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THE DEVELOPMENT OF HIGHER-ORDER THINKING SKILLS ASSESSMENTS: A BIBLIOMETRIC ANALYSIS

تطوير تقييمات مهارات التفكير العليا: تحليل ببليومتري تطوير تقييمات مهارات التفكير العليا: تحليل ببليومتري

Le développement des évaluations des compétences de pensée de haut niveau : une analyse bibliométrique

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الملخص:

يكتسب تطوير تقييمات مهارات التفكير العليا (**HOTS**) أهمية متزايدة في التعليم الحديث لمواكبة التحديات العالمية المتزايدة التعقيد. تحلل هذه الدراسة الببليومترية اتجاهات البحث حول تقييم **HOTS** خلال الفترة 1988–2024، اعتمادًا على بيانات قاعدة **Scopus**. يركز التحليل على الاتجاهات الاستشهادية، التوزيع الجغرافي، تصنيفات المجلات، والمواضيع البحثية الرئيسة. تُظهر النتائج تزايدًا ملحوظًا في المنشورات منذ 2019، مع تصدر إندونيسيا وماليزيا والولايات المتحدة في الإنتاج البحثي. كما يبرز تعاون بحثي مكثف بين دول جنوب شرق آسيا والغرب، مما يعكس شبكة دولية قوية. تنشر الأبحاث في الغالب في مجلات مصنفة ضمن **Q1** و**Q2**، مما يعكس جودة عالية. تشمل المحاور الرئيسة تطوير أدوات التقييم، استراتيجيات التعلم النشط، ودمج التفكير النقدي والإبداعي في المناهج. تشير الاتجاهات الناشئة إلى تزايد استخدام الأدوات الرقمية. توفر الدراسة رؤية شاملة حول البحث في هذا المجال، مع إبراز الحاجة إلى الابتكار في أدوات التقييم الرقمية والتعاون متعدد التخصصات.

الكلمات المفتاحية: الببليومتري، التطوير، مهارات التفكير العليا، تقييم **HOTS**

Abstract:

The development of Higher-Order Thinking Skills (HOTS) assessments is increasingly vital in modern education to address complex global challenges. This bibliometric study examines research trends on HOTS assessment from 1988 to 2024 using Scopus data. It analyzes citation trends, geographical distribution, journal rankings, and key research themes. Findings indicate a sharp rise in publications since 2019, with Indonesia, Malaysia, and the United States as leading contributors. Research collaboration is strong between Southeast Asian and Western countries, reflecting a robust international network. Most studies are published in Q1 and Q2 journals, indicating high research quality. Key research areas include assessment tool development, active learning strategies, and integrating critical and creative thinking into curricula. Emerging trends highlight the increasing use of digital tools. This study provides a comprehensive overview of HOTS assessment research, emphasizing the need for innovative digital assessment methods and interdisciplinary collaboration to enhance educational outcomes.

Keywords: Bibliometric, Development, Higher-Order Thinking Skills, HOTS assessment,

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Résumé :

Le développement des évaluations des compétences de pensée de haut niveau (HOTS) devient crucial dans l'éducation moderne face aux défis mondiaux. Cette étude bibliométrique analyse les tendances de recherche sur l'évaluation des HOTS de 1988 à 2024 à partir des données de Scopus. L'analyse couvre la citation, la répartition géographique, le classement des revues et les thèmes de recherche. Les résultats montrent une hausse des publications depuis 2019, avec l'Indonésie, la Malaisie et les États-Unis comme principaux contributeurs. La forte collaboration entre l'Asie du Sud-Est et l'Occident reflète un réseau international actif. La majorité des études figurent dans des revues Q1 et Q2. Les thèmes clés concernent les outils d'évaluation, l'apprentissage actif et la pensée critique. L'essor des outils numériques souligne le besoin d'innovations et de collaborations interdisciplinaires pour améliorer l'éducation.
Mots-clés : bibliométrie, développement, compétences de pensée de haut niveau, évaluation des HOTS

Introduction

In the context of 21st-century education, Higher-Order Thinking Skills (HOTS) have been recognized as one of the core competencies that students must acquire (Nisfah et al., 2022; Pane et al., 2021). HOTS encompass critical, analytical, and creative thinking skills, which are crucial for addressing the increasingly complex and dynamic global challenges. These skills not only serve to enhance students' intellectual abilities but also prepare them to face a constantly evolving work environment and the demands of modern society, which require high-level thinking abilities (Williams, 2022; Ye & Xu, 2023). Although the concept of HOTS has been widely integrated into curricula in various countries, assessing these skills continues to present significant challenges. One of the most prominent issues is the lack of assessment instruments that can validly and reliably measure HOTS (Hashim et al., 2021; Siregar et al., 2021). Existing assessment tools often only measure basic cognitive abilities, such as memorization and comprehension, while important dimensions of HOTS, such as critical and creative thinking, remain inadequately assessed.

These limitations not only affect the validity of assessments of students' abilities but also hinder the implementation of HOTS in teaching and learning contexts. Research indicates that many teachers still rely on traditional assessment methods that tend to focus on measuring basic cognitive skills, creating a gap between the intended outcomes of HOTS-based curricula and how these skills are assessed in practice (Ballakrishnan & Mohamad, 2020; Sulaiman & Mohd Ayub, 2023). Moreover, current assessment instruments are insufficient in capturing the higher-order thinking skills required in today's workforce and society (Aprilia & Dewi , 2020; Markhamah, 2021). As a result, students often do not receive feedback that accurately reflects their true abilities in higher-order thinking, which ultimately negatively impacts their learning process.

Although numerous studies have discussed the concept of Higher-Order Thinking Skills (HOTS), research specifically exploring methods for assessing these skills remains limited. Most of the existing studies have yet to provide a comprehensive guide on the most effective ways to measure HOTS (Azid et al., 2022; Muntari et al., 2022). As a result, current assessment instruments are not developed systematically, making them often impractical for use in classrooms or broader educational contexts (Puspitasari & Syarif , 2020; Simanjuntak, 2018). In many countries, efforts to implement comprehensive HOTS assessments are often hindered by the limited practical knowledge among educators, leading to difficulties in designing accurate and appropriate assessment instruments

(Fadillah et al., 2023). This results in assessment outcomes that do not adequately reflect students' higher-order thinking abilities, thereby affecting the overall quality of teaching and learning. Without valid and reliable assessment instruments, it is challenging for educators to design instructional strategies that effectively support the development of HOTS and enhance students' critical and creative thinking skills optimally.

