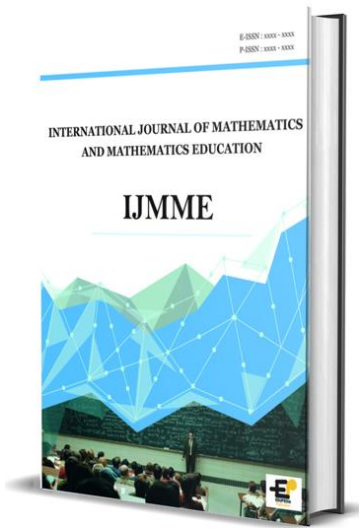

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Research Trends in Higher-Order Thinking Skills in the journal Mathematics Education in Indonesia: from Design to Data Analysis

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Research Trends in Higher-Order Thinking Skills in the journal Mathematics Education in Indonesia: from Design to Data Analysis

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Abstract

The study identified research trends in higher-order thinking skills in Mathematics Education in Indonesia, from Design to Data Analysis. The data came from content analysis of math education articles. As of April 2022, mathematics education articles in the Science and Technology Index (SINTA) are used solely. The Indonesian Ministry of Research, Technology, and Higher Education founded SINTA (http://sinta2.ristekdikti.go.id) to evaluate science and technology. This research shows that qualitative methods, such as theme analysis or grounded theory, can provide insight into student learning, while quantitative methods, such as regression or multivariate analysis, provide statistical analysis of HOTS factors. Recommendations include improving teaching, research, and policymaking on choosing the correct analysis method and institutional support. Diversification and data analysis are essential to improve HOTS research and support Indonesian education development.

Introduction

Recently, there has been a notable emphasis on incorporating Higher-order Thinking Skills (HOTS) into the Indonesian school system, particularly in mathematics. This emphasis aligns with the country's objective to foster persons with knowledge and the ability to think critically, solve problems, and innovate creatively. Tanudjaya (2020) asserts that incorporating HOTS is crucial for cultivating individuals of high calibre who demonstrate exceptional intelligence, creativity, and practical aptitude. Indonesia intends to develop these advanced cognitive capacities to equip students with the necessary skills to tackle the complexities of the contemporary world (Munib, 2019; Rizaldi et al., 2020). This will enable them to significantly contribute to the nation's development and enhance its worldwide competitiveness.

To possess advanced cognitive talents, an individual must employ various mathematical reasoning skills. The talents encompassed in this list are reasoning, analysing (Pollarolo et al., 2022), creating

(Salehudin et al., 2021), organising (Zander & Butler, 2010), and thinking systematically (Jalinus et al., 2019), complexly, critically (Kania et al., 2023), and creatively (Newton et al., 2022). By familiarising themselves with these skills, individuals will acquire the capacity to solve mathematical issues efficiently and develop the aptitude to confront intricate challenges in their daily lives. The habituation process is crucial for cultivating profound and inventive thinking, enhancing the capacity to make informed judgments, resolve complex problems, and generate imaginative and efficient solutions across diverse scenarios. Therefore, acquiring HOTS is crucial for establishing a solid basis for continuous personal growth and lifelong education.

An issue in enhancing HOTS in Indonesia is the need for a comprehensive profile of students' abilities across various educational levels. Ridwan et al. (2022) and Retnawati et al. (2018) stated that students' profiles are essential as they might depict students' ability to apply HOTS to solve real-world problems, including environmental issues. According to Ichsan (2019), a more detailed mapping of students' higher-order thinking skills is needed to identify strengths and weaknesses in the current teaching approach. Without a profound understanding of students' HOTS profiles, it is challenging for educators to design effective and tailored learning strategies. Therefore, in-depth research and evaluation are necessary to develop a comprehensive profile of HOTS to support the development of curriculum and teaching methods that are better equipped to address environmental and other global challenges.

