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Relationship between Elementary School Students' Numeracy and Number Sense

Abstract

Numbers are fundamental mathematical concepts that underlie various other mathematical principles. This research investigates the relationship between number sense and the numeracy abilities of fifth-grade elementary school students. A cross-sectional survey method was used, with 205 respondents voluntarily participating. The results showed a reciprocal relationship between number sense and numeracy in elementary school students. Emphasising number sense can enhance flexibility in numeracy solutions. Number sense can be developed through assigning math tasks related to the students' environment or associating it with other learning processes. The study emphasises the importance of number sense in the primary school mathematics curriculum.

Keywords: *numeracy, number sense, gender, reciprocal relationship, elementary school students*

Introduction

Number is a fundamental mathematical concept that underlies many other mathematical concepts (Purnomo, 2013). Therefore, we can see the significance of the place of numbers in the primary-level mathematics curriculum, most of which is arguably related to numbers (Purnomo et al., 2014). For example, geometry and measurement correlate to each other and to the processing and presentation of data, and their connection to other advanced mathematical concepts such as algebra and others. Therefore, mastery of numbers and their operations becomes crucial and should be emphasised in the learning of mathematics, especially in elementary school.

Policymakers, practitioners, and researchers know that numeracy's benefits extend beyond scientific development. Numeracy is relevant in solving social problems, interacting with society, and equipping individuals to face global competition and future work challenges (Kovas et al., 2013; Munn, 1994). Therefore, several professional institutions and governments are responding to this need by conducting large-scale assessments to evaluate this competence.

The term "numeracy" is often used to describe number skills and their use in different situations, and problem solving processes. This terminology is derived from several researchers (Askew et al., 1997; De Lange, 2003; Kaminski, 2002; Asmara & Purnomo, 2023) who discovered that numeracy focuses more on the numerical aspect, which encompasses three disciplines of mathematical literacy, namely numeracy, quantitative literacy, and spatial literacy, each with distinct but interconnected properties. However, we argue that numerical literacy also encompasses its application to other mathematical literacies. Therefore, numeracy is a person's ability to discover and interpret multi-context-based mathematical problems, process the information, and then make and evaluate the correct judgements to solve these difficulties. For this study, mathematical questions based on multi-contextual scenarios are restricted to numerical issues.

According to some researchers, mastering numbers and their operation involved more than knowing how to use formulas and algorithms. However, it must also require number sense. It is because the "number sense" refers to a person's adaptability, success, and effectiveness in problem-solving abilities in various scenarios or situations. This ability is backed up by conceptual and procedural knowledge of numbers and how they work (Purnomo et al., 2014; Tout, 2020). When students explore numbers, they can use multiple settings and organise them in a way that is not conventional algorithms. This study's hypothesis is that someone like a pupil with a strong cognitive number sense, they would be able to apply their numer-

ical expertise to resolve mathematical issues in circumstances not restricted by conventional protocols (Yang & Sianturi, 2021). In contrast, students with strong numeracy skills are taught to use their intuition with numbers. Their operations have a comprehensive perspective on approaching various context-based mathematical situations.

Previous research on numeracy has focused on assessing students' numeracy abilities in general (Barham et al., 2019; Kuperman et al., 2022; Richards & Islam, 2018) and by gender (Aune et al., 2018; Souza & Fonseca, 2013; Suryadarma, 2015). The same concerns research about number sense that examines students' skills generally (Cheung & Yang, 2018; Mohamed & Johnny, 2010; Purnomo et al., 2014; Wulandari et al., 2021; Yang & Sianturi, 2021) and depending on gender (Gonzalez et al., 2021; Yilmaz, 2017). However, few studies have explicitly examined these factors in relation to the impact of number sense. It has been a while since the previous research looked for factors (Broekman, 2008; McIntosh & Dole, 2000).

Based on the background provided, this study aims to explore the relationship between number sense and numeracy among elementary school students. To achieve this goal, the research questions in this study are formulated as follows:

1. What is the numeracy profile, both in general and by gender?
2. What is the number sense profile, both in general and by gender?
3. What is the relationship between number sense and numeracy?