Furthermore, the development of HOTS assessment methods has not fully kept pace with advances in modern educational theory and practice. Many of the instruments currently in use still rely on traditional approaches that emphasize basic cognitive aspects such as comprehension and memorization, while higher-order thinking skills, such as critical, analytical, and creative thinking, are often inadequately evaluated (Bellaera et al., 2021; Viriyavejakul, 2020). Consequently, students do not receive proper feedback on their higher-order thinking abilities. Therefore, innovation in developing assessment instruments that can better capture the various dimensions of HOTS is urgently needed. This study aims to address this need by conducting a bibliometric analysis to examine how research on HOTS assessment development has evolved between 1988 and 2024, while also identifying trends, challenges, and innovations within this field.

HOTS assessments, with a focus on publications listed in the Scopus database.

To explore, investigate, and assess the evolving trends in scientific research and advancements within academic literature concerning the development of HOTS (Higher Order Thinking Skills) assessment, bibliometric analysis serves as a valuable tool. This analytical method offers a broad, comprehensive perspective on a large corpus of scholarly works (van Nunen et al., 2018). It is applied to evaluate the productivity and research patterns of various contributors such as authors, journals, nations, and institutions, while also enabling the examination of their collaborative networks (Li & Zhao, 2015). In this context, bibliometric analysis is utilized to study global research patterns in HOTS assessment development, specifically through publications indexed in the Scopus database.

(Pritchard, 1969) describes bibliometrics as the use of mathematical and statistical methods to analyze books and various forms of communication. This approach highlights that bibliometric analysis, commonly applied to examine the characteristics of written works, particularly academic literature, relies fundamentally on bibliographic data. Through this method, the volume and patterns within a body of literature can be systematically measured. Over time, researchers have increasingly utilized bibliometric analysis to gain broader insights into the overall research landscape (Ahmi & Rosli , 2019). Emerging research trends can be identified by categorizing publications based on factors such as publication year, authorship, institutional affiliation, or country of origin. Furthermore, the impact and performance of scholarly works can be assessed using various metrics, including citation counts, annual citation rates, h-index, and g-index.

This study is expected to provide guidance for current and future research on HOTS assessment development by examining research progress from 1988 to 2024. The analysis will identify key research trends, researcher collaboration, research impact, and the most dominant directions in this field. Additionally, bibliometric analysis offers a holistic view of the evolution and transformation of HOTS assessment over the past three decades, helping to identify knowledge gaps and areas requiring further investigation (Kamila & Jasrotia, 2023; Mora et al., 2017). Therefore, this study not only offers insights into the evolution of ideas and research trajectories in HOTS assessment development but also provides strategic recommendations for future research directions.

Furthermore, this study contributes significantly to the academic community and supports practical advancements in the field of education.

1- Research Objectives

The objective of this study is to provide a comprehensive landscape of research related to the development of HOTS (Higher-Order Thinking Skills) assessment and to examine the literature within this domain from 1998 to 2024. To achieve this, the research aims to address the following research questions:

1. What are the citation trends associated with the development of HOTS assessment during the study period?
2. What is the geographical distribution and cooperation patterns between countries in the context of HOTS assessment development?
3. How are the journals that publish research on HOTS assessment distributed in terms of quartile rankings?
4. What are the main research foci and the novelty associated with the development of HOTS assessment?

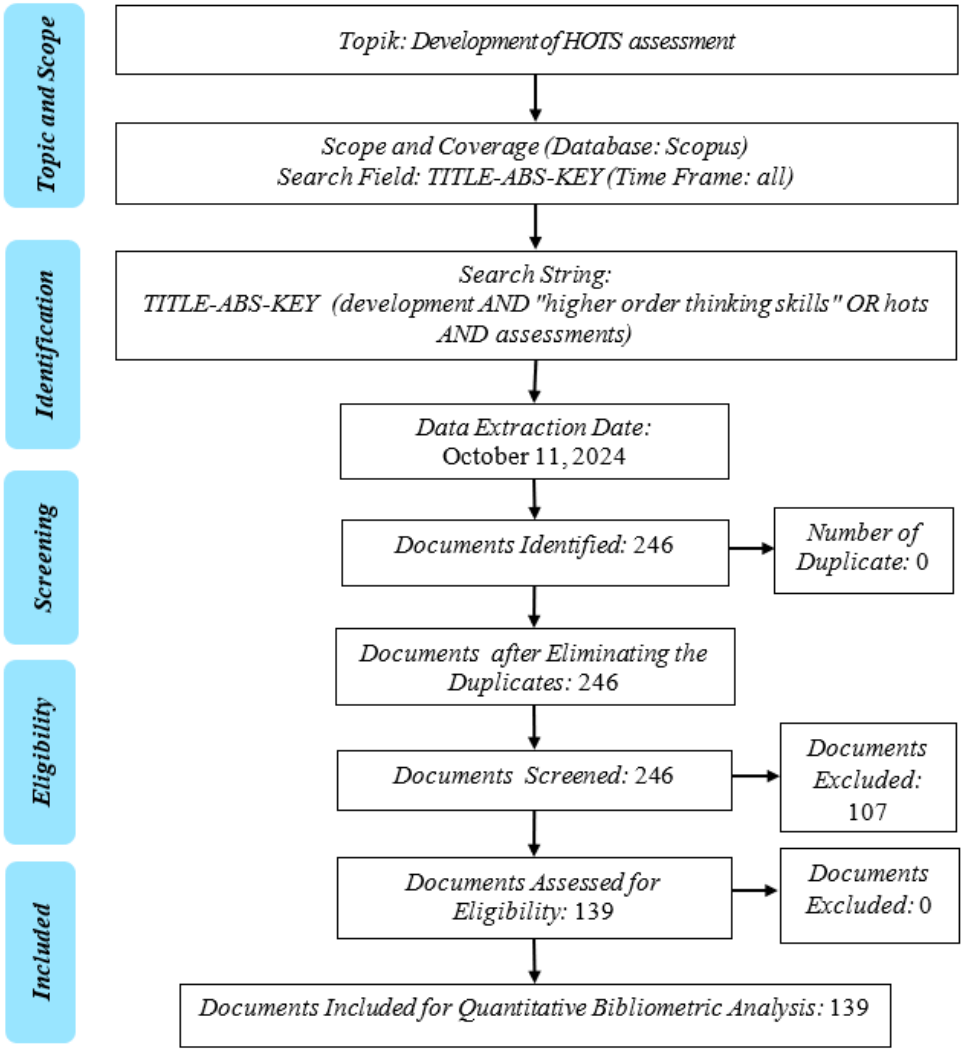
This study seeks to offer a comprehensive overview of research developments in the field of HOTS assessment, while also identifying trends, dominant research areas, and novel elements within this domain over the past three decades. The findings from the bibliometric analysis are expected to serve as a valuable resource for educational practitioners, researchers, and policymakers in understanding future directions for the development of HOTS assessment.

