



Cognitive Studies in Physics Education: A Systematic Review (2019-2023)

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<http://dx.doi.org/10.18415/ijmmu.v12i6.6910>

Abstract

This study provides a comprehensive review of cognitive aspects in physics learning and offers recommendations for future research opportunities for educators and researchers. Through a systematic literature review (SLR), this study analyzed 407 Scopus databases and successfully identified 63 relevant documents discussing cognitive skills in the context of physics learning. Further analysis of publication frequency, research methods employed, researchers' countries of origin indicates a declining trend in research interest in recent years, and the role of cognition in physics learning. Nevertheless, based on the 63 reviewed documents, Indonesia is recorded as the country with the highest research contribution in the field of cognitive aspects in physics learning. The dominance of qualitative methods in this research compared to quantitative methods, research and development (R&D), mixed methods, or classroom action research indicates a strong focus on a deep understanding of students' thinking processes during physics learning. These findings provide a solid foundation for further research in designing and developing various effective learning interventions, thereby improving the overall quality of physics learning.

Keywords: *Cognitive; Physics Learning; Synthesis Paper; Systematic Review*

Introduction

The study of physics, a discipline concerned with the exploration of natural phenomena, is often perceived as complex and abstract. This necessitates students to move beyond rote memorization of formulas and cultivate a deep understanding of underlying concepts. The cognitive approach in physics education has emerged as a pedagogical framework designed to foster a more robust comprehension of physics principles among learners. Students' cognitive styles, such as reflective and impulsive, illustrate the diverse ways in which individuals approach learning and problem-solving (Aini et al., 2019; Dwi Susandi et al., 2019; Warli & Nofitasari, 2021). By prioritizing critical thinking and conceptual understanding, this approach is anticipated to enhance students' ability to apply physics knowledge to real-world scenarios and to effectively solve problems (Ansori et al., 2020; Rahmawatingrum et al., 2019; Sole & Anggraeni, 2020).

The various complexities in physics learning do not limit the issue of gender in terms of understanding. Research has been conducted to determine whether there is a significant difference

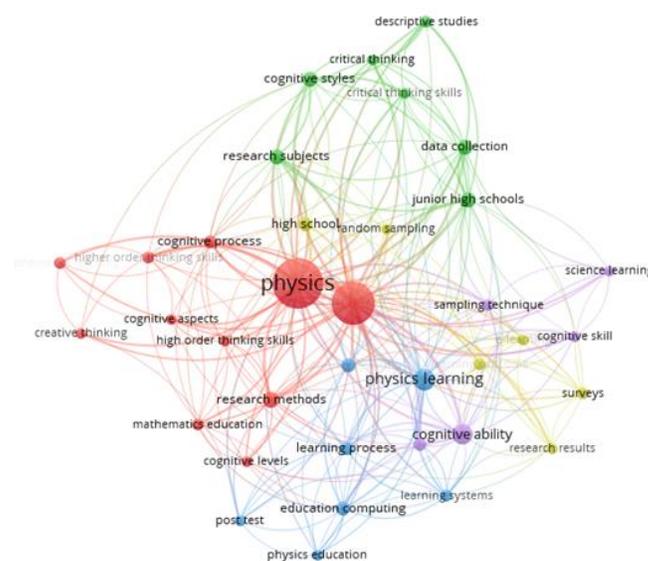
between the cognitive abilities of men and women, but research shows that there is no gender gap in physics learning (Aini et al., 2019). Various types of research methods that have been used to delve deeper into the issue of physics learning position physics as one of the sciences that is always developing following the development of science and technology in general over time.

The intricate nature of physics concepts has compelled researchers to explore more effective instructional strategies. The cognitive perspective, which centers on learners' cognitive processes, has emerged as a prominent focus in physics education research. Despite extensive research aimed at elucidating students' conceptual understanding and addressing misconceptions (Nisa et al., 2019; Sole & Anggraeni, 2020), challenges persist in physics learning.

