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Comparison of Science Education Curricula in Indonesia and Singapore based on the PISA 2022 Framework: Contexts, Knowledge, Competencies, and Attitudes

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Abstract
Significant differences in PISA and TIMSS evaluation results between Indonesia and Singapore underscore the importance of comparing curricula in both countries. This study aims to compare the Indonesian and Singapore curricula through the PISA 2022 framework in terms of context, competencies, knowledge, and attitudes. The method used in this study is a literature review, which involves collecting documents related to both curricula. The data analysis techniques employed were those outlined by Creswell (2014), which involved collecting documents and coding them to identify relationships and comparisons between elements. The results of the study indicate that both the Indonesian and Singapore science curricula have accommodated most of the dimensions covered in the PISA 2022 framework, particularly in terms of scientific competencies, content knowledge, and attitudes toward science. However, a deeper analysis reveals that the Singapore curriculum is generally more systematic, explicit, and structured in covering all PISA indicators, ranging from real-life contexts to procedural and epistemic knowledge, as well as STEM implementation. Indonesia provides more freedom for teachers to innovate in designing learning, although this can lead to inconsistencies in its implementation. These results emphasize the importance of aligning the national curriculum with international standards, while also considering local context and learning flexibility, to enhance the overall quality of science education. This research has implications for the development of a more focused science curriculum and education policy that is aligned with the PISA 2022 framework. These findings can enrich the comparison of the two countries' science curricula, with the need for further research that directly observes curriculum implementation in the classroom.

Keywords: Indonesian curriculum, Singapore curriculum, Science, The PISA 2022 Framework

INTRODUCTION

The quality of science education in various countries is evaluated through international studies such as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), which aim to assess the development of students' abilities and the effectiveness of teaching methods globally (Teig et al., 2022). Data from these two studies have become a crucial basis for policymakers in formulating strategies to enhance the quality of education (Sulistyaningrum, 2020). Differences in results between countries in the PISA and TIMSS surveys have driven the development of comparative studies of education systems, particularly in terms of curriculum and teaching (Arlinwibowo et al.,

2020). A comparison was conducted between Indonesia and Singapore, given their geographical proximity, despite their starkly contrasting science learning outcomes in the PISA and TIMSS surveys.

Comparison of PISA results between Indonesia and Singapore

PISA is a program conducted every three years by the OECD, which aims to measure the knowledge and understanding of 15-year-old students in the fields of mathematics, science, and literacy in everyday life (Sutrimo et al., 2024). Indonesia has participated in the PISA survey since 2000, while Singapore began participating in PISA in 2009. However, a comparison of PISA survey results between Indonesia and Singapore shows significant differences each year (Khurma et al., 2025).

Based on PISA 2009 data, Indonesia's science literacy score was 383, while Singapore scored 500 (OECD, 2010). In 2012, the science literacy scores between Indonesia and Singapore showed that Singapore scored 551, far higher than Indonesia's 382 (OECD, 2013). In 2015, the science literacy scores of both countries improved, with Singapore maintaining its lead at 556, while Indonesia scored 403 (OECD, 2016). In 2018, Singapore's science literacy score was 551, while Indonesia only scored 396 (OECD, 2018). Then, in 2022, science literacy scores showed that Singapore ranked first with a score of 561, while Indonesia ranked 69th with a score of 383 (OECD, 2022). According to Khurma and Jarrah (2025), after analyzing the 2022 PISA data, it was found that perspective-taking and intellectual curiosity directly predict better science achievement. Educational reform in Singapore tends to be more advanced than in Indonesia because the Singapore curriculum emphasizes learning outcomes and processes (Vinodhen, 2020).

Comparison of TIMSS results between Indonesia and Singapore

The comparison of Indonesia's TIMSS results with Singapore's is not much different from the PISA results. TIMSS is a survey conducted every four years by the IEA to measure the mathematical and scientific skills and understanding of eighth-grade students (around 13–14 years old) (Mutakin et al., 2023). The TIMSS results for Indonesia and Singapore in 2003 showed that Indonesia scored 411, while Singapore scored 578 (Martin et al., 2024). In 2007, Indonesia scored 397 and Singapore 567 (Gonzales et al., 2008). In 2011, Indonesia's score dropped to 386, while Singapore's increased to 590 (Martin et al., 2012). In 2015, Indonesia scored 397, while Singapore achieved a score of 618 (Martin et al., 2016). Meanwhile, in the 2019 survey, Indonesia did not participate in the TIMSS survey (Mullis et al., 2020). Based on the TIMSS results, it can be concluded that Singapore's achievements are far superior to Indonesia's, where Indonesia's scores tend to decline from year to year.