2- Method

To gather data concerning the "development of HOTS assessment," the researcher utilized the Scopus database. Scopus was selected due to its broad multidisciplinary scope, frequent updates, and ongoing enhancements, making it one of the most widely used abstract and citation databases for academic research, alongside Web of Science and Google Scholar (JASROTIA et al., 2022; Mora et al., 2017). The data collection process from Scopus followed several critical steps to refine the dataset, as outlined in Figure 1 (Moher, 2009). The first step involved identification, wherein the researcher input the keywords (development AND "higher order thinking skills" OR HOTS AND assessment) into the Scopus search engine. This initial search yielded 246 publications related to the topic.

In the second stage, a screening process was carried out to refine the dataset by eliminating book publications, book chapters, and conference proceedings. After this refinement, a total of 139 articles met the predefined inclusion criteria. Data for this study were gathered on October 11, 2024, as part of the inclusion phase. To examine publication trends related to the development of HOTS assessment, a descriptive approach will be utilized, applying bibliometric analysis to the extracted data from Scopus. Additionally, the distribution of relevant publications from 1988 to 2024 will be visually represented through Microsoft Excel.

Figure 1: Data Collection Process



Source: Author's creation/work

3- Data Analysis

The analysis of publication and citation trends regarding the development of Higher-Order Thinking Skills (HOTS) assessments will span from 1988 to 2024. This analysis will include calculating and visualizing the annual number of publications and the average citations per year using Microsoft Excel and RStudio. Additionally, the h-index and g-index for each publication will be calculated with the assistance of the Publish or Perish (PoP) software. The h-index, as introduced by (Hirsch, 2005), evaluates both the productivity and impact of a scholar or journal's citations. In contrast, the g-index, developed by (Egghe, 2006), refines this by giving more weight to highly cited works, offering a deeper analysis of citation patterns. PoP, created by (Harzing, 2007), is a widely recognized tool that computes various citation metrics, including the h-index and g-index, and draws data from multiple sources such as Google Scholar, Scopus, Web of Science, and CrossRef, making it versatile for bibliometric studies across various databases. Microsoft Excel will also be employed to map the geographical distribution of the data. To examine international collaboration in scientific publications, VOSviewer will be utilized. Furthermore, RStudio will be used to classify and rank the most influential journals in this field.

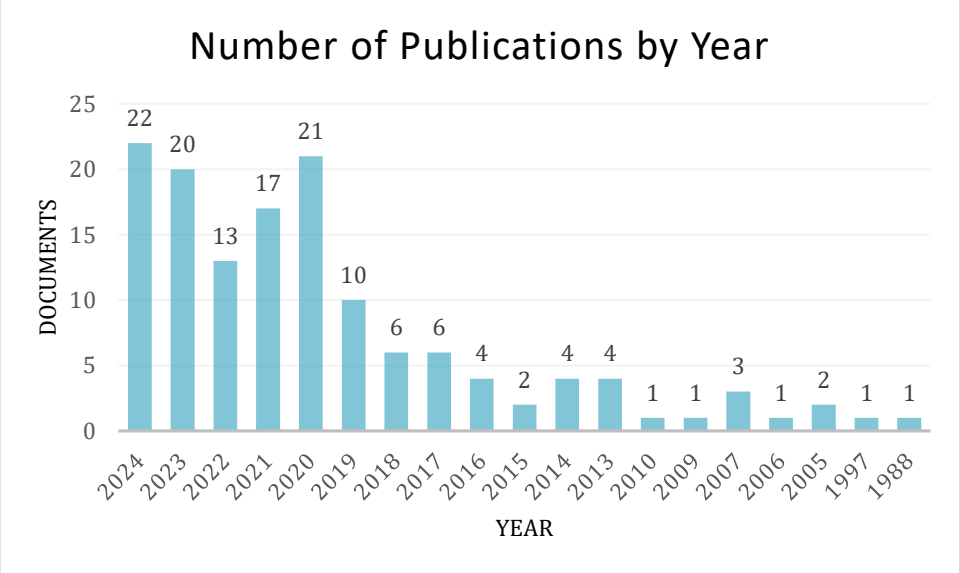
4- Findings and Discussion

The process of data collection for publications on the development of HOTS (Higher-Order Thinking Skills) assessments went through several phases. As a result, 139 relevant publications from the period 1988 to 2024 that met the research criteria were successfully identified. The next phase will involve conducting a descriptive bibliometric analysis. This will be followed by a more in-depth examination of various aspects, including publication and citation trends, geographical distribution, journal rankings, and the main areas of research focus.

5- Publication Trends and Citation Trends

Figure 2 will illustrate the publication trends concerning the development of HOTS (Higher-Order Thinking Skills) assessments from 1988 to 2024. A table summarizing data from 139 publications, organized by their respective publication years, will be presented, as shown below in Figure 2.

Figure 2: Number of Publications by Year of Publication



Source: Author's creation/work-Excel

The graph indicates that 22 documents were published in 2024. The first article related to the development of HOTS assessments was published in 1988 in the Scopus database. However, during the periods of 1987-1998, 1999-2004, as well as in 2008, 2011, and 2012, no publications related to this research were recorded.

Table 1 will present the citation trends related to the development of HOTS (Higher-Order Thinking Skills) assessments from 1988 to 2024. The 139 collected publications will be categorized by year and analyzed based on several parameters, including Total Publications (TP), Number of Cited Publications (NCP), Total Citations (TC), Citations per Publication (C/P), h-index, and g-index. These details will be provided comprehensively in Table 1 below.

Table 1: Citation Analysis of Publications

Year	TP	NCP	TC	C/P	h	g
2024	22	6	8	0,36	1	2
2023	20	11	68	3,40	5	8
2022	13	10	103	7,92	6	10
2021	17	14	213	12,53	8	14
2020	21	18	114	5,43	6	9
2019	10	10	285	28,80	7	10
2018	6	6	120	20,00	5	6
2017	6	6	75	12,50	4	6
2016	4	4	43	10,75	4	4
2015	2	2	75	37,50	2	2
2014	4	4	57	14,25	3	4
2013	4	4	47	14,50	3	4
2010	1	1	10	10,00	1	1
2009	1	1	293	293,00	1	1
2007	3	3	346	115,33	3	3
2006	1	1	29	29,00	1	1
2005	2	2	32	16,00	2	2
1997	1	1	18	18,00	1	1
1988	1	1	3	3,00	1	1

Source: Author's work/creation-PoP

Notes: TP=total of publication, NCP=number of cited publication, TC=total citations, C/P=average citations per publication, , h=h-index, g=g-index