Many studies on HOTS have been conducted in Indonesia, particularly in mathematics education. Several studies focus on HOTS, as performed by Tanudjaya (2020), while other research examines instruments for measuring HOTS (Gusdinata & Somakim, 2020; Ichsan et al., 2020; Sa'dijah, 2016). In addition, some studies examine the influence of instructional design on HOTS (Danczak et al., 2020; Gunawan et al., 2020; Utari & Gustiningsi, 2021). Despite the diversity of topics that have been studied, one prominent aspect is the lack of effort to review the reported information in all of these studies. The lack of a comprehensive review makes it difficult to provide a complete picture of Indonesia's development and implementation of HOTS. This review is crucial for identifying knowledge gaps, integrating existing findings, and providing evidence-based recommendations for improving the quality of education. Therefore, meta-analysis research must incorporate these findings to view HOTS in Indonesian education comprehensively.

This study utilises content analysis on multiple scientific publications of Mathematics education published in Indonesia between 2010 and 2021 to gather information on a range of studies that examine HOTS in the Indonesian context. Specifically, this study addresses the following inquiries: (1) What is the annual trend in the number of studies on HOTS? (2) What is the range of study designs used to investigate HOTS?

Method

Research design

This study employs a content analysis approach utilising the document scanning method to examine a range of studies published in scientific publications in Indonesia. The research methodology employed is analogous to that utilised by (Fauzi & Pradipta, 2018 and Setiawan, 2021 Susetyarini & Fauzi, 2020).

Data source

The data were obtained from the outcomes of content analysis conducted on articles related to mathematics education. The papers are sourced exclusively from mathematics education publications included in the Science and Technology Index (SINTA) as of April 2022. SINTA, accessible at (http://sinta2.ristekdikti.go.id), is a platform created by the Indonesian Ministry of Research, Technology, and Higher Education to assess the progress of science and technology. The SINTA database has a total of 56 journals dedicated to mathematics education. Moreover, articles appraising HOTS were gathered from each of these periodicals. The items examined in this study were published online before April 2022. Of the numerous articles gathered, 141 were explicitly focused on HOTS. Every article was discussed in this investigation.

Instrument

The research utilises a content analysis guide, encompassing many factors about the observed articles, as presented in Table 1. Content analysis often involves the examination of several key factors. The components encompassed are (1) the nature of the research, (2) the participants involved in the research, (3) the tools used to gather data, and (4) the methodologies employed to analyse the data. The categories presented in Table 1 were derived from the research models proposed (Setiawan, 2021; Susetyarini & Fauzi, 2020).

Table 1. Content Analysis Uses Category and Aspect Indicators.

Aspect	Categories	
Types of research	T.1. R and D	T.3. Qualitative Research
	T.2. CAR	T.4. Quantitative Research
Research subject	S.1. Elementary School students	S.8. Undergraduate students
	S.2. VII Grade JHS students	S.9. Posgraduadate students
	S.3. VIII Grade JHS students	S.10. ES teacher
	S.4. IX Grade JHS students	S.11. JHS students
	S.5. X Grade SHS students	S.12. SHS students
	S.6. XI Grade SHS students	S.13. Lecturer
	S.7. XII Grade SHS students	
Data collection	I.1. questionnaire sheet	I.4. interview sheet

Aspect	Categories	
instruments	I.2. observation sheet	I.5. unidentified
	I.3. test sheet	
Data analysis methods	A.1. mean	A.6. ANCONA
	A.2. percentage	A.7. Correlation
	A.3. N-gain	A.8. Unidentified
	A.4. T-test	A.9. Others
	A.5. ANOVA	

Data analysis

Each article was assigned a unique category based on a trait that accurately matched the description. The decision was based on the authors' data in the abstract, method, and discussion sections. In addition, a bar chart was employed to represent the gathered data visually.

Results

The research findings unveil various crucial discoveries that can offer vital perspectives for advancing education in Indonesia. Research indicates that students' HOTS abilities exhibit significant variation across different levels of education. Furthermore, using standardised HOTS assessment instruments is marred by flaws, leading to challenges in effectively gauging students' capacities for critical, analytical, and creative thinking. Furthermore, the learning designs employed in schools frequently fail to adequately facilitate the cultivation of HOTS, as numerous teachers depend on traditional instructional approaches. These findings suggest that a comprehensive strategy is necessary to enhance the quality of education. This includes providing rigorous teacher training, developing a more dynamic curriculum, and using innovative learning methods. Therefore, this research establishes a solid basis for developing more efficient approaches to include HOTS in the national education system.