Comparison of PISA and TIMSS Assessment Indicators

The indicators used in the PISA survey encompass three primary competencies: mathematics, science, and reading. The questions presented are referred to as Higher Order Thinking Skills (HOTS) questions (Silwana & Julianingsih, 2025). PISA measures both theoretical skills and the ability to solve everyday problems. Higher-order thinking skills are the primary focus of PISA assessments (Pratama & Husnayaini, 2022). Meanwhile, the TIMSS survey employs several indicators to assess educational equity, including teaching quality and school life, by focusing on the school environment and students' learning experiences (Apples et al., 2024). TIMSS places greater emphasis on achievements in subjects such as factual knowledge, concepts, and procedures taught in the classroom (Mullis et al., 2020). Therefore, the PISA survey is used as the primary reference in the comparison process between the Indonesian and Singaporean curricula. This is because PISA assesses students' ability to handle real-world situations, an approach that aligns more closely with students' needs in developing 21st-century skills.

The Curriculum in Indonesia

The curriculum in Indonesia has undergone several changes, resulting in improvements in the quality of education. These curriculum changes have also affected the patterns of learning activities in each subject, including science education (Zamista, 2024). A responsive curriculum is key to addressing the dynamics and challenges of the times (Lubis et al., 2024). As the primary reference, the National Education Standards ensure that the curriculum meets the national education expectations (Poerwanti & Istanti, 2020; Amrizal et al., 2023). Currently, the curriculum used in Indonesia includes the 2013 Curriculum (K-13) and the independent curriculum launched in 2022, which serves as an improvement on the 2013 Curriculum, offering greater freedom for schools, teachers, and students in the teaching and learning process (Kemendikbudristek, 2022; Dendodi et al., 2024).

The 2013 Curriculum adopts a scientific approach emphasizing character development, critical thinking skills, and integrated thematic learning, particularly at the junior high school level for science subjects (Daga, 2022). However, the implementation of K13 is still considered too content-heavy and inflexible. Therefore, starting in 2022, the government introduced the Merdeka Curriculum, which offers more flexible learning, focuses on achieving essential competencies, and develops character through the Pancasila Student Profile Strengthening Project (P5) (Widiana, 2023). The distinctive features of the Merdeka Curriculum include differentiated learning, simplification of material, and more holistic assessment that focuses on the overall development of students (Kemendikbudristek, 2022). Therefore, the curriculum in this analysis uses the latest curriculum, namely the Merdeka Curriculum.

The Curriculum in Singapore

The curriculum in Singapore is designed to ensure that students are not only passive users of technology but also capable of thinking critically and creatively in using technology to solve real-world problems (Nuraini et al., 2025). Singapore's education system features a centralized structure in various areas, including national education policy, national curriculum, and school system development. Schools are given autonomy and responsibility in administration and certain professional areas, such as educational practices tailored to the needs of students (Sisman & Karsantık, 2021). The integration of technology in education and collaborative learning is prioritized, creating a dynamic and interactive learning environment that fosters a deeper understanding of concepts. Student-centered learning is a priority, with a curriculum that supports exploration, creativity, and the development of critical and analytical skills. Learning focuses on problem-solving and teamwork, preparing students for the challenges of the global era (Priyono, 2024; Daniati et al., 2024).

Science education has shifted toward an inquiry-based learning approach, with inquiry-based teaching most widely implemented in Singapore, followed by the United States (Nandy, 2024). Singapore's science curriculum centers on science as a research process, encouraging all students to understand and engage with science (Teo & Choy, 2021). One of the main factors influencing student motivation is curiosity. Cultivating curiosity is important because it can increase enthusiasm for learning science (Bjerknes et al., 2024). The science curriculum in Singapore utilizes and encourages student interest (MOE, 2013). Teachers play a crucial role in providing diverse learning experiences as controllers, directors, leaders, facilitators, and sources (Rahmadani et al., 2024).

Relevant Research

Previous research by Arlinwibowo et al (2020) successfully mapped five dimensions of student perceptions of science learning based on the results of the 2015 PISA questionnaire. The findings of Arlinwibowo et al. (2020) indicate that Singaporean students tend to experience structured and practice-based science learning with strong teacher support, while Indonesian students perceive their learning as more open, exploratory, collaborative, and guided by teachers as mentors. The novelty of this study lies in analyzing the science curricula of Indonesia and

Singapore by comparing the curriculum documents of both countries with the PISA 2022 framework, thereby providing a more comprehensive understanding of science curricula aligned with international standards.