Literature Review

Numeracy

Geiger et al. (2015) argue that the term "numeracy" refers to the ability to use and select mathematics in daily life and the ability to utilise mathematics effectively in situations pertaining to one's personal life, career, and discharge of civic duties. Numeracy is a person's ability to recognise and interpret multi-contextual mathematical problems, process them, and then make and evaluate the correct decisions to solve problems. Numeracy goes beyond simply understanding numbers and basic calculations. It encompasses applying mathematical concepts in real-life situations, such as budgeting, measuring, and analysing data (United Nations Relief and Work Agency for Palestine Refugees in the Near East (UNRWA), 2013). Developing strong numeracy skills is crucial in today's complex and data-driven world, enabling individuals to effectively make informed decisions and navigate various challenges.

Another interesting aspect to consider is that, although taught in an integrated manner, mathematics and numeracy differ significantly in empowering knowledge and skills. It is because mathematics learning alone does not necessarily foster numeracy. However, numeracy necessitates mathematical knowledge acquired through the curriculum. Numeracy goes beyond the theoretical understanding of mathematics. It emphasises the practical application of mathematical concepts in real-life situations (Tout, 2020). It equips individuals with the ability to analyse data, interpret statistics, and solve problems using reasoning. It equips individuals with the ability to analyse data, interpret statistics, and solve problems using reasoning. As a result, knowledge and skills such as number sense, which includes intuition and estimation, are essential in helping individuals truly develop numeracy for effective and efficient decision-making.

Number Sense

Number sense is a person's general understanding of numbers and operations and using it to make mathematics decisions with various effective, efficient, and flexible strategies (McIntosh et al., 1997; Purnomo et al., 2014). Moreover, number sense progressively evolves due to investigating numbers, visualising them in different situations, and connecting them in ways not constrained by conventional algorithms (Howden, 1989). For various reasons, developing number sense in primary school is essential, offering four fundamental justifications for why number sense is important. To begin with, number sense is a manner of reasoning that includes adaptability, imagination, and logic. Second, "number sense" refers to a comprehensive understanding of the scope of numerical operations and the relationship between using mathematics in practical applications. Third, while thinking intellectually and expressing numbers, grownups depend more on number sense. Fourth, focusing too much on written computation hinders students' ability to think creatively, understand mathematics, and acquire number sense (Yang & Wu, 2010). Developing number sense allows individuals to approach problem-solving more flexibly and intuitively, enhancing their mathematical proficiency. Additionally, students gain a deeper understanding of mathematics and its real-world applications by proportionally mastering number sense and written computation. As a result, we believe that students with strong number sense are valuable in working effectively and efficiently with numeracy.

Research Methodology

Research Background

The importance of numbers and operations as underlying content for learning other mathematical concepts requires special attention and emphasis in elementary school. Numbers and their operations are also often associated with numeracy skills, which focus on numeracy. Several studies show that to master numbers and their operations, it is not enough to use formulas and algorithms, it requires number sense. This research will focus on quantitatively proving differences in numeracy and number sense abilities based on gender and the relationship between number sense and numeracy among elementary school students.

Sample

This research used a cross-sectional survey to collect data from April to May 2022. The data collection occurred in schools, where instruments were distributed directly and online through the Google Form platform. The study involved 205 fifth-grade elementary school students residing in Yogyakarta City, Indonesia, with an average age of approximately 11. Among the participants, there were 89 male students and 116 female students. Seven elementary schools in the city participated in the survey, with an average of 29 students in each school (SD = 11.88). The schools were chosen through purposive sampling, with the fifth grade selected as it meets the minimum criteria assessment. Similar to the international assessment tool PISA, the Indonesian government's minimum criteria assessment is organised to evaluate the literacy and numeracy skills of elementary school students in Indonesia.

Instruments and Procedures

Two types of instruments were employed to assess students' number sense and numeracy abilities. The first instrument adapted numeracy questions from the National Assessment Programme Literacy and Numeracy (NAPLAN), comprising 40 multiple-choice questions and short fill-ins (NAPLAN, 2016). The maximum score achievable on the numeracy test is 40, with one point awarded for each correct answer. The NAPLAN numeracy test evaluates students' proficiency in numeracy, including their knowledge, skills, and understanding of mathematics. This assessment covers comprehension, fluency, problem-solving, and reasoning

across three mathematical content strands: numbers and algebra, measurement and geometry, and statistics and probability (https://www.nap.edu.au/naplan/whats-in-the-tests).

