Journal of Engineering Science and Technology
Special Issue on ISCoE2024 Vol. 20 No. 3 (2025) 33 - 40

PRAXEOLOGICAL ANALYSIS OF INTERNATIONAL MATHEMATICAL LITERACY QUESTIONS FOR DEVELOPING NUMERACY ASSESSMENTS

A. AISYAH, NANANG PRIATNA*,
DADANG JUANDI, BAMBANG AVIV PRIATNA

Universitas Pendidikan Indonesia, Bandung, Indonesia
*Corresponding Author: nanang_priatna@upi.edu

Abstract

This study aims to analyse international mathematical literacy problems in the quantity content domain. The research employs a praxeological approach based on the Anthropological Theory of Didactics. The results identified task types (T), classifying them into interpretation (2 items), application (3 items), and formulation (1 item), covering mathematical literacy competencies from Level 1 to Level 6. Various mathematical techniques (τ) are examined. From a technological perspective (θ), these tasks align with multiple Core Competencies in the Indonesian mathematics curriculum. Regarding theories (Θ), the content distribution corresponds to mathematics curriculum topics such as data interpretation, algebraic forms, and social arithmetic. Characterizing task types is essential, because it provides insights for developing tasks aligned with international standards. This study contributes to designing mathematical literacy tasks that meet global benchmarks and demonstrates how the praxeological approach can assess the alignment between local curricula and international mathematical competency requirements.

Keywords: International standards, Mathematical literacy questions, Numeracy assessments, PISA, Praxeological analysis.

1. Introduction

The analysis of international mathematical literacy questions for developing numeracy assessments, utilizes the praxeological framework, which is grounded in the Anthropological Theory of Didactics (ATD). Mathematical literacy is a crucial competency in the 21st century, as it enhances students' conceptual understanding, cognitive development, and problem-solving skills [1, 2]. Defined as the ability to interpret, formulate, and employ mathematics in various contexts [3], mathematical literacy is a crucial skill and essential for global competitiveness [4]. To assess the success of mathematics education globally, the OECD through the Program for International Student Assessment (PISA) conducts mathematics literacy evaluations to measure students' abilities in mathematics [5-9].

Praxeology adopts a philosophical approach [10, 11] and is a central concept in the ATD [12, 13], originating from the terms praxis and logos [14]. This concept integrates practices and knowledge, along with their associated activities, using the praxeological model (T, τ, θ, and Θ) [15]. Concretely, praxeology is a four-tuple (T, τ, θ, Θ), a model for studying human knowledge [16], illustrating distinct yet interrelated components. This concept has been elaborated on by several authors, such as Takeuchi and Shinno [17]. Based on praxeological notation (T, τ, θ, Θ), each component is defined as follows: T represents the type of task, which is a set of tasks. These tasks are solvable through techniques denoted by τ. In many contexts (especially those involving mathematical practices), it is crucial to explain and justify techniques, represented by θ, also referred to as the "discourse about the technique." This practical discourse is complemented by the theoretical discourse about the technology itself, denoted by Θ [18]. Mathematical literacy problems in the quantity domain plays a vital role in formulating future teaching objectives and the means to achieve them, particularly concerning number-related content in Indonesia's mathematics curriculum.

This study aims to analyse PISA mathematical literacy problems in the quantity content domain. The method is using the praxeological analysis framework. The novelty is that it provides insight into designing mathematics learning test questions, especially numeracy assessments in accordance with international standard quantity material, classifying task types (T) based on Levels 1–6, providing new insights into the structure and complexity of questions, analysis of alignment with core competencies of the Indonesian curriculum. The findings of this analysis are expected to offer recommendations for the development of evaluation problems and guide the delivery of number-related learning materials aimed at improving students' mathematical literacy in alignment with the Indonesian curriculum framework.

2. Literature Review

Figure 1 shows the definition of mathematical literacy: the ability to formulate, employ, and interpret mathematics in various context [19-21]. Interpret; involves analysing information and developing insights through understanding context and critical thinking, formulate; individuals design mathematical models and use mathematical tools to represent problems quantitatively, employ; focuses on applying the results of the calculations in solving problems and their relevance in real life. This process emphasizes that mathematical literacy includes not only

numeracy skills, but also critical thinking, modelling, and applying strategies in various real-world situations [22, 23].