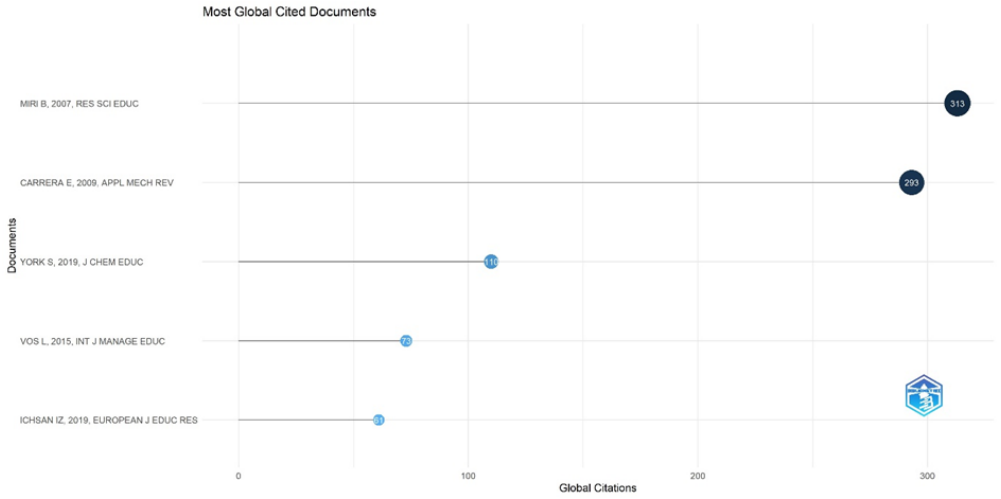
The data in Table 1 show that the highest number of total publications (TP) occurred in 2024, with 22 publications; however, only 6 of these were cited (NCP), resulting in a total of 8 citations (TC) and a low average citation per publication (C/P) of 0.36. In contrast, 2023 also saw a substantial number of publications, with 20 in total and 68 citations, leading to a significantly higher C/P value of 3.40, indicating that each publication received an average of 3.4 citations. The year 2021 stood out with the highest h-index of 8 and a g-index of 14, signifying that the publications from that year were widely cited and had considerable influence.

Interestingly, 2019 recorded the highest number of annual citations, with 285 citations from just 10 publications, resulting in a remarkable C/P value of 28.80, meaning each publication garnered nearly 29 citations on average. Notably, 2007, despite having only 3 publications, saw a total of 346 citations, making it the year with the highest citations per publication. Similarly, 2009 had a single publication but generated 293 citations, indicating that the publications from these years had a significant impact and were highly influential in their respective fields.

It is important to note that Table 1 identifies several years with no publications at all. These include the periods from 1987 to 1998, 1999 to 2004, 2008, 2011, and 2012, during which no publications related to this research were recorded. This suggests a hiatus or decline in research activity during these periods, in contrast to other years that recorded at least one publication.

Figure 3 will highlight the five articles with the highest citation counts between 1988 and 2024. The article with the most citations reached 313, demonstrating a significant impact on research related to the development of HOTS assessment. These articles reflect a growing interest in the topic and have played a key role in shaping the direction of future research. Furthermore, these works underscore the importance of HOTS assessment development and how this research contributes to improving the quality of education through the advancement of HOTS assessment. Additionally, Figure 3 identifies the five articles with the highest citation counts from 1998 to 2024, providing an overview of the research contributions to this field on an international scale.

Figure 3: 5 Most cited articles



Source: Author's work/creation-RStudio

The author will now discuss the findings from the five most-cited articles. As shown in Figure 3, the study by (Miri et al., 2007) has accumulated 313 citations, highlighting its substantial influence in that year. This research, titled *"Purposely Teaching for the Promotion of Higher-Order Thinking Skills: A Case of Critical Thinking,"* underscores the significance of instructional methods specifically designed to enhance Higher-Order Thinking Skills (HOTS) within science education. Conducted as a longitudinal study, it involved three student groups, with the experimental group receiving instruction through approaches aimed at fostering HOTS, including open classroom discussions, inquiry-based experiments, and real-world case studies.

The results showed that the experimental group experienced a significant improvement in critical thinking skills, including openness to ideas, confidence in critical thinking, and maturity in thinking, compared to the control group, which was taught using traditional methods. Furthermore, the study found that consistent application of HOTS strategies was not only effective in enhancing critical thinking abilities during the learning process but also helped maintain these skills over the long term. Teaching strategies that emphasized solving real-world problems and encouraged students to engage in open discussions were found to be crucial in building sustained critical thinking skills. In conclusion, deliberate and sustained teaching that promotes HOTS can better prepare students to face real-world challenges, particularly those that require analytical skills, evaluation, and logic-based decision-making.

The second most-cited study, conducted by (Carrera & Brischetto, 2009), has garnered 293 citations. Titled "A Survey with Numerical Assessment of Classical and Refined Theories for the Analysis of Sandwich Plates," the article provides a numerical evaluation of various plate theories to

assess bending and vibration in sandwich structures. The main findings indicate that higher-order theories (HOTs) effectively reduce errors caused by the length-to-thickness ratio (LTR) in thick plates, thereby improving the accuracy of analysis. This is important in the context of HOTS assessment development, as more accurate evaluation supports critical and analytical evaluation processes. However, HOTs were less effective in addressing errors related to the face-to-core stiffness ratio (FCSR), where layerwise analysis becomes the necessary solution for achieving higher accuracy. These findings emphasize the importance of selecting the appropriate analytical theory based on the specific characteristics of the structural problem to obtain optimal results.

The third most-cited study, conducted by (York et al., 2009), has received 110 citations. The article, titled "Applications of Systems Thinking in STEM Education," identifies several key findings relevant to the development of Higher-Order Thinking Skills (HOTS). Systems thinking, a holistic approach to analyzing complex problems, helps students develop higher-order thinking skills by enabling them to understand the interactions between system components and the patterns emerging from these interactions. The article highlights that applying systems thinking in STEM education, particularly in life sciences, earth sciences, and engineering, supports students in tackling complex, interdisciplinary real-world problems. The findings show that systems thinking primarily focuses on developing students' thinking skills rather than teachers', which is essential for honing critical and analytical thinking, two core elements of HOTS.

Moreover, the methods used to assess systems thinking skills in STEM education, such as assessment rubrics, closed-ended tools, and coding schemes, support the evaluation of higher-order thinking skills in different ways, depending on educational needs. While research on systems thinking is still limited in chemistry education, findings from other STEM disciplines suggest that applying this approach could yield similar results in chemistry education, offering further opportunities for developing HOTS in this field. In conclusion, systems thinking proves to be a powerful tool in developing HOTS by emphasizing systematic analysis, complex problem-solving, and deep understanding of interdisciplinary issues.

