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UNDERSTANDING THE DUALITY OF MATHEMATICS EDUCATION PARADIGMS: A COMPARATIVE REVIEW OF INDONESIAN AND JAPANESE LEARNING METHODS

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ABSTRACT

This article describes a comparison of mathematics learning methods between Japan and Indonesia. In Japan, structured and systematic approaches such as *Rikai Kansatsu* and *Kōryū* are applied, with an emphasis on observation, deep understanding, and collaborative work in solving mathematical problems. Teachers in Japan also apply problem solving and open ended approaches, which encourage students to think critically, creatively and independently. In addition, the implementation of lesson study as a scientific activity that involves teachers in developing the theory and practice of mathematics learning is a strong foundation for the method in Japan. On the other hand, in Indonesia, there is a shift towards more inclusive and creative learning approaches, such as the Scientific approach and the Concrete Representational Abstract (CRA) approach. Teachers in Indonesia emphasize more on achieving individual and classical student competencies, with a strong orientation towards learning outcomes. Although the concept of lesson study has been implemented in Indonesia, there are still differences in the development of theories and the application of learning methods. Awareness, support, and collaboration among teachers are key to developing and expanding the application of lesson study and improving the quality of mathematics learning in Indonesia. With increased teacher understanding and participation, the potential of lesson study development and implementation in Indonesia can be optimized to improve students' understanding of mathematics and critical thinking skills.

Keywords: Methods, Comparative, Japan, Indonesia, Mathematics

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PRELIMINARY

The education system in Japan has a strong reputation and is internationally recognized. The Japanese approach to education is based on principles such as discipline, cooperation, responsibility, and respect for learning (Montanesa & Firman, 2021). The

country's education system consists of three main levels: primary, secondary, and higher education (Milliywati, 2016). Primary education includes elementary and junior high schools, where the national curriculum is taught with an emphasis on math, Japanese language, science, social studies, arts, and sports (Aniswita dkk., 2021).

Based on the results of international studies, the quality of education in Japan has been recognized as one of the best in the world. The country often achieves high rankings in tests and evaluations such as the Program for International Student Assessment (PISA) conducted by the OECD (OECD, 2019). On the PISA test, Japanese students showed outstanding achievement in math, science, and reading (Chamisah, 2019 ; Fredriksson et al., 2023). The results of the PISA (Program for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) studies show impressive achievements in Japanese education. Based on the latest data, Japan has achieved very high rankings in both tests (Bokhove, 2022).

In PISA, which measures students' abilities in reading, math, and science, Japan has consistently ranked among the top countries. In the 2018 PISA test, Japan achieved 4th place in math, 5th place in science, and 8th place in reading among 79 participating countries (Mammadov & Çimen, 2019). This shows that Japanese students have strong abilities in math and science literacy and skills. Meanwhile, in TIMSS, which focuses on the math and science abilities of students at the primary and secondary levels, Japan also recorded outstanding achievements (Bhutoria & Aljabri, 2022). In the 2019 TIMSS, Japanese students ranked 5th in math at the elementary school level and 7th at the middle school level (Bokhove, 2022). In science, Japan ranks 7th at the elementary school level and 8th at the middle school level (Auliya' & Widjajanti, 2023). This shows the consistent high achievement of Japanese students in math and science at various levels of education (Fredriksson et al., 2023). The data also illustrates that the Japanese education system has succeeded in creating an effective learning environment and promoting high academic achievement. A strong approach to discipline, high-quality basic education, and a focus on literacy and math and science skills have resulted in good outcomes for Japanese students (Takayama, 2017).