The second instrument used was the Number Sense test, adopting items from the study by Purnomo et al. (2014). This instrument consisted of 30 multiple-choice questions and short fill-ins. The scoring system was the same as the numeracy test, with one point for correct answers and zero points for incorrect answers, resulting in a maximum possible score of 30. The elements of number sense in this study encompass understanding fundamental ideas related to numbers and operations, recognising number sizes, utilising multiple representations of numbers and operations, identifying the relative effects of operations on numbers, and evaluating the reasonableness of computational results (Purnomo et al., 2014). While some questions were directly adopted and translated into Indonesian with redesigns, others were adapted for the number sense instrument. The questions were translated into Indonesian and adjusted in difficulty to align with the curriculum for elementary schools in Indonesia.

Both exams were administered on separate days. Each test was conducted offline with the assistance of the respective class teachers. The first session of the numeracy tests lasted 50 minutes, while the second session of the number sense test was allotted 35 minutes for completion. The results of the adaptation of the numeracy and number sense instruments were then tested for reliability, and values of 0.65 and 0.76 were obtained. These values fall within the sufficient reliability category (Table 1).

Data Analysis

The data analysis begins with descriptive statistics, such as mean, standard deviation, minimum, and maximum scores for each variable under consideration. The analysis then employs t-tests to investigate gender disparities in performance. The variables number sense and numeracy are then analysed using regression analysis.

Results

Descriptive Data

The results of the descriptive analysis of the numeracy and number sense tests are shown in Table 1. Table 1 also depicts the relationship between the two variables and their reliability.

Table 1. Descriptive Data of Numeracy and Number Sense

	Numeracy	Number Sense	Gender	Age
Numeracy	1			
Number Sense	0.336***	1		
Gender	0.005	0.070	1	
Age	-0.127	0.024	0.132	1
Mean	21.122	14.740	0.434	11.420
Std. Deviation	5.99	5.06	0.497	0.649
Minimum	7.00	4.00	0.000	10.000
Maximum	36.00	29.00	1.000	14.000
Reliability	0.65	0.76	-	-

**. The correlation is significant at the two-tailed 0.001 level.

In Table 1, the numeracy test results showed a mean score of 21.122 (SD = 5.99), with an average of 52% correct answers. The highest-scoring respondents correctly answered 90% of the questions, while the lowest-scoring respondents correctly answered 17%, indicating a significant 29-point difference in scores.

Table 1 displays the number sense test results, indicating a mean score of 14.740 (SD = 5.06), with 14 out of 30 correct answers, compared to less than half in the numeracy test. The highest scorers achieved a 96% accuracy rate by answering 29 questions correctly, while the lowest scorers answered only 13%. Despite having a smaller minimum score than the numeracy test, the number sense test had a narrower range of 25 points.

Table 1 also indicates the reliability and correlations between variables. The reliability for both instruments is at an adequate level, namely 0,65 and 0,76 for the numeracy and number sense tests, respectively. These two variables also have a significant positive correlation (0.336) at a significance level of 0.001 (2-tailed). It indicates that individuals with high levels of Numeracy also tend to have high

Number Sense. Furthermore, there are no other pairs of variables that have significant correlations.

Numeracy and Number Sense Based on Gender

Table 2 displays the results of the numeracy and number sense tests for each gender of respondents. The t-test findings for both variables are also shown in Table 2.

Table 2. Data of Numeracy and Number Sense Based on Gender

	Gender	N	Mean	SD	T
1. Numeracy	Female	116	21.095	5.328	$t\,(203) = -0.074, p = 0.941$
	Male	89	21.157	6.791	
2. Number Sense	Female	116	14.431	4.804	$t\,(54) = -1.003, p = 0.317$
	Male	89	15.146	5.372	

As seen in Table 2, in the numeracy test, the mean of the female responders was 21.095, with a 5.328 standard deviation. In contrast, the mean and standard deviation for male responders were 21.157 and 6.791, respectively. According to the number sense test findings, the mean score of female respondents was 14.431, with a standard deviation of 4.804. Meanwhile, male respondents on this test had a mean of 15.146 with a standard deviation of 5.372. A t-test with a p-value of 0.941 revealed no significant difference in numeracy test scores between female and male respondents, which is greater than 0.05. With a p-value of 0.317, which is also greater than 0.05, the number sense test results indicated no significant difference between the two groups.

