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The Evolution of Higher-Order Thinking Skills (HOTS) Research in Education: A Bibliometric Study

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ABSTRACT

This study aims to examine the evolution of Higher-Order Thinking Skills (HOTS) research in education through a bibliometric approach. The study analyzes scientific publications indexed in major academic databases over a specific period using bibliometric techniques such as co-occurrence, overlay visualization, and density mapping through VOSviewer software. The results show that HOTS research has experienced significant development, with a primary focus on pedagogical aspects, particularly on students, learning strategies, and critical thinking. The co-occurrence analysis reveals that core themes such as higher-order thinking skills, students, and education dominate the research landscape, reflecting a significant focus on the learning process. Temporal visualization reveals a shift from basic educational concepts to more innovative approaches such as problem-based learning and technology-based learning. Recent trends demonstrate increasing attention to the integration of digital technologies, such as artificial intelligence and deep learning, in HOTS development. Meanwhile, the density analysis indicates that although traditional pedagogical themes remain dominant, new topics related to technology and assessment offer broad research opportunities. Overall, this study provides a comprehensive mapping of the intellectual structure and trends of HOTS research and suggests directions for future research in educational innovation and policy.

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1. INTRODUCTION

Education in the 21st century increasingly emphasizes developing students who are able to think critically, creatively, and analytically when facing complex problems [1], [2]. These competencies are often framed within the concept of Higher-Order Thinking Skills (HOTS), which refers to cognitive processes that go beyond memorization and basic understanding [3]. HOTS involve skills such as analyzing, evaluating, synthesizing, and creating new knowledge from existing information. This idea stems from a taxonomy of educational objectives proposed by educational psychologists, which classifies thinking skills into hierarchical levels ranging from low-level to high-level processes [4], [5]. In modern educational discourse, the development of HOTS has become a primary goal because society needs individuals who are able to solve new problems, make

informed decisions, and adapt to rapid technological and social changes [6], [7].

The integration of HOTS into education systems has been significantly driven by global educational reforms. Many countries have revised their curricula to incorporate inquiry-based learning, problem-based learning, and other pedagogical strategies aimed at fostering deeper cognitive engagement. International assessments, such as those evaluating students' reasoning and problem-solving abilities, have also contributed to increased attention to higher-order thinking in the classroom. Educators and policymakers are increasingly recognizing that traditional teaching approaches emphasizing rote learning are insufficient to prepare students for complex, real-world challenges. Consequently, research on HOTS (Higher Order Thinking Skills) has expanded significantly, exploring areas such as instructional design, assessment methods, teacher competencies, and the role of technology in fostering higher-order thinking [8], [9].

Over the past few decades, scholarly interest in HOTS has grown across various disciplines in educational research. Studies have examined how teaching strategies such as collaborative learning, project-based learning, and digital learning environments can stimulate higher-order cognitive processes in students. Other research has focused on developing assessment instruments capable of measuring analytical and evaluative thinking rather than simply memorizing information. Furthermore, the rapid advancement of digital technology and the expansion of online learning environments have opened up new possibilities for developing HOTS (Higher Order Thinking Skills) through interactive simulations, adaptive learning systems, and data-driven instructional approaches. This diversification of research themes demonstrates that HOTS is not only a pedagogical concept but also a growing, multidisciplinary field of research [10], [11].

Despite the growing body of literature on HOTS, the development of this research field is not always systematically mapped. Educational studies often focus on specific teaching strategies, subject areas, or educational levels without examining broader patterns of research development over time. As the number of publications increases, it becomes increasingly difficult for scholars to identify key research trends, influential authors, dominant themes, and emerging topics within the HOTS domain. Understanding these patterns is crucial because it allows researchers to evaluate how knowledge in this field has evolved, identify gaps in the literature, and determine potential directions for future research.