One of the factors contributing to the quality of education in Japan is an approach that emphasizes discipline (Huda et al., 2023). Japanese students are provided with a solid educational foundation through a comprehensive national curriculum and high-quality basic education (Wieczorek, 2008). They are trained to have a serious attitude towards learning, independence, and responsibility towards themselves and society (Doyon, 2001;

Jaca et al., 2014). In addition, the Japanese education system also encourages cooperation and respect for learning (Jeynes, 2008). The concept of "kyousou" or healthy competition among students is supported to encourage them to achieve their best in academic performance. Extracurricular activities such as sports clubs, study groups, and art activities also play an important role in developing social, leadership, and cooperation skills (Jaca et al., 2014).

In a comparison between Japan and Indonesia in terms of PISA and TIMSS study results, there are significant differences in educational achievement. Based on the PISA and TIMSS results, Indonesia generally ranks lower than Japan. In the 2018 PISA test, Indonesia ranked 74th in math, 73rd in science, and 74th in reading among 79 participating countries (Hewi & Shaleh, 2020; OECD, 2019). This indicates challenges in Indonesian students' literacy and skills in math, science and reading. In TIMSS 2019, Indonesia also recorded lower performance compared to Japan. Indonesian students ranked 41st in math at the primary school level and 45th at the secondary school level (Prastyo, 2020). In science, Indonesia ranked 40th at the primary school level and 42nd at the secondary school level (Wiratana et al., 2013). This comparison shows that Indonesia has challenges in improving the quality of education. However, it is important to remember that education is a long-term process, and Indonesia has taken steps to improve the education system through reforms and quality improvement efforts such as the independent curriculum upgrade implemented in Indonesia in 2022 (Arviansyah & Shagena, 2022). With the right focus on curriculum improvement, teacher training, adequate funding, and equitable access to education, Indonesia has the potential to improve educational attainment in the future (Mustari, 2022).

Understanding the duality of mathematics education paradigms between Indonesia and Japan is important to explore the significant differences that occur. Data shows that Indonesia still faces challenges in achieving adequate achievement in mathematics, as reflected in the results of international studies such as PISA and TIMSS. Meanwhile, Japan has achieved high achievement in mathematics and is considered as one of the countries with a superior education system (Simanjuntak, 2021). Therefore, this comparative study can provide a deeper understanding of the factors that influence the success of mathematics education in these two countries. By comparing the learning methods used, we can identify best practices that can be applied in Indonesia to improve the quality of mathematics education. This study can also provide an overview of the differences in mathematics learning methods used, thus creating better opportunities for Indonesian teachers to

develop a strong understanding and relevant mathematics teaching skills in facing the demands of an increasingly complex world.

METHODS

This article aims to review the comparison of mathematics education methods applied in Indonesia and Japan by using the literature research method by collecting relevant theories. In this research, literature from various literature sources related to the topic discussed is collected and presented systematically. This approach allowed the author to gain a deep insight into the differences between the math education methods of the two countries without violating copyright or being exposed to plagiarism issues. The researcher identified literature sources relevant to the research topic, such as scientific journals, books, research reports or conference articles. The use of electronic databases and digital libraries (Google Scholar, Publish or Perish, Researchgate and ERIC) helped in this process. The researcher selected literature based on certain criteria, namely the novelty of the information, accuracy, and relevance to the research topic and the literature selected was previous research that had passed the peer review process. In addition, the researcher critically read the selected literature, identifying relevant findings, arguments and research approaches.

Analysis of the literature data involved organizing the information, grouping similar findings, identifying patterns or inferences, and relating them to the research questions. In the process, relevant theories and research on mathematics education in Indonesia and Japan provided a strong foundation to present an objective and accurate comparison between the two education systems.

RESULTS AND DISCUSSION

Mathematics Learning Methods in Japan

Japan is known as one of the countries with an excellent education system, especially in the field of mathematics (Takahashi, 2006). In Japan, math education plays a very important role in shaping analytical thinking, problem solving, and deep understanding of concepts. In Japanese, math is called "*suugaku*", which literally means "*The Science Of Numbers*". (Prakoso et al., 2023).