Number of Publications

The quantity of publications published indicates the frequency at which the study was undertaken within a particular era. Please verify the items referring to the diagram depicted in Figure 1. Superior intellects have been discovered since 2008. No distinct displacement patterns were observed, including the publication count per annum. However, according to Figure 1, there has been a more significant growth in publications since 2020 compared to previous years.

Most research is generated from researchers' sensitivity to common issues that frequently occur around them. One issue constantly discussed is the low academic performance of Indonesian students in mathematics, as indicated by international surveys such as TIMMS and PISA. Therefore, conducting research is the most effective way to address the issue. Through research, researchers can identify weaknesses and methods that can improve students' high-level thinking skills.

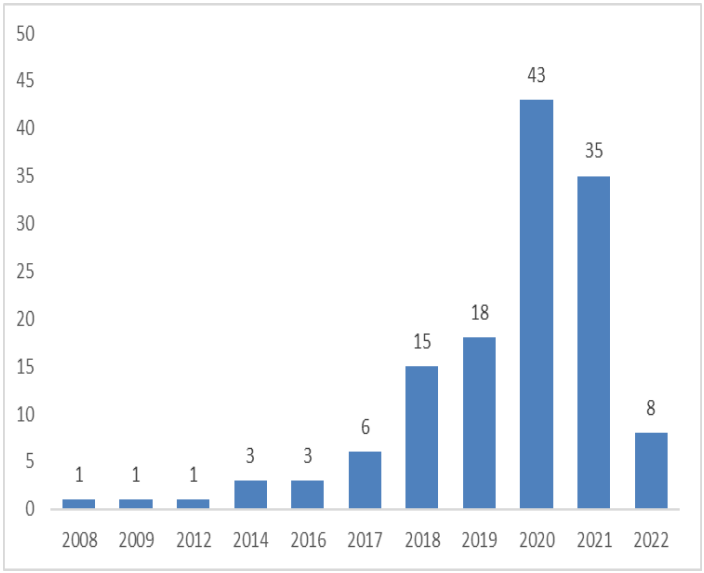

Figure 1. Indonesian Educational Research on Higher-Order Thinking Skill Improved Over 11 Years,

The more studies investigating high-level thinking skills, the more significant the positive impact on education development in Indonesia. The premise is based on the idea that the ultimate goal of research is to enhance educational practices (Coburn & Penuel, 2016). Furthermore, a study will influence educational practices for various reasons, namely: (1) its findings can be regarded as credible information that teachers can implement; (2) it can serve as a fundamental basis for educational decision-making at the national, local, or specific institutional level; and (3) its findings can impact the way teachers think.

Types of Research

In addition to the research topic, this study also seeks to uncover the predominant quantitative distribution preferred by most researchers. Figure 3 indicates that quasi-experimental designs are the predominant experimental research for studying critical thinking skills. Given the more frequent utilisation of quasi-experimental designs compared to other experimental designs, researchers should select the study design that most effectively aligns with their educational concerns (Randler & Bogner, 2008).

The study's selection and configuration significantly impact the emphasis and outcomes of the investigation. According to Figure 2, researchers primarily use qualitative research as the dominant design to study HOTS. Previous studies have consistently found that researchers tend to favour qualitative research designs when investigating students' skills, as evidenced by the more significant number of qualitative studies compared to other types of research. This is directly linked to the benefits of using a qualitative method to define phenomena thoroughly and comprehensively, which enables a more profound comprehension of students' cognitive processes and capabilities.

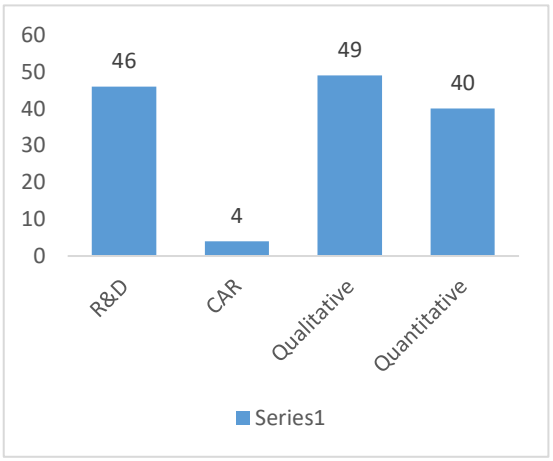

Figure 2. The Distribution of Higher-order Thinking Skill-focused Research by Type