This study adapts the document analysis approach developed by Safrudiannur and Rott (2019), which compares the Indonesian and Singapore mathematics curricula based on PISA 2012 items that focus on integrating problem-solving into the learning process. The results of Safrudiannur and Rott' (2019) research indicate that the Singapore mathematics curriculum is more comprehensive in covering the content tested in PISA 2012 compared to the Indonesian curriculum and exhibits a stronger emphasis on developing problem-solving skills. This study builds on these findings, focusing its analysis on the content and structure of the science curriculum using the PISA 2022 framework.

This study highlights the importance of mapping and evaluating science education curricula in Indonesia in a global context, particularly by comparing them with Singapore's curriculum, which has demonstrated high performance in international assessments such as PISA. The problem addressed in this study is how the Indonesian and Singaporean science curricula compare in the four main aspects of the PISA 2022 framework: context, knowledge, competencies, and attitudes. This study aims to identify the differences and similarities between the two curricula in supporting the development of students' science literacy in facing the scientific challenges of the 21st century. Therefore, this study expands the scope and depth of PISA-based curriculum comparison studies, particularly in the field of science education.

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METHODOLOGY

This study uses the PISA 2022 framework as an external basis for assessing educational performance in both countries (OECD, 2022). The primary focus identified in the PISA 2022 science literacy framework includes context, knowledge, competencies, and attitudes (OECD, 2022). The method employed in this study is a literature review, which involves collecting data through the understanding and analysis of theories related to science curricula in Indonesia and Singapore (Andlini et al., 2022). The secondary data used in the comparison were obtained from phase D learning outcome documents, learning and assessment guide documents, the 7th-grade (lower secondary G1) science syllabus, and the 8th/9th-grade (lower secondary G2/3) science syllabus. These documents are the reference for the science curriculum in secondary schools in Indonesia and Singapore.

Data analysis in this study employed qualitative analysis, as described by Creswell (2014), which involved organizing data by preparing Indonesian and Singapore curriculum guide documents, followed by reading and coding the data. The analytical approach described by Creswell enables researchers to systematically identify and categorize key elements in the curriculum, including context, knowledge, competencies, and attitudes, based on the PISA 2022 framework. This method is also flexible, allowing researchers to explore the hidden meanings behind educational policy narratives without compromising objectivity. The coded curriculum data were then categorized and clustered into PISA 2022 item categories, analyzed for patterns or relationships between data, and organized to understand the differences between the Indonesian and Singapore curricula based on the completeness of PISA items. The final stage involved evaluating reliability and validity, ensuring the validity of the findings through triangulation and member-checking techniques.

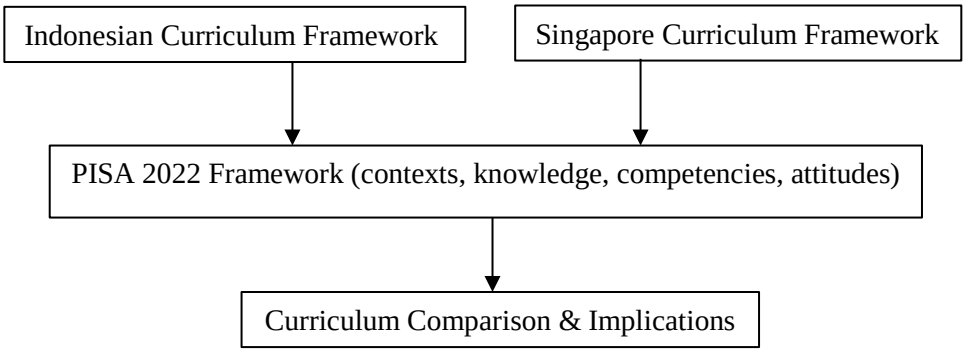

Figure 1. The Framework of This Curricula Comparison Study

RESULTS

This study aims to identify the differences and similarities between the two curricula in supporting the development of students' science literacy and to provide implications for improving science curricula. This study uses the PISA 2022 framework as an external basis for assessing educational performance in both countries (OECD, 2022). The primary focus identified in the PISA 2022 science literacy framework includes context, knowledge, competencies, and attitudes (OECD, 2022).

Indonesian Curriculum Framework

Indonesia utilizes the Merdeka Curriculum, which is based on the Pancasila student profile, as the foundation for the learning process, as illustrated in Figure 2. Competencies in the Pancasila student profile include diversity, critical thinking, independence, faith and devotion to God Almighty, noble character, creativity, and cooperation (KemendikbudRistek, 2024). The science curriculum framework in Indonesia is designed to develop students' scientific understanding and skills by integrating local wisdom. Given Indonesia's status as a multicultural country, integrating local wisdom into the curriculum is an interesting topic (Muyassaroh et al., 2024). The Merdeka Curriculum at the junior high school level consists of one phase, specifically Phase D, for grades 7, 8, and 9 (Ningsih, 2023).