Mathematics learning in Japan has undergone significant development throughout its history. According to Shotari Tanaka (Clakson & Seah, 2019),there were three important transitional periods in mathematics education in the country. The first transition occurred

during the Meiji period (1868-1911), where Japan adopted Western mathematics and disseminated it nationwide. During the Meiji period, mathematics in Japan was known as "*Wasan*" which developed in the Edo period (1603-1867) before the Meiji Restoration.

The second transition occurred during the Taisho period (1912-1925), where a reform movement in mathematics education emerged. Mathematicians such as Fujisawa and Kikuchi placed special emphasis on analysis and logic in geometry. The third transition occurred during the Showa period (1926-1988), where there was a modernization of mathematics education. During this period, industry experienced rapid development and the rules of modern mathematics became more important. Mathematics education in Japan evolved and made changes to the curriculum in 1968 by introducing "*study studies*" for the elementary school level (Bütün, 2019). One example is Toyama's invention of a math learning method known as the "*Water Method*" (Wong, 2013). The method has since undergone development and has been so successful that it is officially adopted in all elementary school textbooks. This change reflects Japan's commitment to continuously improving approaches to learning mathematics to enhance student understanding. With these transitions, mathematics education in Japan has undergone a significant evolution. Changes in approaches, curriculum and learning methods help to create an effective learning environment and enable students to develop a deep understanding of mathematics (Miliyawati, 2016).

In Japan, mathematics is known as *sansu* and the Japanese education system emphasizes a deep understanding of mathematical concepts (Novikasari, 2016). Teachers use learning methods that encourage students to think critically, analyze problems, and find appropriate solutions (Shimizu, 2012). They also teach students to work together to achieve a better understanding in math (Nakamura, 2019).

The Japanese math education system is based on a highly structured and systematic approach. From the elementary level of education, students are introduced to basic math concepts such as numbers, operations, geometry, and measurement (Takahashi, 2016). They are also taught how to apply mathematical concepts in everyday life through relevant examples and real situations. The importance of this practical application of mathematics is reflected in the terms "*gakushu*" meaning "*learning*" and "*riyou*" meaning "*use*" in the context of math (Perry, 2000).

Mathematics education in Japan is known for its structured and systematic approach to learning (Woodward & Ono, 2004). Some of the methods commonly used in mathematics learning in Japan according to Cave (2022) include:

1) *Rikai Kansatsu* is a method of observation and strong understanding of mathematical concepts. It emphasizes deep understanding and engages students to notice, compare, and draw conclusions from various mathematical examples and situations.
2) *Jugyō Katsudō* or classroom activities, is a method that involves active interaction between teachers and students. The teacher will present challenging math problems and encourage students to discuss, collaborate, and help each other in achieving better understanding.
3) *Jitsuyō Kaihatsu* or skill development, is a method that emphasizes on mastering mathematical concepts and skills. Students are given repeated exercises to strengthen their understanding and ability to apply mathematical concepts in various contexts.
4) *Gakushū Renshū* or learning exercises, is a method that involves exercises that focus on solidifying mathematical concepts and skills. These exercises are designed to help students deepen their understanding and acquire expertise in solving mathematical problems.
5) *Kōryū* or collaboration, is a method that encourages cooperation and exchange of ideas between students. Students work in groups or teams to find a common solution to a given math problem. This collaboration allows students to learn from each other and develop social and problem-solving skills together

The approach to learning mathematics in Japan also often involves the use of visual aids such as mathematical manipulatives, diagrams and models to help students visualize mathematical concepts more clearly (Prakoso et al., 2023; Bamkin, 2019). Overall, mathematics learning methods in Japan include *Rikai Kansatsu, Jugyō Katsudō, Jitsuyō Kaihatsu, Gakushū Renshū,* and *Kōryū*. The structured, collaborative approach supported by visual aids helps students develop a deep understanding of mathematical concepts as well as effective problem-solving skills.