The fourth most-cited study, by (Vos, 2015), with 73 citations, is titled "Simulation Games in Business and Marketing Education: How Educators Assess Student Learning from Simulations." It found that most educators using business simulations adopt creative assessment practices aligned with authentic assessment principles, including formative assessments, explaining assessment criteria, and encouraging students to reflect on their learning. The findings also show that simulations help students develop HOTS by engaging them in critical thinking, analysis, evaluation, and complex decision-making processes during simulations. Through this approach, students can more effectively hone higher-order thinking skills, which are essential for solving real-world business problems. Additionally, the study provides insights for educators on areas where students tend to underperform and offers strategies to enhance learning outcomes through better simulation assessments. The results underscore the role of simulations in supporting HOTS development through authentic, reflective-based assessment methods.

The fifth most-cited study, conducted by (Ichsan et al., 2019), has received 61 citations. The article, titled "HOTS-AEP: Higher Order Thinking Skills from Elementary to Master Students in Environmental Learning," reveals several important findings related to the development of HOTS in environmental education. This study assessed students' HOTS across different educational levels (from elementary to master's students) using the HOTS Assessment based on Environmental

Problems (HOTS-AEP) instrument. The results showed that overall HOTS scores were very low across all educational levels, with the highest scores found at the elementary (ES) and master's (MP) levels, but still within the very low category.

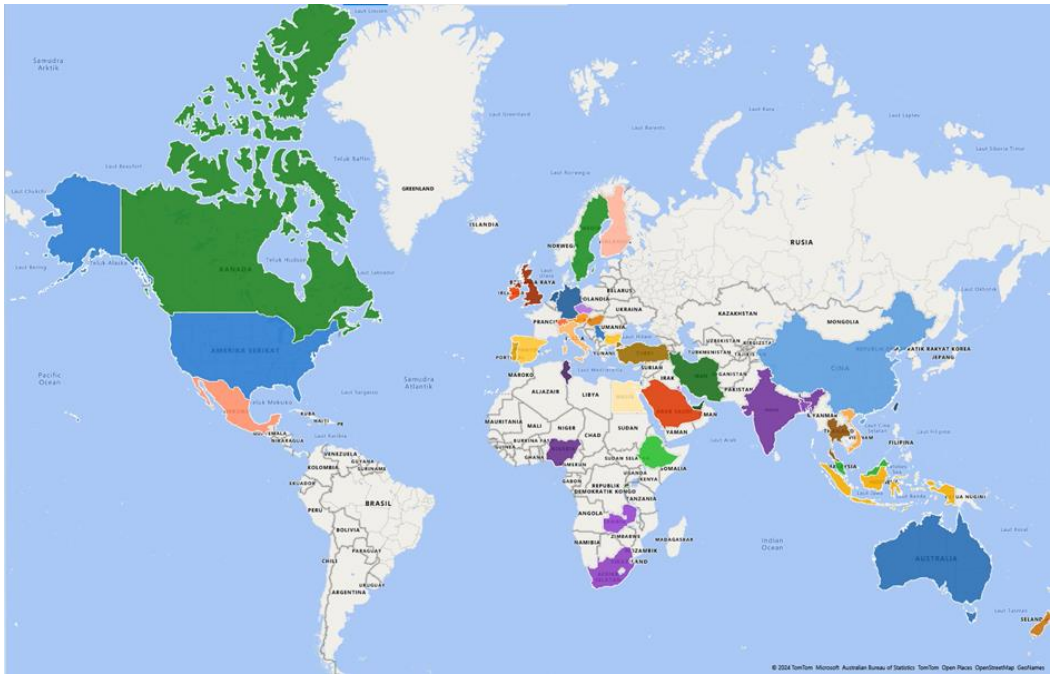
These findings suggest that environmental education should focus more on improving HOTS, including through the development of more effective teaching media, materials, models, and strategies. The HOTS-AEP instrument measures students' abilities to analyze, evaluate, and create solutions to environmental problems, such as water and air pollution. For example, in the C4 (Analyze) aspect, students are asked to analyze pollution-causing factors; in the C5 (Evaluate) aspect, they evaluate the impact of pollution on the environment; and in the C6 (Create) aspect, they are invited to design solutions, such as water filtration systems. While there is significant potential to enhance HOTS through project-based and environmental learning, this study confirms that further efforts are needed to improve students' higher-order thinking skills at all educational levels.

Overall, the findings from these various studies highlight that the application of teaching strategies focused on higher-order thinking skills, such as discussions, experiments, systems thinking, and simulations, not only enhances students' analytical and evaluative abilities but also prepares them to tackle complex real-world challenges. Thus, integrating HOTS into educational curricula can improve learning quality, encourage active student participation, and help students become more effective problem-solvers in the future. Greater efforts are needed to enhance HOTS at all educational levels, particularly through the development of more effective teaching materials, media, and models.

5- Geographical Distribution and Collaborative Relationships between Countries

Figure 4 presents the geographical distribution of authors contributing to research on the development of Higher-Order Thinking Skills (HOTS) assessment. The analysis reveals that researchers from 45 different countries have participated in these publications. A visual representation of the authors' country of origin is provided in the figure below.

Figure 4: Geographical Distribution of Publications



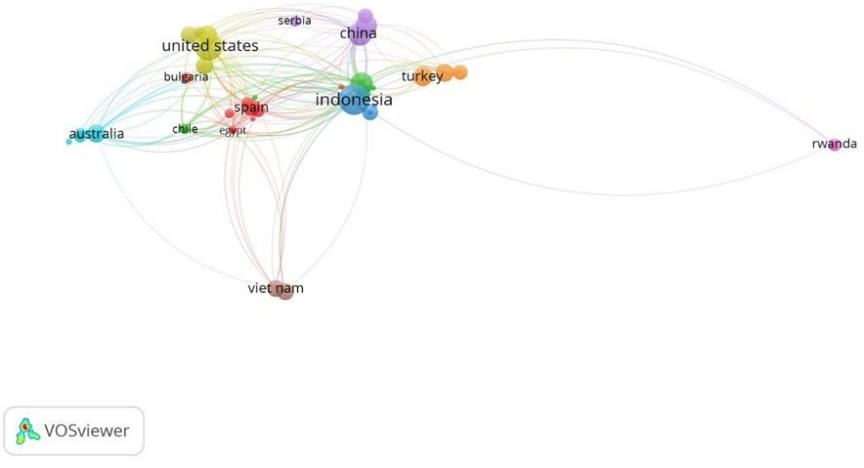
Source: Author's work/creation-Excel

Based on Figure 4, the geographical distribution of publications related to HOTS assessment development spans various countries worldwide, with Indonesia being the largest contributor with 37 documents, followed by Malaysia and the United States, each with 18 documents. In the Asian region, besides Indonesia and Malaysia, countries such as Australia (7 documents), India (7 documents), China (6 documents), and Thailand (4 documents) also make significant contributions, indicating their commitment to HOTS assessment development in education. European countries such as Spain and the United Kingdom (4 documents each), as well as Germany (2 documents), are also involved, although their document output is smaller compared to Asian and American countries. The Middle East region is represented by the United Arab Emirates (3 documents), Israel (2 documents), and Turkey (6 documents), demonstrating their attention to HOTS assessment development. In Africa, South Africa (4 documents) and Nigeria (3 documents) also show involvement. Overall, this table shows that research on the development of HOTS assessments is distributed across various countries, with the largest participation coming from Indonesia, Malaysia, and the United States.