Relationship between Student Number Sense and Numeracy

The regression test assesses the impact of number sense on student numeracy and vice versa. Before this, two datasets were examined for prerequisites such as normality and linearity, enabling the application of parametric tests. Table 3 illustrates the regression results.

Table 3. Numeracy and Number Sense Descriptive Data on responder charging outcomes statistics

Predictor	Numeracy			Number Sense		
	B	SE B	β	B	SE B	β
Number Sense	0.400	0.079	0.337***	-	-	-
Numeracy	-	-	-	0.283	0.056	0.336***
Gender	-0.223	0.801	-0.019	0.697	0.673	0.068

**. The regression is significant at the two-tailed 0.01 level.
***. The regression is significant at the two-tailed 0.001 level.

According to the regression test findings in Table 3, pupils' number sense strongly predicts their numeracy competence ($\beta = 0.337$, $p < 0.001$). Similarly, numeracy ability statistically predicts the number sense of primary school students significantly ($\beta = 0.336$, $p < 0.001$). In contrast, gender variables were unable to significantly predict either number sense ($\beta = -0.019$, $p > 0.05$) or numeracy ability ($\beta = 0.068$, $p > 0.05$).

Discussion

According to the conclusions of this study, the average achievement of respondents in numeracy was 56%, and in number sense, it was 46%. These two results are not significantly different; both are still around 50%, with an 8% difference. Even though it is around the average, the respondents' scores in each variable are very wide. It demonstrates that the individuals' capabilities are still highly diverse.

This study's first finding shows no significant variation in numeracy results based on gender. Researchers think this lack of difference is caused by several factors within and outside the students. For example, differences in the quality of mathematics learning between male and female students do not necessarily cause low numeracy for both, nor does parent involvement in the student's learning process necessarily influence it. It was also stated by Fryer and Levitt (2010) that the many factors that cause no gender gap in mathematics range from demographic and socioeconomic factors to parental characteristics, time spent learning mathematics, and the educational environment. However, although it is very small, there appears to be a gender gap between male and female students in numeracy skills, with an average of 0.062 and a standard deviation of 1.463. Very small differences in these conditions have also been found in several previous studies (e.g., Surya-

darma, 2015; Aune et al., 2018; Aufa & Manoy, 2022; Mellyzar et al., 2022; OECD, 2019). Meanwhile, based on the more detailed data obtained in this research, it can be seen that male students tend to be slightly superior to female students. It is supported by a study that found that the advantage of boys in numeracy is small at age 10, but grows considerably between age 15 and 27 (Borgonovi et al., 2021). Gender gaps in elementary school and adolescence may be related to social gender norms and differences in psychological traits, particularly those related to different cognitive and emotional development timings. Over time, the increasing gender gap in numeracy among elementary school students is in line with the increasing specialisation of men in fields of study and/or work that use numeracy skills more intensively (Contini et al., 2017).

The second finding in this study also show no significant difference in the number of sense profiles based on gender. These results are consistent with the research by Gonzalez et al. (2021), which explained that they did not find any significant differences between genders in the number sense ability of students. Yilmaz (2017) explained that the result differences that occur in these two genders can be influenced by several factors, such as the instructions presented before taking the test, the test environment, or the personal interest of each respondent who takes the test, thereby affecting the average test results of the respondents as a whole. Some of these factors still need further research to prove their validity. However, like numeracy, number sense also has a very small gender gap between men and women, namely an average of 0.715 and a standard deviation of 0.568. It appears that men's number-sense abilities tend to be higher than women's. It is supported by a study of Jordan et al. (2007), which states that the gender effect is small even though male students' number sense tends to be superior to female students. At elementary school age, the number of sense abilities also gradually increases. It can be related to students' reading abilities. In other words, students' initial reading literacy influences their number sense even though their cognitive abilities are the same (Aunola et al., 2004).

The third finding in this research answers the research question about the relationship between numeracy and number sense. The results of this research are consistent with our hypotheses, individuals with good number sense may successfully manage numeracy challenges, but those with high numeracy have a broad perspective and intuition about numbers and their operations. Longitudinal research has shown that number sense significantly affects future mathematics performance and remains predictive across different levels of classes, even after controlling for cognitive factors, age, and reading skills (Dyson et al., 2013; Jordan et al., 2006; 2010; Jordan & Dyson, 2016). It underscores that number sense is

a factor influencing students' numeracy. Students with a strong number sense are also proficient in numeracy. Moreover, the TIMSS international survey, renowned for measuring numeracy skills globally, incorporates number sense as a key element in numeracy tests. Number sense and numeracy are mutually influential, each contributing to the development of the other.