Nevertheless, there has been a noticeable rise in research and development (R&D) research design trends that enhance student skills. This research and development (R & D) methodology is centred on creating and experimenting with educational advancements that enhance the teaching of HOTS. Several reasons may contribute to the absence of Classroom Action Research (CAR) studies to improve students' HOTS. A primary determinant is the constrained timeframe and resources available to teachers for action research within the classroom. Furthermore, more adequate training and support for teachers to carry out CAR research is needed. This scenario signifies the necessity for further endeavours to facilitate and motivate instructors to engage in action research, which can directly enhance students' HOTS. Therefore, employing a variety of study methodologies and providing sufficient support for instructors can be a successful approach to cultivating HOTS in pupils.

Research Subject

The quasi-experimental design is the most frequently utilised research design among researchers, based on facts about the investigation. This demonstrates that, typically, research aims to compare the most effective instructional strategies in empowering students with HOTS. Researchers require study subjects to validate their theories experimentally during the research process.

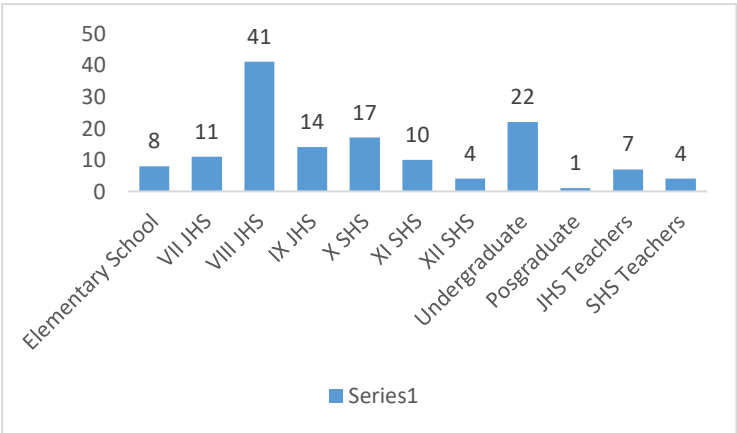

Figure 4. Educational Researches Focus on HOTS in Indonesia

According to Figure 4, junior high school students were the most commonly chosen research subjects, followed by high school and higher education students, respectively. This discovery aligns with a study that examined the content of all mathematics education papers published in Indonesia in 2017.

The dominance of junior high school students is also demonstrated in the research. Based on their study, First-year junior high school students are frequently chosen, but third-year students are rarely considered. Similarly, first-year junior high school students achieved the highest frequency of engagement in research, while third-year students were the lowest. This phenomenon is in line with the tendency of most selective schools to grant permission to researchers to do research in the third year of junior high school or high school due to the tightly scheduled national exams preparation.

Mathematics Topics Selected When Conducting Studies Data Collection Instruments

Research requires instruments to collect data. Researchers have devised measures to assess students' critical thinking. Figure 5 shows that tests are the most popular essential assessment of thinking. Students' high-level question replies access or test critical thinking. Additionally, exams are more objective than surveys and observations.