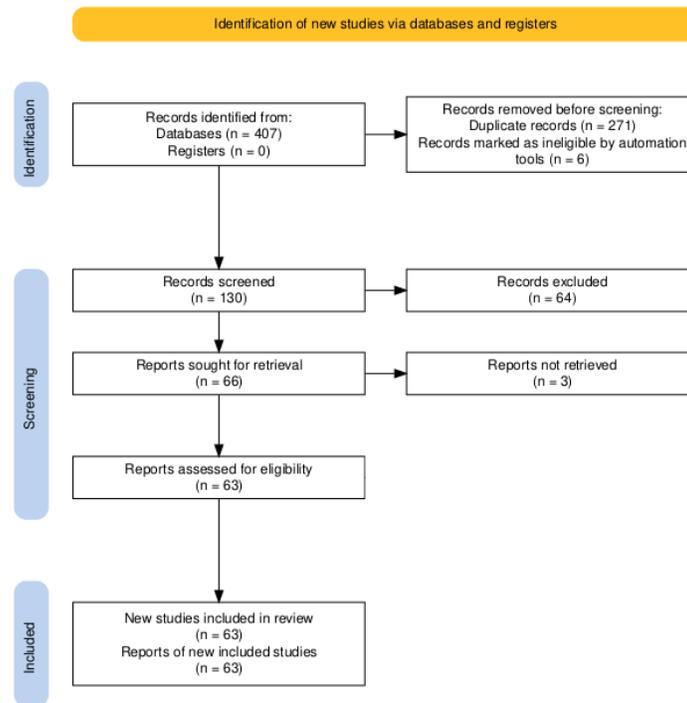
This review seeks to address the following research questions: (i) How has the trajectory of research on cognitive approaches in physics education evolved? (ii) What methodological approaches predominate in this research domain? (iii) Which nations have been at the forefront of this research endeavor?

Method

A systematic literature review was employed to compile relevant literature on cognitive processes in physics learning. The Scopus database was searched using the keywords "cognitive in physics learning," yielding 407 references published between 2019 and 2023. VOSviewer was utilized to visualize the co-occurrence of keywords, as depicted in Figure 2. An initial search identified 407 databases relevant to the research keywords. From this number, an initial screening was conducted to eliminate duplicate data and clearly irrelevant studies. As a result, 277 studies were excluded from the initial screening, leaving 130 studies for further assessment. The next screening stage was conducted manually. Each remaining study was evaluated based on its title and abstract to determine its relevance to the research topic. After a rigorous selection process, 64 studies were deemed irrelevant and excluded from the analysis. Thus, 66 studies were considered potential for inclusion in the study. Efforts were made to obtain full reports of the 66 studies deemed relevant. However, not all studies could find complete reports. Only 63 studies were found to have complete reports and met the established inclusion criteria.



Picture 1. Keyword Co-Occurrence Network Visualized By Vosviewer



Picture 2. SLR Using PRISMA Method

Results and Discussion

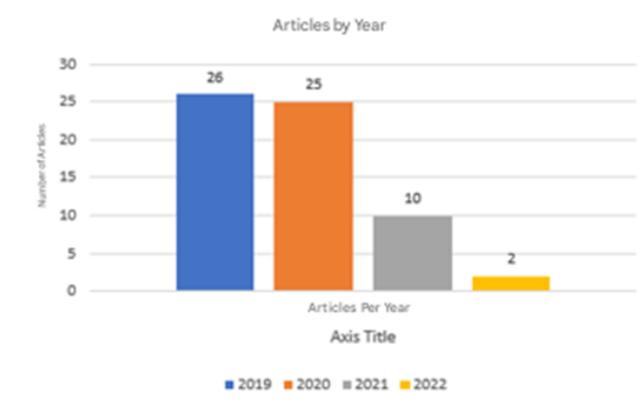
Results

In this study, based on the obtained results regarding cognitive research in physics learning over the past five years (2019-2023), the findings will be elaborated in accordance with the research objectives. The determination of appropriate keywords related to cognition in physics learning is crucial for obtaining relevant and high-quality references.

Annual Research Trends Related to Cognition from 2019-2023

Cognitive approaches in physics learning emerged as an effort to help students build a better understanding of physics concepts. Students' cognitive styles, such as reflective and impulsive. This shows how differences in students' thinking styles can affect how they learn and solve problems (Afriansyah et al., 2019; Aini et al., 2019; Dwi Susandi et al., 2019; Warli & Nofitasari, 2021) and focus on critical thinking and conceptual understanding, and improve students' abilities (Ansori et al., 2020; Rahmawatiningrum et al., 2019; Sole & Anggraeni, 2020). Many studies have investigated the relationship between cognitive skills and learning outcomes in various science subjects, especially mathematics and physics (Ansori et al., 2020; Dwi Susandi et al., 2019; Gunawan et al., 2021; Nisa et al., 2019; Rahmawatiningrum et al., 2019; Risna et al., 2020; Rohaeti, Hindun, et al., 2019; Rohaeti, Putra, et al., 2019; Saputra et al., 2020). Researchers have also explored how educational practices such as lesson study can be used to understand students' cognitive processes during learning (Susanto et al., 2020).