Through observation, Hassinger-Das et al. (2015) found that number sense is one of the factors that contribute to early numeracy difficulties. Numbers, being fundamental mathematical concepts, especially in elementary schools, make number sense a crucial skill for students. The lack of number sense ability is identified as one of the causes of early numeracy challenges. It is further supported by research conducted by Lopez-Pedersen et al. (2022), which explains that low numeracy skills in students are influenced by at least four factors: early numeracy skills, word problem-solving, arithmetic skills, and number sense. Students with low numeracy performance are particularly vulnerable to difficulties in learning mathematics.

Numeracy and number sense are inextricably linked and mutually impact each other. A study states that number sense is one of the benchmarks for numeracy (Australian Council for Educational Research (ACER), 2000). It causes these two things to influence each other, including the same gender similarities. Neither numeracy nor number sense provide significant differences based on gender. In their research, Tin Fallow et al. (2018) discovered that number sense is the first ability taught in early numeracy abilities, especially in kindergarten and elementary school first grade. Number sense is a fundamental ability in numeracy and mathematics. Furthermore, in line with this statement, the research Maclellan (2012) explains that number sense is a general understanding of number knowledge and numeracy processes. Number sense is essential throughout the numeracy process, playing a critical part in finding information, applying knowledge, and assessing problem-solving procedures.

Conclusions

The study investigates the relationship between number sense and numeracy ability. It found that students' number sense can predict their numeracy abilities and vice versa. The research suggests that interventions targeting number sense can positively impact numeracy skills and vice versa. No significant gender differences were found in either area.

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References:

Askew, M., Brown, M., Rhodes, V., Wiliam, D., & Johnson, D. (1997). The contribution of professional development to effectiveness in the teaching of numeracy. *Teacher Development*, *1*(3), 335–356. https://doi.org/10.1080/13664539700200030

Asmara, S. D., & Purnomo, Y. W. (2023). Context of Data and Uncertainty: One of the Challenges for Numeracy Provision in Elementary School Teacher Education. *Acta Scientiae*, *25*(6), 235–271. https://doi.org/10.17648/acta.scientiae.7276

Aufa, N., & Manoy, J. T. (2022). Student's Mathematical Literacy in Solving Asesmen Kompetensi Minimum Question in terms of Gender. *MATHEdunesa*, *11*(1), 219–229. https://doi.org/10.26740/mathedunesa.v11n1.p219–229

Aune, T. K., Ingvaldsen, R. P., Vestheim, O. P., Bjerkeset, O., & Dalen, T. (2018). Relative age effects and gender differences in the national test of numeracy: A population study of Norwegian children. *Frontiers in Psychology*, *9*(JUL), 1–8. https://doi.org/10.3389/fpsyg.2018.01091

Aunola, K., Leskinen, E., Lerkkanen, M. K., & Nurmi, J. E. (2004). Developmental dynamics of math performance from preschool to grade 2. *Journal of Educational Psychology*, *96*(4), 699–713. https://doi.org/10.1037/0022–0663.96.4.699

Barham, A. I., Ihmeideh, F., Al-Falasi, M., & Alabdallah, A. (2019). Assessment of first-grade students' literacy and numeracy levels and the influence of key factors. *International Journal of Learning, Teaching and Educational Research*, *18*(12), 174–195. https://doi.org/10.26803/ijlter.18.12.11

Borgonovi, F., Choi, A., & Paccagnella, M. (2021). The evolution of gender gaps in numeracy and literacy between childhood and young adulthood. *Economics of Education Review*, *82*. https://doi.org/10.1016/j.econedurev.2021.102119

Broekman, H. (2008). *Number Sense, Numeracy and Mathematical Literacy*. *2*(2).

Cheung, K. L., & Yang, D. C. (2018). Examining the differences of Hong Kong and Taiwan students' performance on the number sense three-tier test. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(7), 3329–3345. https://doi.org/10.29333/ejmste/91682

Contini, D., Tommaso, M. L. Di, & Mendolia, S. (2017). The gender gap in mathematics achievement: Evidence from Italian data. *International Journal of …*, *May*, 1–6.