Bibliometric analysis offers a powerful methodological approach for examining the evolution of scientific research in a specific field. By analyzing publication data such as authorship patterns, citation networks, keywords, and research collaborations, bibliometric studies can reveal the intellectual structure and development trajectory of a research field. This approach has been widely used to explore trends in various educational topics, providing insights into how research communities are formed and how knowledge flows between institutions and countries. Therefore, applying bibliometric analysis to HOTS research can provide a comprehensive picture of how scholarly attention to higher-order thinking has evolved, which topics dominate the literature, and how research networks have evolved over time. Such insights are valuable not only for researchers but also for educators and policymakers seeking evidence-based guidance for improving educational practice.

Although research on Higher-Order Thinking Skills has grown rapidly in recent decades, the overall development and structure of this field of knowledge remains underexplored. Many studies investigate HOTS within specific contexts, such as specific subjects, teaching methods, or educational levels, but relatively few have attempted to chart the broader evolution of HOTS research across time, disciplines, and geographies.

2. METHOD

This study uses a bibliometric research design to examine the development and evolution of research on Higher Order Thinking Skills (HOTS) in education. Bibliometric analysis is a quantitative approach used to analyze patterns in scholarly publications, including trends in research output, citation structures, and collaborative networks among academics. This method allows researchers to systematically map the intellectual landscape of a research field and identify its development over time. In this study, bibliometric techniques are used to explore the growth of publications, influential authors, key journals, and thematic developments related to HOTS research. By applying this approach, this study aims to provide a comprehensive overview of how scholarly discussions on HOTS have evolved in educational research.

Data for this study were collected from major academic databases that index peer-reviewed journal articles and conference proceedings related to education and the learning sciences. The search was conducted using keywords related to "Higher-Order Thinking Skills" and "HOTS" in the title, abstract, and author keywords. To ensure relevance and consistency, only publications related to the educational context were included in the dataset. After the initial data collection process, the data were screened to remove duplicate records and documents not directly related to the research topic. The final dataset consisted of selected publications that represent the literature on HOTS research within a specific timeframe.

3. RESULT AND DISCUSSION

3.1 Result

a. Keyword Co-Occurrence Analysis

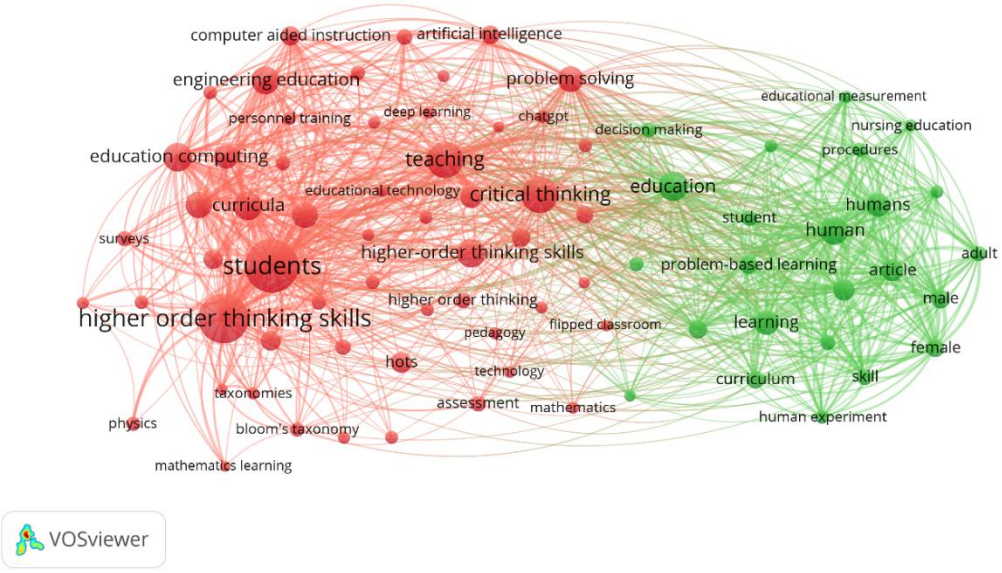

Figure 1. Network Visualization
Source: Processed Data

Figure 1 aboveshows the intellectual structure of Higher-Order Thinking Skills (HOTS) research, which is divided into two main clusters: the red cluster and the green cluster. The red cluster appears denser and focuses on core concepts such as higher-order thinking skills, students, critical thinking, and teaching. This indicates that most HOTS research focuses on pedagogical contexts, particularly how higher-order thinking skills are developed through classroom learning processes. The dominance of nodes such as students indicates that learners are the primary subjects of this research. The red cluster also shows a strong link between HOTS and learning approaches and