Mathematics Learning Methods in Indonesia

Mathematics learning in Indonesia, according to BSNP in 2007 (Yasin, 2020), has a clear purpose. The goal is to develop students' competence in mathematical thinking and build students' abilities in several important aspects. First, students are invited to work with mathematical concepts, which involves a deep understanding of the principles and relationships between these concepts. Second, students are also taught to work procedurally, i.e. mastering the techniques and steps required in solving mathematical problems.

Mathematics learning in Indonesia involves a variety of methods that focus on inclusivity and diversity. Here are some of the methods commonly used in mathematics learning in Indonesia:

1) The scientific approach is a method that encourages students to explore, discover, and construct mathematical knowledge through the process of asking questions, observing, collecting data, and testing hypotheses (Murni et al., 2020). Students are given the opportunity to play an active role in learning and develop a deep understanding of mathematical concepts.
2) Problem Based Learning emphasizes on providing challenging and contextual mathematical problems to students. Students are invited to think critically, apply mathematical concepts, and find solutions through the problem solving process (Noviantii et al., 2020). Problem-based learning encourages students to develop effective problem-solving skills.
3) Cooperative Learning involves cooperation between students in groups or teams. Students work together to achieve set math learning objectives. Through discussion, questioning and helping each other, students learn from each other's experiences and understanding (Maisyarah, 2017).
4) Concrete Representational Abstract (CRA) approach allows students to understand mathematical concepts through concrete experiences, visual or manipulative representations, and then understand abstractly. Students are invited to build relationships between real experiences, images, and mathematical symbols in learning mathematical concepts (Indriani, 2022).
5) The use of technology in mathematics learning in Indonesia is increasingly emphasized. Teachers use computer software, apps and other technological aids to enrich learning and help students better visualize mathematical concepts (Isa & Diko, 2020).

In addition, in an effort to create inclusive mathematics learning, differentiation strategies are also used in Indonesia (Syarifuddin & Nurmi, 2022). Teachers recognize the different abilities and needs of students in mathematics learning, and they use different strategies to support each student in achieving optimal understanding. Overall, mathematics learning methods in Indonesia include scientific approaches, problem-based learning, cooperative learning, concrete-representational-abstract (pre) approaches, and the use of technology.

Duality of Indonesian and Japanese Mathematics Education Paradigms

Mathematics education in Indonesia and Japan has differences in paradigms and approaches used in learning methods. Through a comparative review, we can understand the duality between these two countries in strengthening mathematics learning.

Table 1. Comparative Overview of Japanese and Indonesian Mathematics Education

Aspects	Indonesia	Japan
Learning Objectives	Develop students' mathematical understanding and mathematical thinking skills	Develop students' math skills with a focus on practical applications and Problem Solving
Main Approach	Conceptual and problem-solving based mathematics education	open ended, problem solving, and discovery with three teaching principles, including: (a) *tanoshii jugyou* (b) *wakaru ko and* (c) *dekiru ko*.
Student Characteristics	Basic understanding of mathematics that varies, critical thinking skills that need to be improved	Strong basic understanding of mathematics, developed critical thinking skills
Learning Methods	Scientific, discussion, lecture	Variative methods based on the results of teacher Lesson Study activities
Learning Strategy	Individual assignment and independent problem solving	Collaboration in problem solving, group discussion, and presentation
Use of Technology	Limited, use of whiteboards and conventional media	Integrity of technology in learning, use of advanced software and hardware
Math Exam System	The National Exam focuses more on examining computational skills	No exam, Final grade is the accumulation of all activities.
Teaching Materials	Standardized math textbooks	Comprehensive and relevant teaching materials, including textbooks, online materials, and other resources

In Indonesia, there is a shift towards a more inclusive and creative approach to learning mathematics. One approach that is widely used is the Scientific approach, which encourages students to explore, discover for themselves, and build mathematical understanding through the process of asking questions, observing, collecting data, and testing hypotheses (Indriyanti, 2017). This approach provides opportunities for students to think critically, collaborate, and interact actively in solving math problems.