In this geographical distribution, three countries stand out with the highest number of publications on HOTS assessment development: Indonesia, Malaysia, and the United States. Among these, Indonesia leads with 37 publications. This is consistent with the findings of Handayani et al. (2024), who explored the development of HOTS-based assessment instruments in Indonesia and emphasized the importance of improving the assessment system to promote students' critical, analytical, and evaluative thinking abilities. Through the application of the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), this study successfully developed valid and reliable instruments specifically designed to meet the educational needs of Indonesia. As a result, the instrument not only improved teachers' assessment effectiveness in measuring students' comprehension but also made a significant contribution to the development of a curriculum that emphasizes higher-order thinking skills, supporting the enhancement of national education quality.

Figure 5 illustrates the collaboration patterns between countries. In analyzing these international connections, the researchers did not apply any specific thresholds, meaning that countries with only one publication are included, regardless of whether they have collaborative ties with other nations. A total of 40 countries are represented in Figure 5.

Figure 5: Collaboration between countries



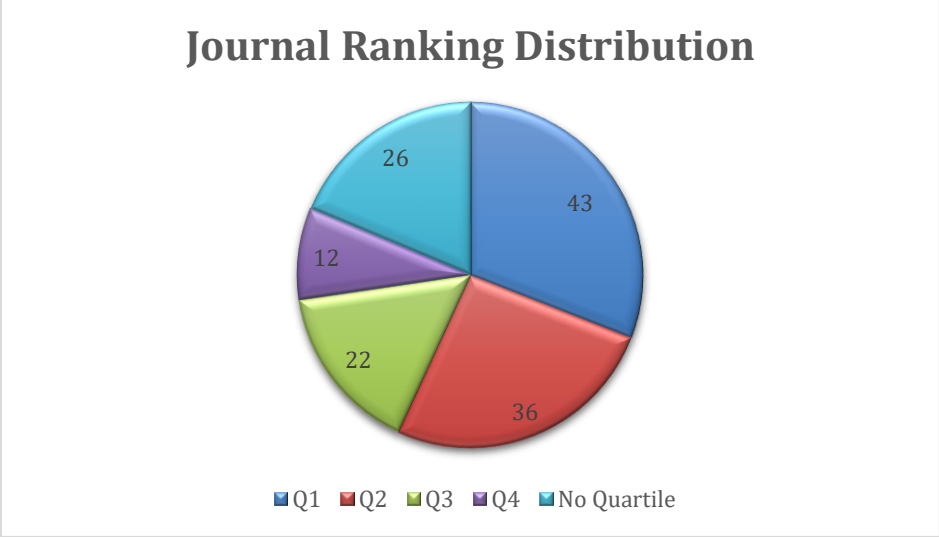
Source: Author's work/creation-VOSviewer

In Figure 5, it is evident that countries such as Malaysia, Indonesia, the United States, and Australia have circles with larger diameters compared to other countries. This indicates a higher level of collaboration with various nations in this field. The visualization using VOSviewer reveals that Malaysia collaborates with 29 countries, while Indonesia works with 28 countries. The United States has partnerships with 24 countries, and Australia engages in collaborative relationships with 22 countries. These collaborations are specifically related to the development of Higher-Order Thinking Skills (HOTS) assessment, showing that these countries are central figures in this domain and have significant influence in driving research and educational development focused on higher-order thinking skills. The high number of international collaborations also reflects these countries' capacity to lead global educational innovation and their influence in disseminating HOTS-oriented assessment practices. This network of partnerships not only highlights their leadership in educational research but also underscores the importance of their contributions to enhancing global education systems through the promotion of critical thinking and problem-solving skills.

6- Distribution of journal rankings and journals with the most articles

In the context of journal rankings relevant to the development of Higher-Order Thinking Skills (HOTS) assessments, information on journal quartile rankings (Q) can be found on the Scimago Journal & Country Rank (Scimagojr) website. The detailed rankings of these journals are presented in the following figure.

Figure 6: Ranking based on journal quartile score



Source: Author's work/creation-Excel

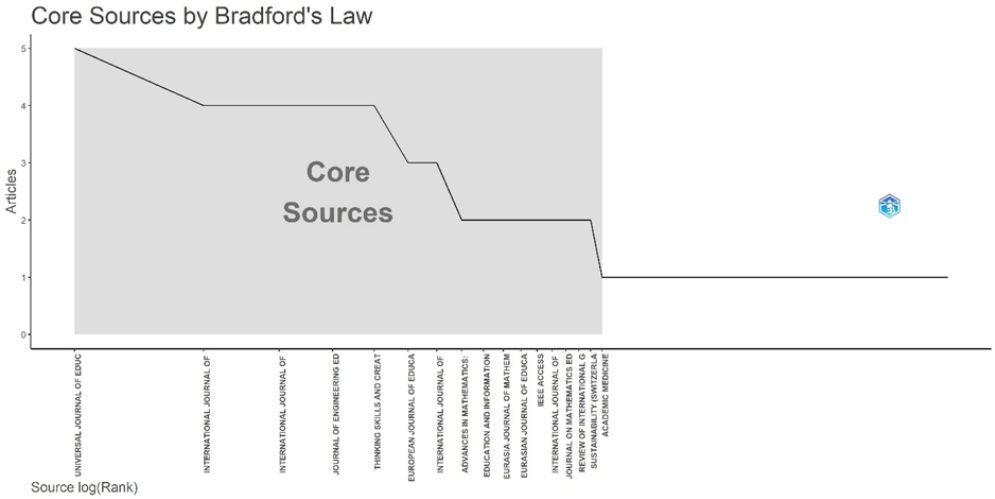
Based on Figure 5, publications related to the development of Higher-Order Thinking Skills (HOTS) assessments exhibit a significant trend in being published in high-impact journals, particularly those ranked in the Q1 quartile, with a total of 43 publications. The second position is occupied by Q2 journals, contributing 36 publications, followed by 22 publications in Q3 journals, 12 in Q4 journals, and 26 publications in unranked journals (No Quartile). The high number of publications in Q1 journals reflects broad recognition of research in this area, which is considered of high quality and significantly contributes to the development of educational theory and practice.