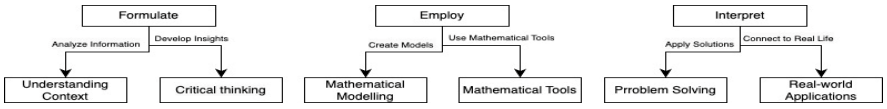

Fig. 1. The flow of numeracy literacy.

3. Method

This study employs a qualitative research method with a praxeological approach, selecting PISA problem sets based on the quantity content domain. The praxeological framework includes the following components: task type (T), which is determined by the process components and the level of PISA mathematical literacy competency; technique (τ), which refers to the problem profile in the 2012 PISA mathematical literacy questions; technology (θ), which corresponds to the core competencies in the national mathematics education curriculum in Indonesia, commonly known as the 2013 Curriculum; and theory (Θ), which refers to mathematics textbooks aligned with K13 and published by the Ministry of Education of the Republic of Indonesia.

4. Results and Discussion

The praxeological analysis is examined through the praxis block and the logos block [24, 25], which are subsequently described within their respective categories. The framework for praxeological analysis in this study is defined as follows.

Figure 2 shows that the type of task (T_1), comparing and calculating values to meet the given criteria (τ_1), organizing, presenting, and comparing data in lists or tables to determine sufficient memory for transferring a 350 MB photo album, aligned with core competency 3.8 in the 2013 Curriculum (θ_1), data interpretation; mathematics material for grade V at the elementary school level (Θ_1). This task measures mathematical literacy by identifying numerical data, comparing memory capacity, and assessing its adequacy. The assessment includes data analysis, problem-solving strategies, and the application of mathematical logic in technology.

Ivan wants to transfer a photo album of 350 MB onto his memory stick, but there is not enough free space on the memory stick. While he does not want to delete any existing photos, he is happy to delete up to two music albums.

Ivan's memory stick has the following size music albums stored on it.

Album	Size
Album 1	100 MB
Album 2	75 MB
Album 3	80 MB
Album 4	55 MB
Album 5	60 MB
Album 6	80 MB
Album 7	75 MB
Album 8	125 MB

By deleting at most two music albums is it possible for Ivan to have enough space on his memory stick to add the photo album? Circle "Yes" or "No" and show calculations to support your answer.

Fig. 2. Task T_1.

Figure 3 shows that the type of task (T_2), identifying and summing numbers, then detecting errors in the addition presented in the problem (τ_2), identifying the reasons for errors made in data entry during the addition of three monetary values using a calculator; aligned with Core Competency 3.5 in the 2013 Curriculum (θ_2), algebraic forms; mathematics material for grade VII at the junior high school level (Θ_2). This task measures mathematical literacy by identifying numerical data, verifying calculations, and analysing errors. Assessment includes numerical accuracy, problem-solving skills, and the application of mathematical logic in real-world contexts.

Fig. 3. Task T_2.

Figure 4 shows that the type task (T_3), determining whether the given amount of money is sufficient to purchase selected items with a specific discount percentage (τ_3), analysing discounts through percentage calculations to support purchasing decisions, aligned with Core Competency 3.9 in the 2013 Curriculum (θ_3), social arithmetic; mathematics material for grade VII at the junior high school level (Θ_3). This task measures mathematical literacy by identifying financial data, calculating the final price after discounts, and assessing the adequacy of funds for the purchase. This process measures financial decision-making skills, logical reasoning, and the application of mathematics to real-world transactions.

Music City has a sale. When you buy **two or more** items at the sale, Music City takes **20%** off the normal selling prices of these items.

Jason has 200 zeds to spend.

At the sale, what can he afford to buy?

Circle "Yes" or "No" for each of the following options.

Items	Can Jason buy the items with 200 zeds?
MP3 player and the headphones	Yes / No
MP3 player and the speakers	Yes / No
All 3 items – the MP3 player, the headphones and the speakers	Yes / No

Fig. 4. Task T_3.