technologies, such as educational technology, artificial intelligence, deep learning, and chatGPT. This indicates that recent research is beginning to integrate digital technology and artificial intelligence in HOTS development. Furthermore, the emergence of terms such as engineering education and computer-aided instruction indicates that HOTS implementation is not limited to general education but also extends to technical and vocational education.

Meanwhile, the green cluster focuses more on aspects of implementation, evaluation, and the human context in education. Keywords such as education, learning, curriculum, problem-based learning, and educational measurement indicate that research in this cluster emphasizes how HOTS skills are integrated into the curriculum and how these skills are measured and evaluated. The presence of terms such as human, male, female, and adult indicate that research also considers demographic characteristics in the learning process. The relationship between the two clusters demonstrates a strong integration between conceptual and implementation approaches in HOTS research. Connecting nodes such as critical thinking, education, and learning serve as bridges connecting pedagogical theory with educational practice. This reflects that HOTS research develops holistically, not only at the theoretical level but also in real-world applications across various educational contexts, including problem-based learning and the flipped classroom.

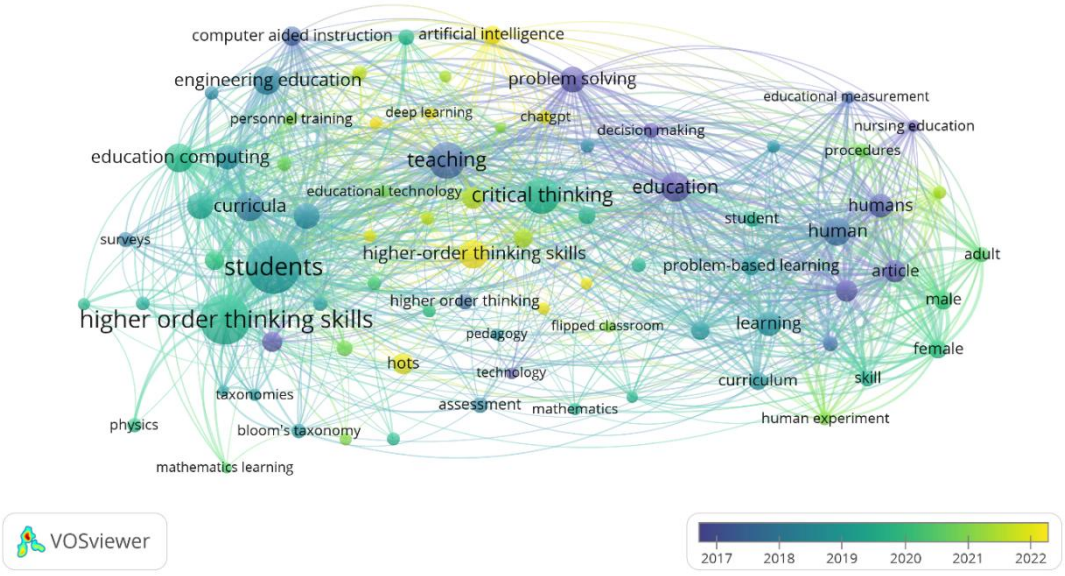

Figure 2. Overlay Visualization
Source: Processed Data

Figure 2 aboveshows the temporal development of Higher-Order Thinking Skills (HOTS) research from 2017 to 2022, marked by a color gradation from blue (older) to yellow (newer). In the initial phase (around 2017–2018), research was dominated by basic topics such as education, humans, learning, and curriculum. This indicates that HOTS research in the early period still focused on the conceptual foundations and general context of education, including a basic understanding of the learning process and student characteristics. Entering

the middle period (2019–2020), there was a shift in focus towards more specific pedagogical aspects, such as teaching, critical thinking, problem solving, and higher-order thinking skills themselves. The green color that dominates these nodes indicates increasing attention to learning strategies that can develop HOTS directly in the classroom. In addition, approaches such as problem-based learning and flipped classrooms began to emerge as innovative methods that support the strengthening of higher-order thinking skills.