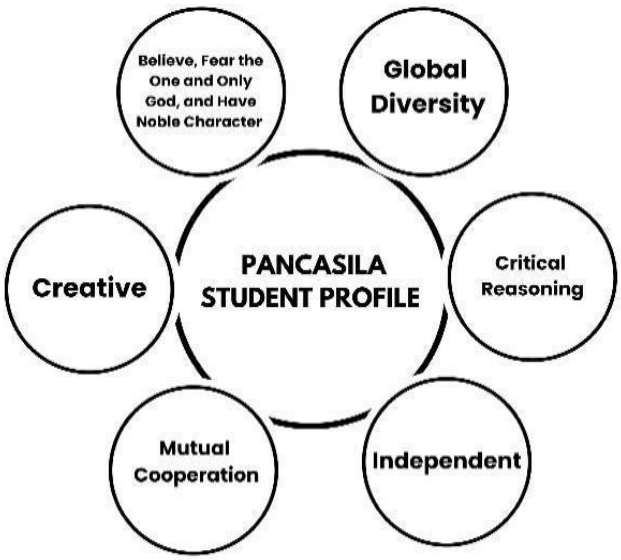

Figure 2. Pancasila Student Profile (Kemendikbud Ristek, 2024)

The learning objectives of integrated science in Indonesia align with the Pancasila student profile, specifically to develop curiosity and interest in natural phenomena and understand their mutual influence on human life (Kemendikbudristek, 2024). Being able to think actively in protecting and preserving the environment and managing natural resources well (Kemendikbudristek, 2024). Being able to develop inquiry process skills to identify, formulate, and solve problems through concrete actions (Kemendikbud Ristek, 2024) and being able to contribute to solving personal and environmental problems (Kemendikbudristek, 2024) and being able to develop knowledge and understanding of concepts in science and apply them in daily life (Kemendikbudristek, 2024).

In the Merdeka Curriculum, science learning outcomes are divided into two main elements, namely science content and science process skills (Aisah & Agustini, 2024). Each element is applied to four content areas: living things, substances and their properties, energy and its transformations, and the Earth and space. Understanding scientific concepts requires the ability to think systematically, comprehend concepts and their relationships, including causal relationships, as well as the hierarchical levels of concepts within biology, physics, chemistry, Earth, and space (Kemendikbudristek, 2024).

Process skills based on the Pancasila learner profile, using an inquiry approach, include observing, asking questions, predicting, planning, conducting investigations, processing data and information, analyzing, evaluating, and reflecting, as well as communicating results (Kemendikbudristek, 2024). This study aims to identify the differences and similarities between the two curricula in supporting the development of students' science literacy and to provide implications for improving science curricula. This study uses the PISA 2022 framework as an external basis for assessing educational performance in both countries (OECD, 2022). The primary focus identified in the PISA 2022 science literacy framework includes context, knowledge, competencies, and attitudes (OECD, 2022).

Singapore Curriculum Framework

The science curriculum framework in Singapore encourages science education to provide a strong foundation for life, learning, citizenship, and work, as shown in Figure 3. Science learning materials in Singaporean secondary schools are categorized into three levels: G1, the easiest level; G2, the standard level; and G3, the most challenging level (Tan, 2024). The goal of the science curriculum is to encourage and nurture students to master science literacy, make decisions, and take responsible action in their daily lives. The science curriculum also facilitates students by providing the scientific foundations for STEM innovation (MOE, 2024).

Figure 3. Singapore Curriculum Framework (MOE, 2024)

There are three core elements in the Singapore science curriculum framework: inspire, inquire, and innovate. These three core elements are used to achieve the vision, which is for students to be inspired and enthusiastic about learning science to help solve global challenges and pursue careers in the field of science. Second, students possess a strong foundation and enthusiasm for scientific inquiry, and they are confident in applying scientific principles by critically evaluating ideas based on scientific evidence. Third, students apply science to innovate in solving real-world problems and contribute to STEM research, innovation, and entrepreneurship (MOE, 2024). STEM application is suitable for science learning because STEM-based learning can train students to apply their knowledge to create designs as a form of problem-solving (Astuti et al., 2023).