Figure 5 shows that the type of task (T_4), calculating with percentages in real-world contexts (τ_4), applying the concept of percentages to estimate the weight difference between two penguin eggs, aligned with core competency 3.9 in the 2013 Curriculum (θ_4), social arithmetic; mathematics material for grade VII at the junior high school level (Θ_4). This task measures mathematical literacy by identifying

penguin egg weight data, calculating their differences as percentages, and interpreting their significance. Assessment includes analysis of numerical relationships, logical reasoning, and application of mathematical concepts in real-world contexts.

Normally, a penguin couple produces two eggs every year. Usually the chick from the larger of the two eggs is the only one that survives.

With rockhopper penguins, the first egg weighs approximately 78 g and the second egg weighs approximately 110 g.

By approximately how many percent is the second egg heavier than the first egg?

A. 29%
B. 32%
C. 41%
D. 71%

Fig. 5. Task T_4.

Figure 6 shows that the type of task (T_5), applying percentage calculations in real-world situations (τ_5), using percentage concepts to estimate the speed of a kite in flight; aligned with Core Competency 4.9 in the 2013 Curriculum (θ_5), social Arithmetic; mathematics material for grade VII at the junior high school level (Θ_5). This task measures mathematical literacy by identifying kite speed data, calculating variations in percentages, and interpreting factors that affect its movement. Assessment includes analysis of quantitative relationships, logical reasoning, and application of mathematical concepts in real-world contexts.

One advantage of using a kite sail is that it flies at a height of 150 m. There, the wind speed is approximately 25% higher than down on the deck of the ship.

At what approximate speed does the wind blow into a kite sail when a wind speed of 24 km/h is measured on the deck of the ship?

A. 6 km/h
B. 18 km/h
C. 25 km/h
D. 30 km/h
E. 49 km/h

Fig. 6. Task T_5.

Figure 7 shows that the type task (T_6), evaluating criteria against the advertised selling price of a holiday apartment (τ_6), understanding and analysing various situations to evaluate the selling price of a holiday apartment that Cristina could potentially afford; aligned with Core Competency 3.9 in the 2013 Curriculum (θ_6), social arithmetic; mathematics material for Grade VII at the junior high school level (Θ_6). This assignment measures mathematical literacy by identifying relevant financial data, using arithmetic operations and percentages to analyse affordability, and interpreting the results for financial decision making. Assessments include economic understanding, budgeting skills, and the application of mathematical logic in real-world financial contexts.

To assess the price of the holiday apartment, Christina has asked for an expert's evaluation. To estimate the value of a holiday apartment, the expert uses the following criteria:

Price per m²	Base price:	2500 zeds per m²			
Additional value criteria	Travel time to town centre:	More than 15 minutes: +0 zeds	From 5 to 15 minutes: +10 000 zeds	Less than 5 minutes: +20 000 zeds	
	Distance to beach (in a direct line):	More than 2 km: +0 zeds	From 1 to 2 km: +5000 zeds	From 0.5 to 1 km: +10 000 zeds	Less than 0.5 km: +15 000 zeds
	Parking spot:	No: +0 zeds	Yes: +35 000 zeds		

If the value estimated by the expert is greater than the advertised selling price, the price is considered to be "very good" for Christina as the potential buyer.

Show that based on the expert's criteria, the selling price on offer is "very good" for Christina.

Fig. 7. Task T_6.

Figure 8 shows three types of tasks classified as: interpreting, applying, and formulating which are spread across various levels of mathematical literacy competency, starting from competency level 1 to level 6. This classification differentiates the complexity of mathematical tasks based on the level of competence. Low levels focus on basic interpretation of numerical information, while high levels demand in-depth analysis, application of concepts, and problem formulation.

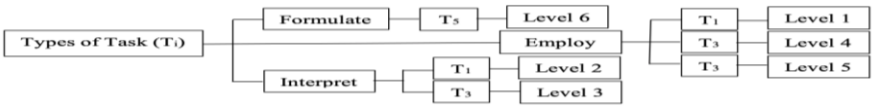

Fig. 8. Task type and its classification.