In the most recent period (2021–2022), marked in yellow, research has begun to focus on integrating technologies into HOTS development, such as artificial intelligence, deep learning, and chatGPT. Furthermore, terms like educational technology and assessment have become increasingly prominent, highlighting the importance of technology for not only learning but also for HOTS evaluation. This trend confirms the evolution of HOTS research toward a more digital, adaptive, and innovation-driven approach, in line with the demands of education in the era of digital transformation.

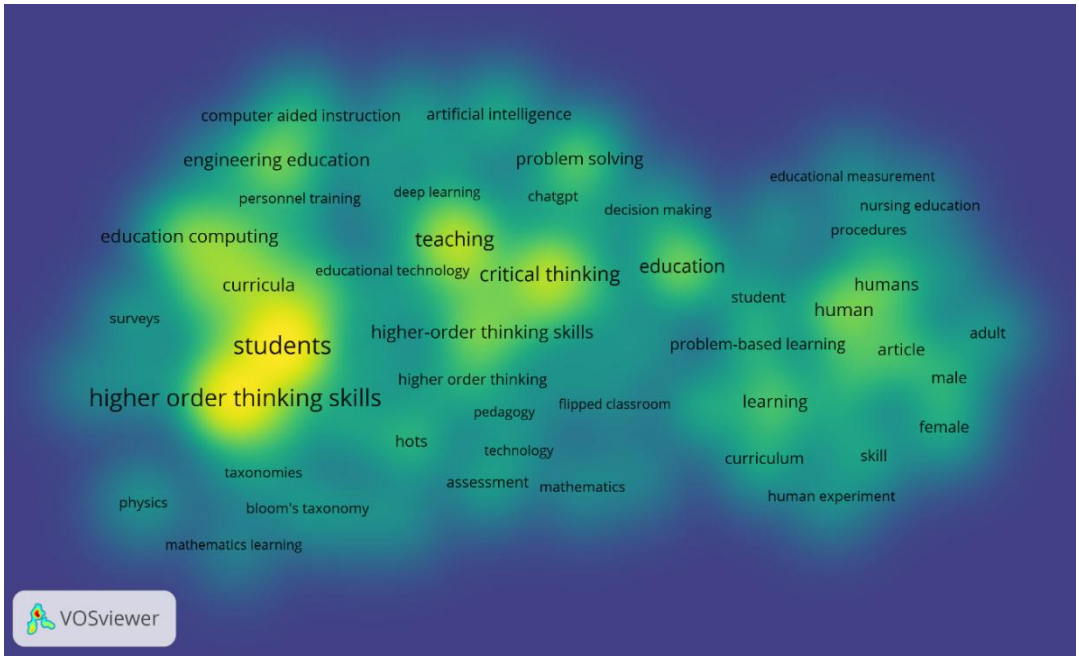

Figure 3. Density Visualization
Source: Processed Data

Figure 3 aboveshows the density of keyword occurrences and their relevance in Higher-Order Thinking Skills (HOTS) research. Areas with bright yellow, particularly for the keywords "students" and "higher-order thinking skills," indicate that these two concepts are central to the existing literature. This indicates that most HOTS research focuses on students as the primary subject and on the development of higher-order thinking skills themselves. Furthermore, keywords such as "critical thinking," "teaching," and "education" also appear in areas with relatively high intensity, indicating that pedagogical aspects and the learning process are an important focus in this study.