The outer circle represents the strong foundations of science, encompassing core ideas, practices, values, ethics, and attitudes (MOE, 2024). Core ideas make science learning coherent and meaningful, connecting conceptual fields (physics, chemistry, biology) (MOE, 2024). Scientific practices include ways of thinking and behaving in science (WOTD), understanding the nature of scientific knowledge (NOS), and connecting science, technology, society, and the environment (STSE) (MOE, 2024). Values, ethics, and attitudes in science are employed to consider the ethical implications of science (MOE, 2024). The aim of incorporating scientific values into the curriculum is to cultivate students' ethical values in society. Science education prepares students to behave ethically in society and participate in environmental issues (Monsalve-Silva et al., 2025).

The Singapore science curriculum places students as researchers in their learning process and scientific inquiry, while teachers support and facilitate students' learning experiences (Yeo & Tan, 2021). Teachers also encourage students' curiosity; if teachers present learning that stimulates curiosity, students will be more active in asking questions, observing, and seeking answers to the phenomena they encounter (Rahmadhani, 2025).

Curriculum Comparison between Indonesia and Singapore based on the PISA 2022 Framework

This study uses the PISA 2022 science framework as a reference for comparing the science curricula of Indonesia and Singapore. PISA assesses scientific knowledge in contexts relevant to the curricula taught in participating countries. The PISA 2022 framework is analyzed based on four components: context, competencies, knowledge, and attitudes (OECD, 2022a). Each component of the Indonesian and Singaporean curricula will be compared with the PISA 2022 framework. The tables in this study summarize the results of coding and interpreting the curriculum documents of both countries. A critical analysis of the coverage of context in the Indonesian and Singapore curricula based on the PISA 2022 framework is presented in Table 1.

Table 1. Comparison of Indonesian and Singapore Curricula Contexts based on PISA 2022 Framework.

Context of PISA 2022	Indonesian	Singapore	Analytical Summary
Health and disease	All subtopics not covered	Covered at all G1/G2/G3 grades	Singapore has a more comprehensive health and disease context
Natural resources	All subtopics not covered	Covered at all G1/G2/G3 grades	Singapore is well-equipped on the topic of sustainability and resources
Environmental quality	All subtopics covered	Covered at all G1/G2/G3 grades	Both countries have the exact contextual requirements, but the depth and methods of teaching can vary
Hazards	All subtopics covered	Covered at all G1/G2/G3 grades	Both countries have the exact contextual requirements, but the depth and methods of teaching can vary
Frontiers of science and technology	Most subtopics are not covered	Mostly covered at the G1/G2/3 grades	Singapore is more responsive to technology and innovation

A comparison of the Indonesian and Singaporean curricula based on the PISA 2022 framework reveals that the Singapore curriculum aligns more closely with the PISA 2022 context in the field of science. All five topics are covered in the Singaporean curriculum, both in Grade 1 and in Grades 2 and 3. Meanwhile, Indonesia only covers two topics comprehensively in its science curriculum, namely environmental quality and hazards. A significant difference is evident in the Singapore curriculum guidelines, which provide detailed information on each context, whereas the Indonesian guidelines only cover topics in general terms. Furthermore, a comparison of the competencies of the Indonesian and Singapore curricula, based on PISA 2022, is presented in Table 2.

Table 2. Comparison of Indonesian and Singapore curricula Competencies based on PISA 2022.

PISA 2022 Scientific Competencies	Indonesian	Singapore	Analytical Summary
Explaining phenomena scientifically	All subcompetencies are covered	All subcompetencies are covered the G1/G2/G3 grades	Both curricula support basic scientific explanation skills
Evaluate and design scientific investigations	Most subcompetencies are covered	Most subcompetencies are covered at the G1/G2/G3 grades	Both curricula need to equip students in the design and evaluation of scientific experiments more systematically
Interpreting scientific data and evidence	All subcompetencies are covered	All subcompetencies are covered the G1/G2/G3 grades	Both curricula strongly support data literacy and the ability to robustly evaluate evidence-based arguments

A comparison of competencies between the Indonesian and Singapore curricula reveals similar results, namely that they meet most of the competencies outlined in the PISA 2022 framework. Neither curriculum yet meets the competencies in evaluating and designing scientific investigations. Inquiry-based learning in Indonesia and Singapore has not been well-formulated to distinguish and evaluate scientific questions, nor to assess the reliability and objectivity of data. However, there are differences in learning design between Singapore and Indonesia. In the Indonesian curriculum guidelines, teachers are given the freedom to design

their learning processes, whereas in Singapore, learning outcomes are predetermined as a reference for teachers in their teaching. The advantage of the Indonesian curriculum is that teachers can design learning creatively and innovatively, adapting it to the individual needs of each student and their specific environment. The disadvantage of the Indonesian curriculum is that there is no guarantee that all teachers have the same understanding of learning outcomes, so ideal learning may not always be achieved. A comparison of the science content knowledge in the Indonesian and Singapore curricula, based on PISA 2022, is presented in Table 3.

