








Bibliometric Analysis of Higher-Order Thinking Skills: An Increasing Important Competency

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Abstract. This research aims to analyze trends and determine whether developing new educational values that emphasize higher-order thinking skills is possible. The data source in this study is Google Scholar. The keywords used are Higher-order Thinking Skills, Problem-Based Learning, and 21st Century Skills until 2022. After the data is collected, a bibliometric analysis is performed. The results showed that based on data collection conducted for 28 years (1995-2022), 996 journals were obtained. Research on HOTS as a whole is experiencing an increasing trend. Since 2007, research on HOTS has increased yearly. The highest in 2021 was 189 journals, even though there was a decrease in publications in 2022 to 164 journals. There are 6 clusters, with 63 items, the highest occurrence rate, a 'problem' occurring 837 times, and a link strength of 1.306. The development of research on HOTS has become an exciting and essential topic in education, psychology, neuroscience, and other social science fields. HOTS refer to the ability to think critically, creatively, and analytically, and different HOTS involve complex problem-solving, abstract reasoning, information synthesis, and conceptual understanding.

Keywords: 21st Century Skills, Higher-Order Thinking Skills, Problem-Based Learning.

1 INTRODUCTION

The Industrial Revolution 4.0 is expected to bring changes to everyday human life that will become a mainstay of community needs in the future [1]. As a form of effort to solve problems in society in the future, students must be able to demonstrate critical thinking skills and be creative in building, using, and applying information about the surrounding environment. As an effort so that students can develop these competencies for society in the future, a type of teaching is needed that can give them the ability to have initiative, dare to be different in terms of thinking, and present a sense of freedom to find out.

The ability to think is a skill that students must possess; problem-based learning is a learning model that involves students working in groups or small groups, which spurs

them to have the ability to think in analyzing, integrating, and solving problems [2]. To solve problems faced now and in the future to have Higher-Order Thinking Skills (HOTS), Problem-Based Learning (PBL) skills will train students. HOTS are essential learning outcomes in education [3]. The core problem in the 21st Century is HOTS. In this Century, individuals will face HOTS as the influence of PBL on 21st-century learning with unusual problems, uncertainties, and dilemmas. When they succeed in having these skills, students can be critical, logical, reflective, metacognitive and creative [4].

HOTS are also called metacognitive abilities [5]. That is, a person will know when to control the chosen plan, be able to monitor and evaluate progress, be adaptable and flexible, and solve problems in various contexts. Therefore, someone with HOTS can analyze, evaluate, and create and have control over the chosen plan. Even this skill makes him able to adapt to various contexts. Based on the Program for International Student Assessment (PISA) survey conducted by the Organization for Economic Cooperation and Development (OECD), the average score of Indonesian students is still low, ranking 69 out of 76 countries, with relatively high-order thinking. So, it is necessary to apply action in the cognitive dimension to positively impact the HOTS that students must have, given the importance of these skills in the 21st Century. Improving HOTS can be done by starting learning that presents a problem or questions through a problem-based learning model. Then, students are given time to think together to find information and develop existing problem-solving strategies. Issues are presented at the beginning of learning and serve as a stimulus for learning activities.

With the many benefits derived from this learning, this research will analyze trends and determine whether it is possible to develop new values in the field of education that emphasize higher-order thinking skills. Nine hundred ninety-nine studies will discuss higher-order thinking skills, problem-based learning, and 21st-century skills published until 2022. This study aims to conduct bibliometric reflection and visualize research trends on the topics discussed.

2 METHODS

The data source in this study is Google Scholar. The keywords used are Higher-Order Thinking Skills, Problem-Based Learning AND 21st Century Skills, until 2022. Based on data collection conducted for 28 years (1995-2022), 999 journals were obtained, but three journals did not have complete data, so they were excluded from the research data. So that the data to be analyzed in this study amounted to 996 journals.

A helpful method is bibliometric analysis to analyze the production of publications and scientific research trends in various research fields by grouping the metadata obtained from indexing journal databases and assessing the results obtained [6]. The bibliometric analysis provides a quantitative method for reviewing and reviewing existing literature in each field [7], where one can obtain detailed information such as author, keywords, Journal, country, institution, references, etc. Thus, the development of a field can be accessed through bibliometric analysis based on modern computer technology [8]. Graphical and visual results can complement the study of the literature.

In addition, bibliometric analysis is also commonly used to monitor research development on a particular topic. This method is often used in literature research and statistical mathematics and statistics to identify patterns in scientific works. Bibliometric analysis is a systematic and rigorous approach to identifying qualitative and quantitative changes in research topics [9].

The highest number of publications regarding HOTS was in 2021, with a total journal of 189. In the previous year's development, this research developed slowly. The development of this research is due to the implications of Piaget and Vygotsky's constructivist theories that educational instructions should not hinder the learner's initiative and the determination of each individual's destiny. The essence of cognitive theory is to make each individual a creative learner who can build on his knowledge. Learning is a social event that must occur because of group work and collaboration with more capable individuals. This theory suggests that people construct their understanding and knowledge of the world by testing ideas and approaches based on prior knowledge and experience. One of the essential teaching techniques teachers can focus on and relate to Piaget and Vygotsky's theory for different educational settings is problem-based learning [10].