Meanwhile, areas with green to blue colors indicate relatively less dense or still developing topics, such as artificial intelligence, deep learning, chatGPT, and approaches like problem-based learning and flipped classroom. This indicates that the integration of technology and learning innovation in the context of HOTS is a newer research direction and still has significant potential for development. Furthermore, the emergence of terms such as "educational measurement" and "assessment" in areas with medium density indicates attention to HOTS evaluation, although it has not yet become a dominant focus.

b. Citation Analysis

Table 1. Most Cited Article

Citations	Author and Year	Title
866	[12]	A SWOT analysis of ChatGPT: Implications for educational practice and research
851	[13]	Education and thinking: The role of knowledge
686	[14]	Education for life and work: Developing transferable knowledge and skills in the 21st century
469	[15]	Development of systems thinking skills in the context of earth system education
435	[16]	Changing how and what children learn in school with computer-based technologies
396	[17]	Higher order thinking skills and low-achieving students: Are they mutually exclusive?
384	[18]	Problem-Based Learning
367	[19]	Purposely teaching for the promotion of higher-order thinking skills: A case of critical thinking
349	[20]	Problem solving by 5-6 years old kindergarten children in a computer programming environment: A case study
339	[21]	What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms?

Source: Scopus, 2026

3.2 Discussion

The discussion of the results of this bibliometric analysis indicates that research on Higher-Order Thinking Skills (HOTS) in education has developed significantly and has an increasingly complex intellectual structure. Based on the co-occurrence map, it is clear that core concepts such as higher-order thinking skills, students, critical thinking, and teaching have become the focus of attention in the literature. This confirms that HOTS development is still very much oriented towards the learning process and the role of students as the main subject. This dominance of pedagogical themes indicates that research focuses more on how learning strategies can improve higher-order thinking skills, compared to other aspects such as policies or the education system at a macro level.

HThe cluster visualization results demonstrate the integration of pedagogical approaches with technological developments. The emergence of keywords such as artificial intelligence, deep learning, and chatGPT indicates that HOTS research is beginning to transform toward digitalized learning. This technological integration not only enriches learning methods but also opens up new opportunities for developing critical and creative thinking skills. However, based on the density map, these technology-

based topics are still at a lower density, indicating that this field is still relatively new and has not been explored in depth.

From a temporal perspective, overlay visualization analysis indicates a shift in research focus from conceptual aspects to more applicable and innovative implementations. In the initial phase, research focused more on basic educational concepts and learning characteristics. Subsequently, the focus shifted to developing learning strategies such as problem-based learning and flipped classrooms. In the most recent period, research trends have shifted toward utilizing digital technology to support HOTS. This shift reflects the dynamic development of education, which is adapting to changing times, particularly in facing the challenges of the digital era and the industrial revolution 4.0.

The analysis also shows that HOTS evaluation aspects, such as assessment and educational measurement, are beginning to receive attention, although they have not yet become a primary focus. This indicates a research gap that needs to be addressed, particularly in the development of evaluation instruments capable of validly and comprehensively measuring HOTS. Appropriate evaluation is key to ensuring that HOTS development occurs not only at the conceptual level but also can be measured and implemented effectively in educational practice. The findings of this study confirm that HOTS research is in a transition phase toward a more integrative, innovative, and technology-based approach. Nevertheless, significant opportunities remain for research development, particularly in deeper technology integration, strengthening evaluation methods, and exploring more diverse educational contexts.

4. CONCLUSION

Based on the results of the bibliometric analysis, it can be concluded that research on Higher-Order Thinking Skills (HOTS) in education has developed dynamically with an increasingly complex and multidisciplinary scientific structure. The main focus of research is still dominated by pedagogical aspects that emphasize the role of students, the learning process, and the development of critical thinking, but is gradually shifting towards the integration of technologies such as artificial intelligence and digital learning innovations. Furthermore, although attention to HOTS evaluation is starting to increase, this aspect still requires further strengthening. The evolution of HOTS research shows a direction that is increasingly adaptive to the demands of 21st-century education, while also opening up broad opportunities for further research in the development of more comprehensive evaluation methods, technologies, and systems.

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