De Lange, J. (2003). Mathematics for Literacy. In *Quantitative Literacy: Why Numeracy Matters for Schools and Colleges* (pp. 75–89). http://www.maa.org/ql/pgs75 89.pdf.

Dyson, N. I., Jordan, N. C., & Glutting, J. (2013). A Number Sense Intervention for Low-Income Kindergartners at Risk for Mathematics Difficulties. *Journal of Learning Disabilities*, *46*(2), 166–181. https://doi.org/10.1177/0022219411410233

Fryer, R. G., & Levitt, S. D. (2010). An Empirical Analysis of the Gender Gap in Mathematics. *Journal of Media Economics*, *2*(2), 210–240. https://doi.org/10.1257/app.2.2.210

Geiger, V., Goos, M., & Forgasz, H. (2015). A rich interpretation of numeracy for the 21st century: a survey of the state of the field. *ZDM – International Journal on Mathematics Education*, *47*(4), 531–548. https://doi.org/10.1007/s11858-015-0708-1

Gonzalez, A. M., Odic, D., Schmader, T., Block, K., & Baron, A. S. (2021). The effect of gender stereotypes on young girls' intuitive number sense. *PLoS ONE*, *16*(10 October). https://doi.org/10.1371/journal.pone.0258886

Hassinger-Das, B., Jordan, N. C., & Dyson, N. (2015). Reading stories to learn math: Mathematics vocabulary instruction for children with early numeracy difficulties. *Elementary School Journal*, *116*(2), 242–264. https://doi.org/10.1086/683986

Howden, H. (1989). Teaching Number Sense. *The Arithmetic Teacher*, *36*(6), 6–11. https://doi.org/10.5951/AT.36.6.0006

Jordan, N. C., & Dyson, N. (2016). Catching Math Problems Early: Findings From the Number Sense Intervention Project. In *Continuous Issues in Numerical Cognition: How Many or How Much* (pp. 59–79). Elsevier Inc. https://doi.org/10.1016/B978-0-12-801637-4.00003-2

Jordan, N. C., Glutting, J., & Ramineni, C. (2010). The importance of number sense to mathematics achievement in first and third grades. *Learning and Individual Differences*, *20*(2), 82–88. https://doi.org/10.1016/j.lindif.2009.07.004

Jordan, N. C., Kaplan, D., Locuniak, M. N., & Ramineni, C. (2007). Predicting First-Grade Math Achievement from Developmental Number Sense Trajectories. *Learning Disabilities Research & Practice*, *22*(1), 36–46. https://doi.org/10.1111/j.1540-5826.2007.00229.x

Jordan, N. C., Kaplan, D., Oláh, L. N., & Locuniak, M. N. (2006). *Number Sense Growth in Kindergarten: A Longitudinal Investigation of Children at Risk for Mathematics Difficulties*.

Kaminski, E. (2002). Promoting mathematical understanding: Number sense in action. *Mathematics Education Research Journal*, *14*(2), 133–149. https://doi.org/10.1007/BF03217358

Kovas, Y., Voronin, I., Kaydalov, A., Malykh, S. B., Dale, P. S., & Plomin, R. (2013). Literacy and Numeracy Are More Heritable Than Intelligence in Primary School. *Psychological Science*, *24*(10), 2048–2056. https://doi.org/10.1177/0956797613486982

Kuperman, V., Wild, H., & Kyro, A. (2022). *How representative are student convenience samples ? A study of literacy and numeracy skills in 32 countries*. 1–22. https://doi.org/10.1371/journal.pone.0271191

Lopez-Pedersen, A., Mononen, R., Aunio, P., Scherer, R., & Melby-Lervåg, M. (2022). Improving Numeracy Skills in First Graders with low performance in early numeracy: A Randomized Controlled Trial. *Remedial and Special Education*. https://doi.org/10.1177/07419325221102537

McIntosh, A., & Dole, S. (2000). Number Sense and Mental Computation: Implications for Numeracy. *Improving Numeracy Learning*, 34–37.