Mathematical literacy questions in the quantity domain assess high-level competencies, focusing on analysis, evaluation, and solution creation rather than routine procedures [26]. Problem-solving techniques vary by task and require real-life application, reinforcing their relevance [27]. The technology used aligns with Indonesia's mathematics curriculum, covering data interpretation, algebra, and social arithmetic. Praxeological analysis of various types of tasks [28] in international mathematical literacy questions, which are aligned with core competencies in the national mathematics curriculum in Indonesia, provides important insights in designing evaluation questions in mathematics education, especially numeracy assessments that are aligned with international standards. By integrating in-depth analysis, the findings are expected to serve as a foundation for recommendations in developing more effective and relevant evaluation problems [29, 30].

5. Conclusion

This study demonstrates the significance of praxeological analysis in evaluating international mathematical literacy questions within the quantity content domain. By categorizing task types (T), into interpretation, formulation, and employ, the varying levels of mathematical literacy competencies assessed; the techniques (τ), used in solving these tasks are diverse; the technology (θ), aligns with multiple core competencies in the Indonesian mathematics curriculum; the theory (Θ), connects the question content to data interpretation, algebraic forms, and social arithmetic. The insights gained from this analysis contribute to the development of numeracy assessment tasks that align quantity material with international standards.

Acknowledgments

We received scholarships from the Higher Education Financing Center (BPPT), the Indonesian Education Scholarship (BPI), and the Indonesian Endowment Fund for Education Agency (LPDP).

References

1. Prabowo, A.; Suparman, S.; Li, C.S.; Janan, D.; and Damayanti, T.D. (2023). The effect of reading literacy to mathematics comprehension of elementary school students in Indonesia and Malaysia. *International Journal of Evaluation and Research in Education* (*IJERE*), 12(1), 546-554.

2. Barberán-Mendoza, M.L.; and Alcívar-Castro, E.J. (2022). The understanding of mathematical notions for the cognitive development of students. *International Journal of Health Sciences*, 6(S5), 657-665.
3. Indrawati, F.A.; and Wardono, W. (2019). Pengaruh *self efficacy* terhadap kemampuan literasi matematika dan pembentukan kemampuan 4C. *PRISMA, Prosiding Seminar Nasional Matematika*, 2, 247-267.
4. Suprapto, E.; Suryani, N.; Siswandari, S.; and Mardiyana, M. (2023). Students' mathematical literacy skill in term of gender differences: A comparative study. *International Journal of Evaluation and Research in Education* (*IJERE*), 12(4), 2280.
5. Anggoro, A.Y.; Julie, H.; Sanjaya, F.; Rudhito, M.A.; and Wiadnyana, D.P. (2019). The mathematics education department students' ability in mathematical literacy for the change and relationship problems on the PISA adaptation test. *Journal of Physics*: *Conference Series*, 1397(1), 012085.
6. Dores, O.J.; and Setiawan, B. (2019). Meningkatkan literasi matematis mahasiswa calon guru sekolah dasar dalam membelajarkan matematika. *Jurnal Pendidikan Matematika Indonesia*, 4(1), 42-46.
7. Hewi, L.; and Shaleh, M. (2020). Refleksi hasil PISA (The programme for international student assesment): Upaya perbaikan bertumpu pada pendidikan anak usia dini. *Jurnal Golden Age*, 4(1), 30-41.
8. Noviana, K.Y.; and Murtiyasa, B. (2020). Kemampuan literasi matematika berorientasi PISA konten quantity pada siswa SMP. *JNPM* (*Jurnal Nasional Pendidikan Matematika*), 4(2), 195-211.
9. Ridzkiyah, N.; and Effendi, K.N.S. (2021). Analisis kemampuan literasi matematis siswa SMA dalam menyelesaikan soal program for international student assessment (PISA). *JIPMat*, 6(1), 1-13.
10. Diskin, K.; and Hutchinson, P. (2024). Critical praxeological analysis: Respecifying critical research. *Qualitative Research in Psychology*, 21(4), 512-535.
11. Hausberger, T. (2018). Structuralist praxeologies as a research program on the teaching and learning of abstract algebra. *International Journal of Research in Undergraduate Mathematics Education*, 4, 74-93.
12. Chevallard, Y. (2007). Readjusting didactics to a changing epistemology. *European Educational Research Journal*, 6(2), 131-134.
13. Chevallard, Y. (2019). Introducing the anthropological theory of the didactic an attempt at a principled approach. *Hiroshima Journal of Mathematics Education*, 12, 71-114.
14. Putra, Z.H. (2019). Praxeological change and the density of rational numbers: The case of pre-service teachers in Denmark and Indonesia. *Eurasia Journal of Mathematics, Science and Technology Education*, 15(5), 1711.
15. Putra, Z.H. (2019). Elementary teachers' knowledge on fraction multiplication: An anthropological theory of the didactic approach. *Journal of Teaching and Learning in Elementary Education*, 2(1), 47-52.
16. dos Prazeres Santos, S.; and Santos Farias, L.M. (2022). The anthropological theory of the didactic in Brazilian researches. *The Mathematics Enthusiast*, 19(2), 501-524.