Table 3. Comparison of Indonesian and Singapore curricula science content knowledge based on PISA 2022.

Knowledge of the content of science	**Indonesian**	**Singapore**	**Analytical Summary**
Physical Systems	All subtopics covered	All subtopics are covered at the G1/G2/G3 grades	Both curricula cover physical systems
Living Systems	All subtopics covered	All subtopics are covered at the G1/G2/G3 grades	Both curricula cover living system material
Earth and Space Systems	Most subtopics are covered	Most subtopics are not covered.	Singapore shows a massive gap in the teaching of geosciences and astronomy

A comparison of the content of the Indonesian and Singapore curricula reveals significant differences. The Singaporean science curriculum does not cover topics related to the Earth and space systems, which require specialized knowledge, whereas the Indonesian curriculum includes several subtopics related to these topics. However, the Singaporean curriculum covers more complex topics related to physical systems and living things than the Indonesian curriculum, with a more holistic approach to subtopics. Although both have similar content, the implementation of the Singaporean curriculum contains more complex and detailed content. Additionally, in the Singaporean curriculum, the G2/G3 group has broader and deeper content compared to the G1 group. A comparison of procedural knowledge between the Indonesian and Singapore curricula, based on PISA 2022, is presented in Table 4.

Table 4. Comparison of Procedural Knowledge Indonesian and Singapore Curricula based on PISA 2022.

	Procedural Knowledge	Indonesian	Singapore	Analytical Summary
a.	The concept of variables, including dependent, independent and control variables	Covered	Covered at all G1/G2/G3 grades	Both curricula cover explicitly and systematically
b.	Concepts of measurement, e.g. quantitative (measurements), qualitative (observations), the use of a scale, categorical and continuous variables	Covered	Covered at all G1/G2/G3 grades	Both curricula are aligned with the standards of scientific experimentation
c.	Ways of assessing and minimising uncertainty, such as repeating and averaging measurements	Not covered	Covered at all G1/G2/G3 grades	The Indonesian curriculum has not addressed this aspect, whereas the Singapore Curriculum has fully covered it
d.	Mechanisms to ensure the replicability (closeness of agreement between repeated measures of the same quantity) and accuracy of data (the closeness of agreement between a measured quantity and a true value of the measure	Not covered	Covered at all G1/G2/G3 grades	The Indonesian curriculum lacks scientific accuracy and needs to strengthen its foundational concepts
e.	Common ways of abstracting and representing data using tables, graphs and charts, and using them appropriately	Covered	Covered at all G1/G2/G3 grades	Both curricula are adequate in the processing and visualization of scientific data
f.	The control-of-variables strategy and its role in experimental design or the use of randomised controlled trials to avoid confounded findings and identify possible causal mechanisms	Not covered	Covered at all G1/G2/G3 grades	The Singapore curriculum trains experimental design skills more systematically than the Indonesian curriculum
g.	The nature of an appropriate design for a given scientific question, e.g. experimental, field-based or pattern-seeking	Covered	Covered at all G1/G2/G3 grades	Both curricula are based on a scientific thinking approach with an experimental design

The results of a comparison of procedural knowledge in the Indonesian and Singapore curricula based on PISA 2022 show that the Singapore curriculum has more comprehensive steps in the learning process than the Indonesian curriculum. The Indonesian curriculum only covers four procedures, while the Singapore curriculum covers all procedures at the G1 and G2/3 levels. The procedures that are not yet complete in the Indonesian curriculum are how to deal with data uncertainty and ensure data replication and accuracy. The comparison of epistemic knowledge between the Indonesian and Singaporean curricula, based on PISA 2022, is presented in Table 5.

Table 5. Comparison of Indonesian and Singapore Curricula epistemic knowledge based on PISA 2022.