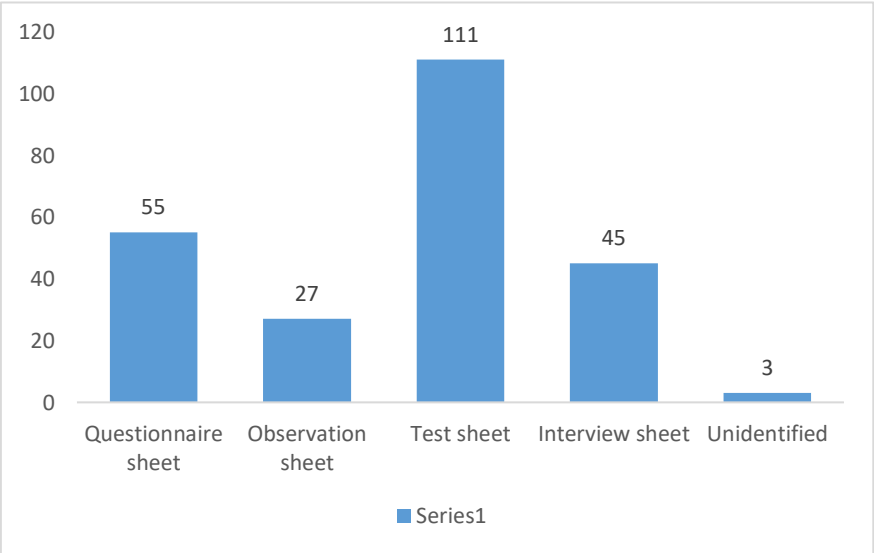

Figure 5. Selection of Data Collection Tools for Indonesian Educational Research using HOTS as a Priority,

Scientific journals in Indonesia frequently discuss assessments that assess pupils' HOTS. The HOTS test assesses students' critical, analytical, and creative thinking beyond knowledge acquisition and application. Essay and project-based assessments are famous because they allow students to analyse, evaluate, and solve complicated problems. Multiple-choice tests with complex situations can also assess higher-order thinking by challenging students to choose the best answer based on in-depth reasoning. Test-based data collectors may not report instrument validity and accuracy. Before collecting data, the instrument's validity and reliability must be validated (Bajpai & Bajpai, 2014; Kania & Kusumah, 2023). Evidence of

validity and dependability is crucial for persuading readers to prioritise higher-order thinking skills. In Indonesia,

Indonesian journals report that the HOTS test helps pupils recognise their higher-level thinking skills and deficiencies. Several studies have examined the HOTS test, which assesses pupils' maths application in unexpected contexts. Teachers should adopt HOTS in the classroom, according to Sulaiman et al. (2020) and Rossini, who emphasise active learning and diversified instructional media and assessment as learning, respectively. Amrina et al. (2024) develop HOTS-based assessment instruments for prospective elementary school teachers, whereas Huliatunisa et al. (2022) analyse sixth-grade teaching techniques. These studies show that the HOTS test can improve students' critical thinking and that teacher training and support are needed to administer it.

Many studies have shown the relevance of HOTS testing, but its implementation in daily practice still needs to be improved (Khoiriah et al., 2020; Rintayati et al., 2020). Significant barriers include inadequate resources, teacher training, and time to construct and assess these assessments. Researchers, educators, and policymakers must work together to overcome these challenges and integrate HOTS evaluation into Indonesian education. Thus, kids can better prepare for complicated academic and life challenges.

Data Analysis Methods

Data analysis method selection accuracy affects study validity. Figure 6 shows 111 research that employed tests (Figure 5), but most used the percentage technique to analyse the data. The broad usage of percentage approaches may reflect the intricacy of HOTS data. The percentage method must be improved in describing kids' complicated higher-order thinking abilities.

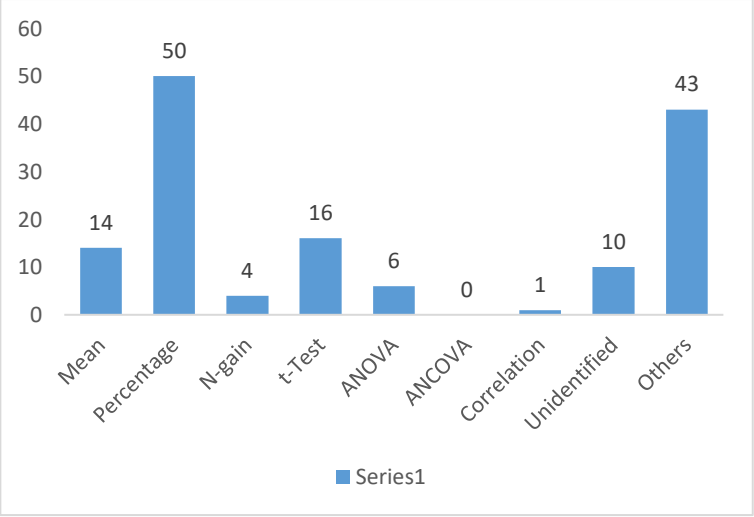

Figure 6. Indonesian HOTS-focused Educational Research Data Analysis Method Selection