17. Takeuchi, H.; and Shinno, Y. (2020). Comparing the lower secondary textbooks of Japan and England: A praxeological analysis of symmetry and transformations in geometry. *International Journal of Science and Mathematics Education*, 18(4), 791-810.
18. Wijayanti, D.; and Winslow, C. (2017). Mathematical practice in textbooks analysis: Praxeological reference models, the case of proportion. *REDIMAT*, 6(3), 307-330.
19. Umbara, U.; and Suryadi, D. (2019). Re-interpretation of mathematical literacy based on the teacher's perspective. *International Journal of Instruction*, 12(4), 789-806.
20. Ozkale, A.; and Ozdemir Erdogan, E. (2022). An analysis of the interaction between mathematical literacy and financial literacy in PISA. *International Journal of Mathematical Education in Science and Technology*, 53(8), 1983-2003.
21. Al-Sarry, M.J.S. (2020). The effect of multiple representations in teaching mathematical concepts in mathematics literacy among intermediate level students. *PalArch's Journal of Archaeology of Egypt/Egyptology*, 17(10), 734-749.
22. Rizki, L.M.; and Priatna, N. (2019). Mathematical literacy as the 21st century skill. *Journal of Physics*: *Conference Series*, 1157(4), 042088.
23. Szabo, Z.K.; Körtesi, P.; Guncaga, J.; Szabo, D.; and Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability*, 12(23), 10113.
24. Utami, N.S.; Prabawanto, S.; and Suryadi, D. (2024). How do Indonesian students learn function concepts? A praxeological analysis of textbook. *Journal on Mathematics Education*, 15(2), 451-472.
25. Yunianta, T.N.H.; Suryadi, D.; Dasari, D.; and Herman, T. (2023). Textbook praxeological-didactical analysis: Lessons learned from the Indonesian mathematics textbook. *Journal on Mathematics Education*, 14(3), 503-524.
26. Prayekti, N. (2023). Higher order thinking skill of IX grade students in solving mathematics problems based on Bloom's taxonomy. *International Journal of Current Science Research and Review*, 6(12), 7797-7804.
27. Aisyah, A. (2018). Deskripsi kemampuan komunikasi matematis siswa SMPN 17 kota Jambi. *Jurnal Ilmiah Dikdaya*, 7(2), 1-12.
28. Kania, N.; Suryadi, D.; Kusumah, Y.S.; Dahlan, J.A.; Nurlaelah, E.; and Elsayed, E.E. (2024). Comparative praxeology: Assessing high-level cognitive skills in TIMSS and Indonesian national examinations. *International Journal of Applied Learning and Research in Algebra*, 1(1), 25-47.
29. Farokhah, L.; Herman, T.; Wahyudin, W.; and Abidin, Z. (2024). Global research trends of mathematics literacy in elementary school: A bibliometric analysis. *Indonesian Journal of Educational Research and Technology*, 4(3), 279-290.
30. Saefurohman, S.; Maryanti, R.; Azizah, N.N.; Al Husaeni, D.F.; Wulandary, V.; and Irawan, A.R. (2021). Efforts to increasing numeracy literacy of elementary school students through Quiziz learning media. *ASEAN Journal of Science and Engineering Education*, 3(1), 11-18.