McIntosh, A., Reys, B., Reys, R., Bana, J., & Farrell, B. (1997). *Number sense in school mathematics: student performance in four countries* (Issue 1997). https://ro.ecu.edu.au/ecuworks

Mellyzar, M., Unaida, R., Muliani, M., & Novita, N. (2022). Hubungan Self-efficacy dan Kemampuan Literasi Numerasi Siswa: Ditinjau Berdasarkan Gender [The Relationship between Self-efficacy and Students' Numeracy Literacy Ability: Viewed Based on Gender]. *Lantanida Journal*, *9*(2), 104. https://doi.org/10.22373/lj.v9i2.11176

Mohamed, M., & Johnny, J. (2010). Investigating number sense among students. *Procedia – Social and Behavioral Sciences*, *8*(5), 317–324. https://doi.org/10.1016/j.sbspro.2010.12.044

Munn, P. (1994). The early development of literacy and numeracy skills. *European Early Childhood Education Research Journal*, *2*(1), 5–18. https://doi.org/10.1080/13502939485207491

NAPLAN. (2016). *National assessment program – literacy and numeracy*. *May*, 1–23.

OECD. (2019). *PISA 2018 Results WHERE ALL STUDENTS CAN SUCCEED: Vol. II*. OECD Publishing. https://doi.org/10.1787/f7986824-en

Purnomo, Y. W. (2013). Komputasi Mental untuk Mendukung Lancar Berhitung Operasi Penjumlahan dan Pengurangan pada Siswa Sekolah Dasar [Mental Computation to Support Fluent Counting in Addition and Subtraction Operations in Elementary School Students]. *In National Seminar on Mathematics and Mathematics Education. Department of Mathematics Education (Educational of Mathematics) FMIPA UNY.*, 657–662.

Purnomo, Y. W., Kowiyah, K., Alyani, F., & Assiti, S. S. (2014). Assessing Number Sense Performance of Indonesian Elementary School Students. *International Education Studies*, *7*(8), 74–84. https://doi.org/10.5539/ies.v7n8p74

Richards, J., & Islam, M. S. (2018). Assessing literacy and numeracy among primary school students: A pilot survey in rural Bangladesh. *International Journal of Educational Development*, *61*(June 2017), 55–63. https://doi.org/10.1016/j.ijedudev.2017.12.001

Souza, M. C. R. F. De, & Fonseca, M. D. C. F. R. (2013). Numeracy Practices and Gender Relations: Tensions and Inequalities in the Work Activities of Female and Male Students at Youth and Adult Education. *Revista Brasileira de Educação*, *18*, 55. https://doi.org/doi.org/10.1590/S1413-24782013000400007

Suryadarma, D. (2015). Gender differences in numeracy in Indonesia: evidence from a longitudinal dataset. *Education Economics*, *23*(2), 180–198. https://doi.org/10.1080/09645292.2013.819415

ten Braak, D., Kleemans, T., Størksen, I., Verhoeven, L., & Segers, E. (2018). Domain-specific effects of attentional and behavioral control in early literacy and numeracy development. *Learning and Individual Differences*, *68*, 61–71. https://doi.org/10.1016/j.lindif.2018.10.001

Tout, D. (2020). Evolution of adult numeracy from quantitative literacy to numeracy: Lessons learned from international assessments. *International Review of Education*, *66*(2–3), 183–209. https://doi.org/10.1007/s11159-020-09831-4

United Nation Relief and Work Agency for Palestine Refugees in the Near East (UNRWA). (2013). *The Teacher's Role in Promoting Literacy and Numeracy*. UNRWA. https://www.unrwa.org/sites/default/files/teachers_role_in_promoting_literacy_and_numeracy.pdf

Wulandari, N. P., Ekowati, D. W., Novitasari, D., Hamdani, D., & Gunawan, G. (2021). Spatial Reasoning Profile of the Students with Good Number Sense Ability. *Journal of Physics: Conference Series*, *1933*(1). https://doi.org/10.1088/1742-6596/1933/1/012077

Yang, D.-C., & Sianturi, I. A. J. (2021). Sixth Grade Students' Performance, Misconception, and Confidence on a Three-Tier Number Sense Test. *International Journal of Science and Mathematics Education*, *19*(2), 355–375. https://doi.org/10.1007/s10763-020-10051-3

Yang, D.-C., & Wu, W.-R. (2010). The Study of Number Sense: Realistic Activities Integrated into Third-Grade Math Classes in Taiwan. *Journal of Educational Research*, *103*(6), 379–392. https://doi.org/10.1080/00220670903383010

Yilmaz, Z. (2017). Young children's number sense development: Age related complexity across cases of three children. *International Electronic Journal of Elementary Education*, *9*(4), 891–902.

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