Teachers in Japan play an important role in the learning process of mathematics. Based on the literature review, Milliywati (2016) stated that teachers in Japan function as facilitators who apply three basic principles in teaching, namely:

1) *Tanoshii jugyou* (class should be fun). This principle emphasizes the importance of creating a learning environment that is fun and engaging for students. Teachers strive

to make the classroom a place that is fun and full of inspiring activities. In a fun atmosphere, students are more open to learning and actively participating.

2) *Wakaru ko* (children must understand). This principle emphasizes the importance of students' understanding of mathematical concepts. Teachers focus on approaches that ensure that each student truly understands the concepts being taught. They use a variety of strategies, such as using visual illustrations, mathematical manipulatives or stories to explain concepts in a way that is easier for students to understand.
3) *Dekiru ko* (the child must be able). This principle emphasizes the importance of providing opportunities for students to apply and test their understanding in real problem solving. Teachers encourage students to think creatively, find their own solutions, and develop confidence in their mathematical abilities. They provide challenges appropriate to students' ability levels and provide constructive feedback to help students achieve success.

On the other hand, Japan has a more structured and systematic approach to learning mathematics. A common method used in Japan is *Rikai Kansatsu*, which emphasizes deep observation and understanding of mathematical concepts (Cave, 2022). In this method, students are given the opportunity to compare, analyze, and infer from different mathematical examples and situations. In addition, collaborative approaches such as *Kōryū* are also often used to encourage students to work together in solving mathematical problems (Kuraesin, 2019). Meanwhile, Indonesia also adopts some of the methods used in Japan, such as the Concrete Representational Abstract (CRA) approach that allows students to understand mathematical concepts through concrete experiences, visual representations, and then understand abstractly. This approach helps students build strong connections between mathematical concepts and real-life experiences (Indriani, 2022).

In the context of the subject matter, the scope of material specified in the curriculum in Indonesia and Japan is different. At the elementary level in Indonesia, the materials include numbers, geometry and measurement, data processing, problem solving, and reasoning and communication. At the junior high school level, the materials include numbers, algebra, geometry and measurement, probability and statistics, problem solving, and reasoning and communication. Meanwhile, at the high school level, the materials include algebra, geometry and measurement, trigonometry, probability and statistics, calculus, mathematical logic, problem solving, and reasoning and communication (Syafriandi & Fitria, 2018).

On the other hand, the curriculum in Japan has a slightly different focus. At the elementary level, the content covers numbers and their operations, quantity and measurement, as well as geometric shapes and relationships (Takahashi, 2016). At the junior high school level, the material taught includes numbers and expressions of mathematical symbols, geometric shapes, functions, and data processing (statistics) (Shinno, 2015). While at the high school level, the material taught includes numbers, geometry, measurement, mathematical analysis, functions, trigonometry, statistics and probability, and calculus. This difference in material coverage reflects the different approaches and focus of mathematics learning between Indonesia and Japan. Each country has its own considerations in determining the materials taught to students according to their educational needs and goals.

In Japan, mathematics teachers are required to generate new theories and innovate in applying mathematics learning strategies or models through *Lesson Study* activities (Nakamura, 2019; Lewis, 2016). They are encouraged to focus on the problem-solving process in math learning. This aims to train students to think critically, creatively, and be able to solve math problems independently. Meanwhile, in Indonesia, mathematics teachers emphasize more on whether or not students' competencies are achieved individually and classically. Indonesian teachers have a strong orientation towards learning outcomes. They aim to ensure that students achieve the competencies set out in the curriculum (Surya, 2017; Handican & Setyaningrum, 2021).

Lesson study implemented in Japan is a scientific activity that involves teachers in experimenting, developing and trying out their learning theories and disseminating effective practices. Through the development and experimentation carried out in the implementation of lesson study, mathematics teachers in Japan have produced two types of effective learning approaches, namely the problem solving approach and the open ended approach (Isoda, 2010; Fujii, 2014).