To strengthen the position of HOTS assessment research at the international level, it is crucial to increase the number of publications in high-quality journals such as those ranked in Q1. Given the

ever-evolving nature of education, HOTS-related research requires more serious attention, as this approach has proven effective in enhancing learning outcomes. Greater collaborative efforts between academics and education practitioners are needed to promote high-quality research in this field. Improving both the quality and quantity of publications in reputable journals is expected to refine teaching methods, enhance global competitiveness in education, and ensure the relevance of research in the development of HOTS assessments for more effective and innovative learning.

The distribution of journal rankings is based on quartile (Q) values. Out of a total of 139 publications, 43 were published in top-tier Q1 journals. This data is presented using Biblioshiny from R Studio, which illustrates the distribution of quartiles for journals in which articles related to HOTS assessment development were published, providing insights into the quality and reputation of these journals.

Figure 7: Core Sources by Bradford's Law



Source: Author's work/creation-RStudio

Figure 7 illustrates the distribution of core sources based on Bradford's Law, a bibliometric theory used to identify the most productive journals in a specific research field. This law divides journals into zones that reflect their contribution to the total number of publications, in this case, on the topic of Higher-Order Thinking Skills (HOTS) assessment development. The shaded area labeled "Core Sources" highlights the journals with the highest publication contributions, showing that the majority of articles on this topic are published by a small number of journals. Journals such as the *Universal Journal of Educational Research*, the *International Journal of Evaluation and Research in Education*, and the *International Journal of Instruction* appear on the left side of the graph, indicating that they publish the largest number of articles compared to other journals. In line with Bradford's Law, moving to the right of the graph, the number of articles published by other journals decreases, illustrating the typical distribution where a small number of journals are responsible for most publications, while others contribute fewer articles.

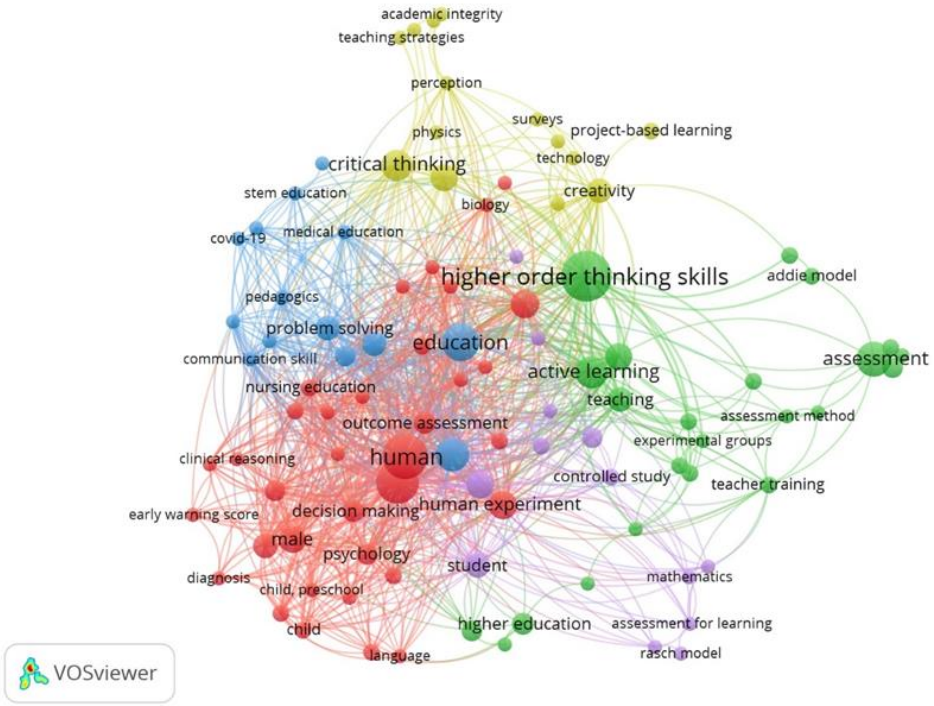
This analysis is crucial for researchers working on HOTS assessment development, as it not only identifies the most productive journals but also provides strategic guidance for selecting journals for scholarly publication. Figure 7 offers key insights into the core journals referenced in this field, enabling researchers to target journals with the highest visibility and impact. By choosing these core journals, researchers can enhance the dissemination of their findings and make significant contributions to scientific progress, particularly in the development of HOTS assessments in

education. This underscores the importance of a publication strategy based on bibliometric analysis, which can maximize scientific impact and increase the influence of research results within the global academic community.

7- Research Focus and Novelty

At this stage, the researcher has set a specific threshold, requiring each keyword to appear in at least two publications. With this condition, all included keywords will be identified and displayed using VOS viewer. The total number of keywords identified is 99, as shown in Figure 8 below.

Figure 8: Research Focus



Source: Author's work/creation-VOSviewer

The research focus is divided into five distinct clusters, as illustrated in Figure 8. Each cluster, represented by a different color red, green, blue, yellow, and purple corresponds to a specific area of study related to the development of Higher-Order Thinking Skills (HOTS) assessments. These clusters reflect the categorization of research into five primary aspects. A detailed explanation of each cluster is provided below:

1. The first cluster (red) consists of 35 items. In this cluster, the keywords "Human" and "Outcome Assessment" play a central role, indicating that these keywords, related to the development of HOTS assessments, are the primary focus of research in this cluster.

2. The second cluster (green) consists of 23 items. In this cluster, the keywords "active learning" and "curriculum" are the main focus. This suggests that the research in this cluster centers on "active learning" and "curriculum" in the context of HOTS assessment development.

3. The third cluster (blue) consists of 14 items. In this cluster, the keywords "education" and "problem solving" play a central role, indicating that the research in this cluster primarily focuses on "education" and "problem solving" as key elements in the development of HOTS assessments.

4. The fourth cluster (yellow) includes 14 items. In this cluster, the keywords "critical thinking" and "creativity" are the main focus. This suggests that the research in this cluster is centered on "critical thinking" and "creativity" in the context of HOTS assessment development.

5. The fifth cluster (purple) includes 13 items. In this cluster, the keywords "student" and "sustainable development" are the main focus. This suggests that the research in this cluster is focused on "student" and "sustainable development" in the context of HOTS assessment development.

The first research focus is on "Human" and "Outcome Assessment," as highlighted in the study by (Dewi et al., 2021). This article found that many teachers still face difficulties in developing student learning assessment instruments, particularly those oriented toward Higher-Order Thinking Skills (HOTS). These instruments are crucial for measuring students' abilities in analysis, evaluation, and creation, in alignment with the demands of the 2013 curriculum. The development of the instrument followed the 4D model (Define, Design, Develop, Disseminate), involving validity and reliability testing. The resulting instrument was proven to be valid, reliable, and suitable for use in HOTS-based science learning assessments. Both students and practitioners provided positive feedback, confirming the instrument as high-quality and beneficial in improving students' critical thinking skills.