There has been a decreasing trend in research on cognitive approaches in physics education from 2019 to 2023. The highest number of publications was recorded in 2019 (n=26), followed by a subsequent decline. This suggests a shift in research focus within the field of physics education across different countries. Figure 2 presents the development of research on cognition in physics learning.



Picture 3. Documents On Cognition in Physics by Year

The Diversity of Research Methodologies Employed in Cognitive Studies of Physics Learning

The variety of research methods focusing on cognitive aspects in physics learning indicates a diversity of approaches used by researchers to investigate and understand how students' cognitive processes develop in the context of physics learning. Based on the analysis of several studies from 2019 to 2023, qualitative approaches dominate research on cognition in physics learning. This is evident from the higher frequency of using qualitative methods compared to quantitative methods, research and development (R&D), classroom action research, and mixed methods. This diversity of methods provides a more comprehensive picture of the complexity of student-centered physics learning and the effectiveness of various teaching strategies implemented. The diversity of research methods related to cognition in physics learning is shown in Table 1.

Every research methodology possesses distinct attributes and offers unique contributions to comprehending phenomena. Qualitative inquiry enables an in-depth exploration of the meanings and experiences of individuals within rich contexts. Quantitative research, with its capacity for generalization, is particularly valuable for uncovering general patterns and testing hypotheses. In contrast, Research and Development (R&D) is centered on applying knowledge to develop innovative solutions. Classroom action research (CAR) is focused on enhancing teaching practices. Mixed methods, by integrating the strengths of both qualitative and quantitative approaches, provide a more holistic perspective. Concurrently, literature reviews serve as a robust foundation for research by offering a comprehensive understanding of the relevant literature.

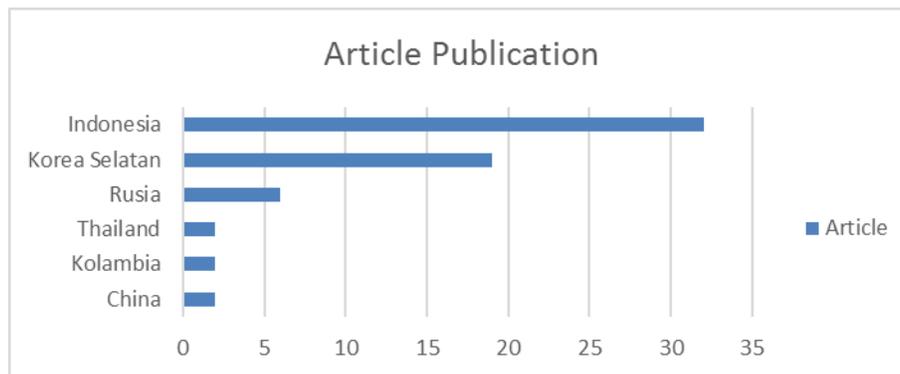
This research found that qualitative methods are the primary tool for investigating cognitive aspects of physics learning, highlighting researchers' interest in understanding the nuances of students' thinking processes. While qualitative methods provide rich, contextualized data, quantitative methods complement these by offering empirical evidence that can be generalized to larger populations.

Table 1. Various Methods Used in Cognitive Approaches to Physics Learning

Method	Quantity
Qualitative	40
Quantitative	20
R & D	1
Class Action assessment	1
Mixed Methods	1

Nations that Have Made Substantial Contributions to the Field of Cognitive Research in Physics Education

The substantial body of research suggests the potential for developing more effective physics learning models that are aligned with students' cognitive characteristics. It also underscores the keen interest among researchers in these countries to gain a deeper understanding of the cognitive processes underlying physics learning. Indonesia ranks first with the highest number of publications, at 32 articles. This indicates Indonesia's significant research activity and interest in this field. South Korea follows closely with 19 publications, signifying this country's substantial contributions to research on cognition in physics learning. Other countries such as Russia, Thailand, Colombia, and China have also contributed, although their publications are fewer than those of Indonesia and South Korea. The evolution of research related to cognition in physics learning is depicted in Figures 4 and 5.



Picture 4. Documents related to cognition in physics education, categorized by country.

Conclusion

A review of 63 articles published from 2019 to 2023 on cognition in physics education shows an increasing trend each year. Among several research methods, qualitative methods were more frequently used in cognitive research in physics education, followed by quantitative methods, research and development (R&D), classroom action research, and mixed methods. This research affirms the importance of understanding students' cognitive processes in physics learning to improve learning effectiveness.

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