Epistemic knowledge	Indonesian	Singapore	Analytical Summary
Basic Concepts of Science	All subtopics covered	All subtopics are covered at the G1/G2/G3 grades	Both curricula cover core science concepts, including the nature of theory, the purpose of science, and various types of scientific reasoning
Justification and Scientific Reasoning	Some subtopics covered	All subtopics are covered at the G1/G2/G3 grades	Singapore's curriculum covers scientific knowledge justification more comprehensively, whereas Indonesia has not covered aspects such as measurement error
Scientific Research and Methodology	Most subtopics are covered	All subtopics are covered at the G1/G2/G3 grades	Both address scientific inquiry and hypothesis testing, but Singapore is stronger in the use of scientific models and collaboration
Social and Ethical Dimensions in Science	Not all subtopics are covered	All subtopics are covered at the G1/G2/G3 grades	Singapore emphasizes the role of science in addressing social issues and the importance of scientific values, such as publication and peer review, which are not yet evident in M01

A comparison of epistemic knowledge in the Indonesian and Singapore curricula, based on PISA 2022, reveals that the Singapore curriculum's epistemic knowledge is more comprehensive than that of the Indonesian curriculum, particularly in terms of the role of constructs and features in justifying the knowledge produced by science. The Singapore curriculum integrates epistemic knowledge into every learning topic using a STEM approach. In Indonesia, epistemic knowledge is applied to process skills to support scientific understanding. A comparison of attitudes toward science in the Indonesian and Singapore curricula, based on the 2022 PISA results, is presented in Table 6.

Table 6. Comparison of Attitudes Towards Science Indonesian and Singapore Curricula based on PISA 2022.

Attitudes towards science in PISA 2022	Indonesian	Singapore	Analytical Summary
a. Interest in science	Covered	Covered at all G1/G2/G3 grades	Both curricula explicitly encourage students' interest in science
b. Valuing scientific approaches to enquiry	Covered	Covered at all G1/G2/G3 grades	Both curricula demonstrate an appreciation for the scientific process as a means of acquiring knowledge
c. Environmental awareness	Covered	Covered at all G1/G2/G3 grades	Curricula in both countries include awareness of environmental issues as part of science education

A comparison of attitudes toward science between the Indonesian and Singapore curricula based on PISA 2022 shows similar results. Both curricula promote attitudes toward science, including interest in science, appreciation of the scientific approach to inquiry, and environmental awareness. Attitudes toward science in the Indonesian curriculum are addressed through process skills, whereas the Singaporean curriculum is implemented through STEM-based learning. The comparison results indicate that the Singaporean curriculum has more PISA items than the Indonesian curriculum. Therefore, a more in-depth study of these comparison results is required.

DISCUSSION

Framework of Science Curriculum in Indonesia and Singapore

The Merdeka Curriculum implemented in Indonesia emphasizes the application of Pancasila values in every aspect of learning (Lukitoyo et al., 2023). This curriculum is designed to develop students' competencies in a balanced manner by integrating scientific knowledge and scientific process skills (inquiry). The primary focus of this curriculum is to cultivate students' curiosity about natural phenomena while promoting an understanding of humanity's role in preserving the environment and natural resources. In science education, Indonesia also integrates local wisdom as part of the educational process, reflected in four main topics: living things, matter and its properties, energy and its changes, and the earth and space. The Merdeka Curriculum aims to enable students to understand and apply science in their daily lives, grounded in strong national values (Ndari & Mahmudah, 2023; Alifiyah et al., 2024).

The Singapore science curriculum emphasizes the development of a strong foundation of scientific knowledge and practical skills that can be applied in daily life. The learning materials in Singapore categorize the science curriculum into three levels: G1 (basic level), G2 (standard level), and G3 (advanced level), which are designed to cater to the needs and abilities of students (MOE, 2024a; MOE, 2024b). The three main principles in the Singapore curriculum are inspiration, inquiry, and innovation (Deng & Gopinathan, 2006). These principles aim to inspire students, foster a spirit of scientific inquiry, and encourage innovation through the Inspire, Inquire, Innovate approach to learning. The curriculum also emphasizes the importance of ethical values in science, including respect for diversity and consideration of the social and environmental implications of scientific discoveries. Singapore emphasizes a more in-depth approach to developing critical and creative thinking skills in students (Yeo & Tan, 2021; Teig et al., 2022).

Curriculum Comparison

A comparison between the Indonesian and Singapore curricula, in the context of the 2022 PISA results, reveals significant differences (OECD, 2022b). The Indonesian science curriculum tends to be more limited, covering only two main topics, namely environmental quality and natural hazards, with a focus on understanding ecological quality and the impact of disasters. In contrast, the Singaporean curriculum covers a broader range of topics, including health issues, natural resources, and natural disasters, with more detailed discussions at the basic level (G1) and intermediate/advanced levels (G2/3) (MOE, 2024a, 2024b). In addition, Singapore has more detailed curriculum documentation, providing clear classroom teaching guidelines and enabling teachers to deliver material in a more structured and consistent manner. In Indonesia, although there are general guidelines, the delivery of material is more open to interpretation, providing flexibility but risking inconsistency in curriculum implementation between schools (Nasution et al., 2022).