The second research focus is on "active learning" and "curriculum," as seen in the study by (Wilson et al., 2024). This article discusses the impact of curriculum reform based on an immersive block model that integrates active learning in higher education. The research was conducted at an Australian university, analyzing over 27,000 academic success data points and nearly 8,000 student satisfaction records. The results indicated that this model significantly improved academic success, particularly in the first year of study. However, student satisfaction decreased compared to traditional semester models, especially in the fields of science and engineering. These findings highlight the importance of optimizing active learning and considering student responses across disciplines when implementing curriculum changes.

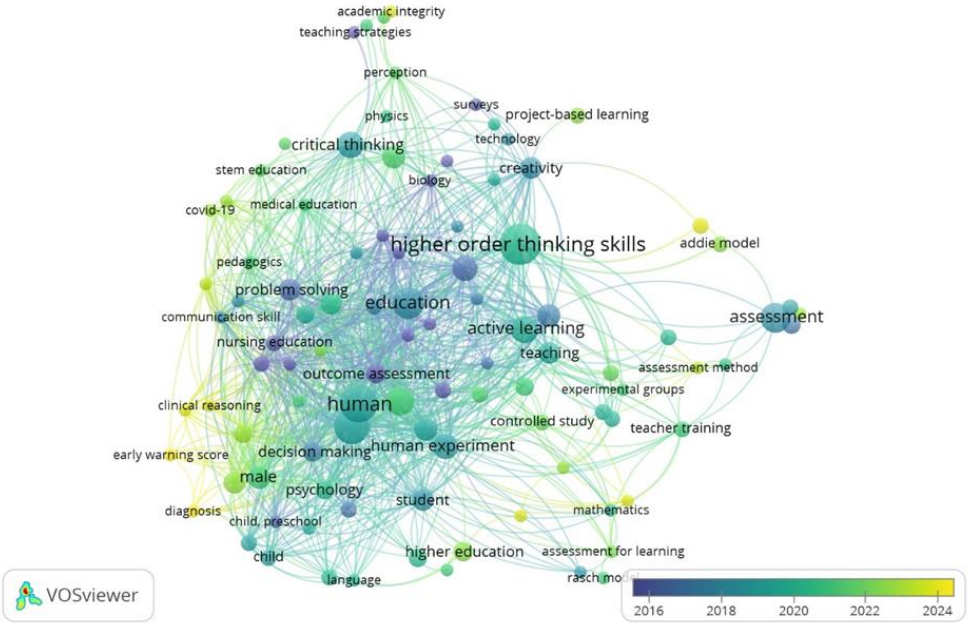
The third research focus is on "education" and "problem solving," as explored in the study by (Güley & Keskinkılıç, 2024). This article examines the effects of the Project Approach-Based Science Education Program (PABSEP) on the problem-solving abilities of preschool children. The study involved 70 children, with 35 in the experimental group receiving the PABSEP program for 10 weeks, and 35 in the control group following only the national education program of Turkey. The results showed that children in the experimental group exhibited a significant improvement in problem-solving abilities compared to the control group, both overall and in specific aspects such as problem identification and the ability to find unconventional solutions. The program proved effective, with lasting results after its completion.

The fourth research focus is on "critical thinking" and "creativity," as examined in the study by (Ellianawati et al., 2025). This article on STEAM-based collaborative learning emphasizes the development of critical and creative thinking skills, which are closely related to HOTS. The findings indicate that this approach effectively enhances students' abilities to think critically and creatively. Critical thinking skills are demonstrated through students' abilities to analyze problems, consider deductions, and identify assumptions. Creative thinking is shown through fluency, originality, and flexibility as students develop projects related to renewable energy. Project-based and collaborative

learning encourages students to explore new ideas and develop innovative solutions, which are essential components of HOTS.

The final research focus is on "students" and "sustainable development," as explored in the study by (Ellianawati et al., 2025). The findings of this article indicate that students' awareness, knowledge, and accessibility to the Sustainable Development Goals (SDGs), particularly SDG 4 on quality education, need improvement. While most students are aware of the SDGs, many lack a deep understanding of the specific goals and face limited access to relevant information. This is crucial because HOTS, such as analysis, evaluation, and the application of concepts, are essential for empowering students to become agents of change in society. With HOTS, students can analyze global issues like sustainability, create innovative solutions, and actively contribute to achieving the SDGs by applying global information in local contexts.

Figure 9: research topics



Source: Author's work/creation-VOSviewer

In Figure 9, the color-coded visualization represents the temporal distribution of keywords used in research related to the development of Higher Order Thinking Skills (HOTS) assessments from 2016 to 2024. The colors indicate both the period of emergence and the degree of novelty of the research topics. Blue highlights themes that have been widely discussed in earlier literature, while yellow signifies more recent topics that are currently the focus of ongoing research. The transition from blue to yellow demonstrates the evolution of research trends, with newer themes such as "assessment instrument," "assessment method," "online assessment," "professional development," "educational technology," "academic integrity," "clinical reasoning," "nurse," "early warning score," and "diagnosis" reflecting emerging areas in the context of HOTS assessment development.

The visualization further underscores the novelty of HOTS-related research by revealing the interconnections and relationships between various keywords. Researchers can examine these connections to identify significant trends, where the frequency and proximity of keywords indicate which topics are gaining prominence. This also provides insights into potential gaps in the literature, offering opportunities for further exploration in under-researched areas.

It is important to note that the keyword "Higher Order Thinking Skills" (HOTS) is not always directly linked to all emerging themes. Some new keywords or topics that are not yet strongly connected to the broader framework may signify innovative areas of research. These less-explored themes represent opportunities for the introduction of new concepts that can enrich the existing body of literature on HOTS assessments and expand the scope of future research. Identifying these emerging areas is crucial for guiding future research directions and fostering the development of more comprehensive and innovative approaches in the field of HOTS assessment.

Conclusion

This study demonstrates that the development of Higher-Order Thinking Skills (HOTS) assessments has seen significant growth, particularly in the last decade, as the importance of higher-order thinking abilities in addressing global challenges becomes more widely recognized. The bibliometric analysis reveals that the publication trends related to HOTS assessment have accelerated since 2019, with the largest contributions coming from Indonesia, Malaysia, and the United States. The geographical distribution and cooperation patterns between countries underscore the strength of international networks in this field, further advancing HOTS assessment methodologies across regions. Journals publishing research on HOTS assessment are predominantly ranked in the highest quartiles (Q1 and Q2), indicating high research quality and broad academic recognition. The main research foci include the development of assessment instruments, the implementation of active learning, and the integration of critical and creative thinking into curricula. Recent innovations are particularly focused on the use of digital tools and online assessments, providing more accurate and practical solutions for measuring HOTS. Moving forward, research in this area should prioritize the development of more advanced digital instruments and interdisciplinary approaches to enhance HOTS assessments in an increasingly dynamic global education context.

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