Previous research has shown that data analysis procedures matching the data type improve study validity and dependability. Qualitative analysis, like theme or grounded theory, might help assess pupils' higher-

order thinking processes. Qualitative analysis, an incredibly grounded theory, can help teachers evaluate and improve students' HOTS (Garaka & Samob, 2020; Kania, Kyaruzi, & Angraini, 2023). This method can identify motivation, contextual learning, and scientific questioning as essential elements in these skills development. Practical assessment can also foster HOTS (van den Berg, 2004). It can model and coach pupils through challenging thinking activities. Setting hard questions, encouraging group conversations, and encouraging metacognition and reflection help students develop HOTS (Angraini et al., 2024; Kania & Juandi, 2023; Mao, 2023; Palwa et al., 2024). More advanced quantitative analytic approaches like regression or multivariate analysis can reveal more about pupils' HOTS ability. Thus, future research should prioritise data analysis approaches that match research goals and data types. This will strengthen the research and provide more significant insights into students' HOTS, which can help build more effective and appropriate instructional practices.

Discussion

Research validity and reliability depend on the choice of data analysis method. Proper approaches can reveal pupils' HOTS, whereas improper ones can misinterpret them. Proper teaching can disclose students' higher-order thinking capabilities (HOTS), whereas improper ones can misinterpret them (Balakrishnan & Mohamad, 2020; Susilo et al., 2023). Schönborn et al. (2014) found that touch and infrared thermal imaging improve students' knowledge. The graph demonstrating data analysis methods utilising percentages shows a HOTS study pattern. This raises doubts regarding how healthy percentage techniques reflect HOTS data complexity. This opens up discussion of other data analysis methodologies, including advanced qualitative and quantitative analysis.

Qualitative analysis like theme analysis or grounded theory might reveal pupils' HOTS processes. It can also explain students' HOTS assignment context, motivation, and tactics. Qualitative studies show that students employ systematic thinking to solve HOTS problems (Bakry & Bin Bakar, 2015). Teachers still need HOTS knowledge and skills to improve students' HOTS, handle HOTS-related difficulties, and measure HOTS (Retnawati, 2018). According to Yuliati & Lestari (2018), pupils must enhance their HOTS practice question answers. In constructing HOTS-based evaluations, instructors' conceptual understanding, digital literacy, motivation, divergent thinking, and creativity are essential, according to (Widana et al., 2020). These findings emphasise the need for more research on students' HOTS circumstances, motives, and techniques. However, quantitative analysis like regression or multivariate analysis can reveal the statistical aspects that affect pupils' HOTS abilities. It also shows that suitable qualitative and quantitative analysis methodologies help better comprehend students' HOTS. This applies to more effective curriculum development, teaching methods, and results-focused educational evaluation.

Future HOTS studies in Indonesia should vary data analysis approaches. Qualitative and quantitative analysis can be combined depending on study goals and data type. Qualitative analysis, such as theme or grounded theory, might help illustrate pupils' HOTS processes. Further quantitative approaches like regression or multivariate analysis can reveal statistical aspects affecting pupils' HOTS.

Researchers, educators, and policymakers must also be educated about choosing appropriate analytical methodologies. Education stakeholders can achieve this through training, workshops, and knowledge exchange. Educational institutions and the government must provide adequate assistance to employ more advanced analytical approaches and implement HOTS research results in curriculum development, teaching tactics, and academic evaluation.

Conclusion

In conclusion, Indonesian HOTS research results' validity, reliability, and relevance depend on the data analysis method used. The graph illustrating the popularity of percentage approaches in data analysis shows the necessity for variation in analytical techniques, including qualitative and quantitative analysis, depending on research objectives and data type. Future recommendations include increasing awareness of the necessity of choosing appropriate analytical methods, holding training and knowledge exchange, and performing further research to uncover analytical method strengths and shortcomings. HOTS research can provide a more complete and accurate picture of students' higher-order thinking abilities, helping Indonesian education become more successful and relevant.

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