Both countries face similar challenges in developing student competencies, particularly in evaluating and designing scientific investigations. The curricula in Indonesia and Singapore have not yet fully developed high-level scientific skills in formulating scientific questions and evaluating data objectively and reliably. However, Singapore excels in terms of learning outcomes, where learning objectives are clearly defined and measurable, providing concrete guidelines for teachers in designing instruction (MOE 2024a; Deng & Gopinathan, 2006). In Indonesia, although teachers are given freedom to innovate in designing instruction, this can lead to variations in the understanding and application of scientific competencies across schools.

In terms of science content knowledge, there are significant differences between the two countries. The Indonesian curriculum encompasses several subtopics related to Earth and space systems, including the structure and energy of the Earth system and the changes occurring within it (Kemendikbudristek, 2022; Fadilah & Fitriyani, 2024). However, not all relevant topics are discussed in depth. On the other hand, the Singaporean curriculum does not emphasize content related to Earth and space systems. However, it focuses more on physical systems and living

organisms, providing more detailed and comprehensive explanations. Singapore emphasizes the development of more in-depth knowledge at the advanced level (G2/3) (MOE, 2024a; MOE, 2024b). The Indonesian approach tends to present topics in a general manner, which does not provide students with a deep understanding of science.

In terms of procedural knowledge, there are essential differences between the two curricula. The Indonesian curriculum covers several topics related to measurement, variables, and methods for assessing uncertainty in experiments. However, the discussion of scientific procedures, especially in ensuring replication and data accuracy, has not been discussed in depth. In contrast, Singapore has a more structured and detailed approach to teaching scientific methods, including assessing and minimising measurement uncertainty and ensuring data accuracy. This indicates that Singapore places a greater emphasis on developing students' scientific skills within the context of experiments and scientific procedures, which are crucial for establishing a solid understanding of science (MOE, 2024a; Yeo & Tan, 2021).

A comparison of attitudes toward science in the Indonesian and Singapore curricula shows a similar level of completeness. The Indonesian curriculum integrates attitudes toward science into the learning process, with a focus on process skills. The Singapore curriculum applies attitudes toward science in every step of the learning process and integrates them with STEM-based learning. Both countries share a similar perspective on scientific attitudes in education, including an interest in science, a value for the scientific approach to inquiry, and environmental awareness. The primary difference in their implementation lies in the fact that the Singapore curriculum emphasises the development of 21st-century skills, whereas the Indonesian curriculum emphasises the integration of Pancasila values (Kemendikbudristek, 2022; Yeo & Tan, 2021).

A comparison between the Indonesian and Singaporean science curricula highlights significant differences in the structure and implementation of learning. Singapore has a more detailed and structured curriculum, resulting in more consistent and in-depth teaching. On the other hand, Indonesia gives teachers more freedom to design innovative learning, although this has the potential to cause inconsistencies in its implementation. Although both curricula face similar challenges in developing scientific skills, Singapore is more advanced in its emphasis on structured scientific competencies and more in-depth data evaluation. Both countries still need to strengthen the development of students' scientific inquiry and experimental science skills to prepare them for global challenges in science and technology (Teig et al., 2022).

CONCLUSION AND IMPLICATIONS

This study found that both Indonesian and Singapore science curricula have accommodated most of the dimensions covered in the PISA 2022 framework, especially in terms of scientific competence, content knowledge, and attitudes towards science. However, in-depth analysis reveals that the Singapore curriculum is generally more systematic, explicit, and structured in covering all PISA indicators, ranging from real-life contexts to procedural and epistemic knowledge, as well as STEM implementation.

The Indonesian curriculum provides more coverage of geoscience and space content, allowing teachers to exercise creativity in designing contextualised learning that meets local needs. However, this flexibility is also a challenge because not all teachers have a standardised guide that is consistent with the expected learning outcomes. In contrast, the Singapore curriculum sets more measurable and targeted learning outcomes at each level of education (G1, G2, G3), thus supporting equity in education quality and readiness for international assessments such as PISA.

A fundamental weakness in the Indonesian curriculum lies in the lack of critical scientific procedures, such as variable control, data uncertainty, and the accuracy of experimental results, which potentially hinders the development of students' higher-order thinking skills. Meanwhile, the Singapore curriculum excels in the epistemic and socio-ethical integration of science, strengthening students' understanding of the nature of science and its

application in society. These results emphasise the importance of adapting national curricula to international standards without neglecting the local context and flexibility of learning, to improve the overall quality of science education. The findings can enrich the comparison of science curricula between the two countries, highlighting the need for further research that directly observes the implementation of the curriculum in the classroom.

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