3 RESULTS AND DISCUSSION

Metadata results from HOTS are published on the Google Scholar database using Publish or Perish and VosViewer. The years used in this study are 28, from 1995 to 2022. The number of journals obtained was 996 documents, totalling 40,177 citations. The average number of citations per year is 1,434,89, and the number of citations per Journal is 40,22. The average number of authors per Journal is 2,49, with an H-Index of 91 and a G-Index of 179.

Research on this topic has started to develop since 1995. In recent years, considerable discussion has been about the quality and quantity of education provided. There has been a call to change the curriculum for entry-level students and a plea for innovative teaching techniques [11]. From 1995 to 2006, research began to grow even though the early years showed no research had been conducted. Since 2007, research topics have started to discuss skills such as critical thinking, reflective inquiry, and team learning were identified as essential for workplace PBL [12], A problem-based learning model: Showcasing an educational paradigm shift [13] and developing the topic relating to improving and extending learning.

Research on HOTS as a whole is experiencing an increasing trend; since 2007, that topic research has increased yearly. There has been a significant increase in research; in 2007, there were ten journals; in 2021, there were 189 journals, even though there was a decrease in 2022 to 164 journals. Table 1 shows the total number of citations from the top 10 journals with the highest citations.

Research with 3,196 citations from 2006 suggests that the study reviews several of the most popular inductive teaching methods, including inquiry, problem-based, project-based, case-based, discovery, and just-in-time teaching. The study describes each

method, compares them, and reviews the effectiveness of the research. Inductive strategies are consistently at least as effective as deductive methods for reaching a wide range of learning objectives, while the strength of the evidence varies [14].

Table 1. Top 10 Citation in Higher-Order Thinking Skills' Publications.

No.	Cites	Title	Year	Authors
1	3.196	Inductive Teaching and learning methods: Definitions, comparisons, and research bases	2006	MJ Prince, RM Felder [14]
2	1.753	A comparative analysis of international frameworks for 21st-century competencies: Implications for national curriculum policies	2012	J Voogt, NP Roblin [15]
3	1.079	Teaching critical thinking and Problem-solving skills	2008	LG Snyder, MJ Snyder [16]
4	1.076	A review of laboratory instruction styles	1999	DS Domin [17]
5	852	Educational video game design: A review of the literature	2007	MJ Dondlinger [18]
6	730	Seamless flipped learning: a mobile technology-enhanced flipped classroom with effective learning strategies	2015	GJ Hwang, CL Lai, SY Wang [19]
7	617	Learning about Problem-based learning: Student Teachers integrating technology, pedagogy and content knowledge	2009	HJ So, B Kim [20]
8	584	Boundary crossings: Cooperative learning, collaborative learning, and problem-based learning.	2014	N Davidson, CH Major [21]
9	567	Problem-based learning: Influence on students' learning in an electrical engineering course	2011	A Yadav, D Subedi, MA Lundeberg [22]
10	561	Problem-based learning: Where did it come from, what does it do, and where is it going?	1997	SA Gallagher [23]

National curricula must adapt dramatically to meet 21st-century competencies. Horizontal coherence was found between frameworks on 21st-century competencies and their importance. Practice and intentions were still far apart, showing vertical consistency issues. Implementing 21st-century competencies in national curriculum policies has ramifications and recommendations [15]. In 2016, the last seven years of high-cited research, they explained that Critical Based Learning (CBL) is a teaching approach used in medical areas to apply theory to practice using human cases. The effects of CBL range from knowledge gains to patient care outcomes [24].

Network visualization shows node links and interactions. The network visualization from this study is shown in Figure 1 and Figure 2. Complex nodes and interactions are common in networks. Complex data can be simplified by graphing it. Each graph point in Figure 1 indicates a cluster member. More friends have bigger knots, while less attached members have smaller ones. Then, the lines linking nodes show cluster member relationships. Closer nodes are connected. The nodes' colours and sizes in the Figure show cluster members' traits. Central entities are cluster members with links or in the centre of the network with many nodes. It influences this cluster and helps maintain social relationships.

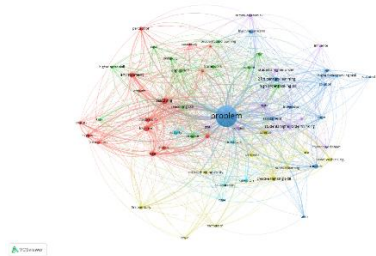


Fig. 1. Network Visualization of Higher-Order Thinking Skills' Keyword.

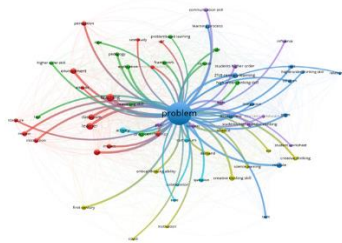


Fig. 2. Network Visualization of Higher-Order Thinking Skills' Term.

