229-021-03300-7

Schoenfeld, A. H. (2016). Research in Mathematics Education. *Review of Research in Education*, *40*(1), 497–528. https://doi.org/10.3102/0091732X16658650

Sellar, S., & Lingard, B. (2013). The OECD and global governance in education. *Journal of Education Policy*, *28*(5), 710–725. https://doi.org/10.1080/02680939.2013.779791

Veenman, K., Tolboom, J. L. J., & van Beekum, O. (2022). The relation between computational thinking and logical thinking in the context of robotics education. *Frontiers in Education*, *7*. https://doi.org/10.3389/feduc.2022.956901

Yustitia, V., Siswono, T. Y. E., & Abadi. (2021). Numeracy of prospective elementary school teachers: a case study. *Journal of Physics: Conference Series*, *1918*(4), 042077. https://doi.org/10.1088/1742-6596/1918/4/042077

White, P., & Cranitch, M. (2010). The Impact on Final Year Pre-Service Secondary Teachers of a Unit in Teaching Literacy and Numeracy across the Curriculum. Australian Journal of Teacher Education, 35, 54-63. https://doi.org/10.14221/AJTE.2010V35N7.5.