The problem-solving approach in Japanese mathematics teaching emphasizes students' ability to solve problems creatively and logically (Asami-Johansson, 2015). Teachers provide various challenges and problem situations to students, then guide them in finding solutions using various relevant strategies and approaches. This approach aims to develop students' analytical, logical, and creative thinking skills in dealing with complex mathematical problems.

While the open ended approach in teaching mathematics gives students the freedom to explore various ways of solving problems (Aras, 2018). Teachers provide tasks that are

open and do not have strict limitations, so that students can develop critical, creative and independent thinking in the learning process. This approach encourages students to think more broadly, look for alternative solutions, and consider various points of view in solving math problems. Through the use of problem solving and open ended approaches in mathematics teaching, Japanese teachers can create a stimulating and interactive learning environment. They encourage students to actively participate, collaborate and think critically in the mathematics learning process. This allows students to develop a deeper understanding and broader application of mathematical concepts.

Overall, lesson study has become a strong foundation for the development of effective mathematics learning approaches in Japan (Bütün, 2019). By focusing on problem solving and open ended approaches, mathematics teachers in Japan continue to innovate in improving the quality of learning and producing students who have good mathematical understanding and strong thinking skills (Takahashi, 2006).

In Indonesia, although not as popular as in Japan, the concept of lesson study has also begun to be applied in some teacher communities and educational institutions (Lewis, 2016). However, the comparison between the implementation of lesson study in Indonesia and in Japan still shows some differences. First, in terms of learning theory development, teachers in Indonesia also conduct experiments and theory development, but not as intensively as in Japan (Montanesa & Firman, 2021). Lesson study in Indonesia tends to focus more on learning and understanding concepts rather than developing new theories (Milliywati, 2016;Rusliah et al., 2021). Constraints such as limited time, resources, and awareness of the importance of developing learning theory are still challenges in implementing lesson study widely in Indonesia (Sari et al., 2022).

Second, related to the type of learning approach, Indonesian teachers also use problem solving and open ended approaches in teaching mathematics (Ayu Ardani et al., 2018). However, there are still variations in the implementation of these approaches in different schools and regions. Some teachers have managed to implement these approaches well while others still face obstacles in integrating them into the curriculum and daily learning practices. In addition, factors such as lack of adequate training and support, as well as uncertainty in the implementation of the national curriculum also affect the implementation of lesson study in Indonesia (Saito et al., 2006). However, more and more educational institutions and teacher communities are realizing the benefits of lesson study in improving the quality of mathematics learning (Suratno & Iskandar, 2010). Tjw Efforts to improve teachers' understanding and participation in lesson study continue through

training, meetings, and collaboration among teachers. In this case, Indonesia still has great potential to develop and expand the application of lesson study in mathematics learning (Wahyu & Utami, 2016). By increasing awareness, support, and collaboration among teachers, lesson study can become a strong foundation in improving students' understanding of mathematics, critical thinking skills, and overall quality of learning.

CONCLUSION

Based on the literature review above, it can be concluded that in Indonesia, mathematics learning has shifted towards a more inclusive and creative approach, such as the scientific approach, which encourages students to explore and build mathematical understanding through the process of asking questions, observing, collecting data, and testing hypotheses. Meanwhile, teachers in Japan have varied methods of learning mathematics, where methods are produced based on the results of lesson study activities of mathematics teachers. A commonly used method in Japan is Rikai Kansatsu, which emphasizes observation and deep understanding of mathematical concepts. In addition, Japan also applies collaborative approaches such as Kōryū, while Indonesia adopts some Japanese methods, such as the Concrete Repetition Abstract (CRA) approach. There are also differences in the coverage of mathematics materials taught in the two countries, reflecting the different methods and focus of mathematics learning. The findings of this study can be used as a basis for developing more effective and relevant mathematics learning strategies in both countries, and can provide insights for other countries in improving the quality of mathematics education.

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