The clusters in this study group have many scientific papers with similar qualities or trends. Clustering identifies theme patterns or research trends in scientific journals. Analyzing publication linkages and similarities might reveal a study field's structure and dynamics. This study uses keyword clustering to organize publications by keyword similarity or linkage in the journals sampled. There are 6 clusters, with Cluster 1 containing 15 keywords: attitude, case study, classroom, content knowledge, environment, influence, instruction, learner, literature, perception, review, self, teaching, technology, and use. Cluster 2 has 12 connected items. Clusters 3 to 5 have 12, 10, and 9 pieces. Engineering, impact, importance, mathematics, paper, science, stem, and technology are understudied in HOTS cluster 6. Research on themes with few keywords can be expanded.

Figure 2 illustrates a phenomena or event's highest frequency. Identifying the most common keywords in a text or document is called text analysis. HOTS overlay graphic indicates recent related word research. HOTS research has dominated since 2018. This issue will be easier to explore with new research. Overlapping visualizations can assist in uncovering patterns and fluctuations in periodic data across several years. Different colours signify groups or the research topic, and blue to yellow represents time.

There are two variants of density visualization. To discuss the technical implementation of density visualization. In item density visualization, items are represented by their labels in the same way as in-network and overlay visualization. Each point on the item density visualization has a colour that indicates the item density at that point [25].

The colour of a point in the visualization is obtained by mixing the colours of different clusters. The weight given to the colour of a particular cluster is determined

by the number of items belonging to that cluster in the neighbourhood of the point. Like in the item density visualization, the weight of an item is taken into account as well.

The development of research on HOTS has become an exciting and essential topic in education, psychology, neuroscience, and other social science fields. HOTS refer to the ability to think critically, creatively, and analytically, and different HOTS involve complex problem-solving, abstract reasoning, information synthesis, and conceptual understanding. Studies explore how higher-order thinking skills can be taught and applied in various fields of education, including mathematics, science, literature, arts, etc.

Metacognition, critical thinking, creative thinking, cognitive processes, core thinking skills, and subject-specific knowledge as determinants of thinking skills programs [26]. Successful approaches to teaching thinking skills include cognitive acceleration and brain-based approaches, which can help escalate the achievement standards and create thinking students, thinking classrooms, thinking curricula, and thinking schools [27].

A meta-analysis of problem-based learning can improve critical skills in solving problems. With problem-based learning, students can develop ideas to challenge what is being studied (physics, biology, and chemistry) [28]. The 21st-century learning measure requires good basic reasoning aptitudes to develop high-order thinking abilities (HOTS). Critical thinking helps students solve social, intellectual, and practical problems. A problem-based learning paradigm can help students improve HOTS by engaging in critical thinking [29].

Teachers may analyze how they implement curricula, interpret educational standards and program goals, and collaborate on the relevance of critical thinking across disciplines as part of their professional development. In doing so, educators should adopt a good mix of teacher-centred and student-centred learning, focus on process rather than output, thinking rather than learning, what is needed rather than what is convenient, and examine what happened in the past and how it affects what is happening now to predict what will be needed in the future. This curriculum may help students become critical thinkers who can contribute to a dynamic global community [25].

4 CONCLUSIONS

This study examines trends to evaluate if HOTS-focused educational values may be created. Based on Google Scholar examination of Higher-Order Thinking Skills, Problem-Based Learning, and 21st Century Skills. The results confirmed that this investigation covered 28 years, from 1995 to 2022. The 996 journals yielded 40.177 citations. Average annual citations are 1.434,89, and journal citations are 40,22. The average Journal author count is 2,49, with an H-Index of 91 and a G-Index of 179.

There has been much discussion concerning education quality and quantity since 1995. There have been calls for entry-level curriculum changes and creative teaching methods. From 1995 to 2006, research increased despite limited effort. Workplace PBL abilities like critical thinking, reflective inquiry, and team learning have been studied since 2007. Problem-based learning: Changing education and extending learning. This

study reviews several of the most popular inductive teaching methods, including inquiry learning, problem-based learning, project-based learning, case-based learning, discovery learning, and just-in-time teaching, according to research with 3.196 citations from 2006.

Complex data can be simplified by graphing it. The network visualization reveals that those with more friendships have larger knots, and those with fewer have smaller knots. The lines linking nodes show cluster member relationships. Connections increase with node proximity. This study has 6 clusters. Activity, collaboration, curriculum, inquiry, and time are rarely studied in HOTS cluster 6. Research on clusters with few terms can be expanded.

HOTS appears 837 times for a connection strength of 1.306. Clusters of keywords are then correlated with these keywords. A multi-period overlay graphic can reveal patterns and variations in data. Different colours signify groups or the research topic, and blue to yellow represents time. Creative, analytical, sophisticated, abstract, and critical problem-solving, information synthesis, and conceptual comprehension are HOTS. Studies evaluate HOTS instruction in math, science, literature, art, and other subjects.

Current knowledge is represented by bibliometric analysis publications. Therefore, this paper's findings apply to this field.

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