International Journal of Evaluation and Research in Education (IJERE)
Vol. 13, No. 3, June 2024, pp. 1816~1824
ISSN: 2252-8822, DOI: 10.11591/ijere.v13i3.26849

A systematic literature review: how do we support students to become numerate?

Viona Adelia, Ratu Ilma Indra Putri, Zulkardi
Doctoral Program of Mathematics Education, Faculty of Teacher Training and Education, Sriwijaya University, Palembang, Indonesia

Article Info

Article history:

Received Feb 15, 2023
Revised Jun 15, 2023
Accepted Jul 11, 2023

Keywords:

Critical orientation
Numeracy
Numeracy learning
Numeracy problem
Numerate

ABSTRACT

Numeracy is the essential skill for life situations that involve mathematical elements and developing students' numeracy skills is considered a primary goal of mathematics education. Despite its importance, numeracy can be challenging to teach, and it is not a guaranteed result of classroom mathematics learning. Through a systematic literature review, 35 studies about supporting students in becoming numerate in classrooms or courses are explored, this literature review also explained abilities included as numeracy, recommendations for teachers are given as well as some examples was given, also opportunities and directions for further research are identified, including guidelines for enhancing students' numeracy competence.

Corresponding Author:

Ratu Ilma Indra Putri
Doctoral Program of Mathematics Education, Faculty of Teacher Training and Education, Sriwijaya University
Palembang, South Sumatera 30128, Indonesia
Email: ratuilma@unsri.ac.id

1. INTRODUCTION

Developing students' abilities to solve real-life quantitative problems is increasingly seen as a goal of mathematics education [1]–[3]. The essential skill needed for life situations that involve mathematical elements is called numeracy [4]–[6], and although many other terms have been used, including quantitative literacy and mathematical literacy [2], [6], [7], we will use the term numeracy in the current article. Numeracy is as important as literacy for allowing an individual to be an active and thoughtful citizen [8]–[10]. Many countries incorporate numeracy skills into their educational curricula [11]–[13], including Indonesia, which reformed its education system in 2019 by integrating literacy and numeracy competencies [14]. This change was made because the Indonesian Ministry of Education and Culture (MoEC) determined that students were unable to apply their mathematical knowledge in other fields [15]. Consistent with this determination, many studies have found that numeracy is closely related to skills needed in working life, a primary ability that enables professional success, and something that recruiters specifically look for [16]. This fits with the very definition of numeracy, which encompasses skills useful in life situations—in this case, working life. Notably, there is also a robust relationship between numeracy and citizenship [8].

Despite its importance and the fact that every student has the right to be numerate after completing compulsory schooling [6], numeracy can be challenging to teach [4], [9], and it is not a guaranteed result of classroom mathematics learning [1]. To help address this challenge, the current study aims to explore existing studies about supporting students in becoming numerate in classrooms or courses. This study also identifies opportunities and directions for further research, including guidelines for enhancing students' numeracy competence.

2. RESEARCH METHOD

This article is a systematic literature review conducted in eight steps: i) composing the research problem; ii) developing and validating the review protocol; iii) searching the literature; iv) inclusion screening; v) quality appraisal; vi) data extraction; vii) analysis and synthesis of the data; and viii) reporting the findings [17]. Step 1 is composing the research problem. The goal of this article is to explore existing studies about supporting students in becoming numerate, and the research problem was formulated to meet that goal. The research question is therefore "Using the results of a systematic literature review of numeracy-themed articles, how do we support students in becoming numerate in the classroom?"

Second step is developing and validating the review protocol. This step entailed the selection of inclusion criteria. For this review, articles were included that were published between 2000 and 2022 and that considered the characteristics of numerate individuals, numeracy learning, numeracy problems, and factors related to teaching numeracy. The articles selected were not limited to the mathematics classroom because numeracy is needed across diverse contexts.

In step 3 (inquiring the literatures), Google Scholar, and ScienceDirect were searched using the keywords numeracy, quantitative literacy, and mathematical literacy, and only 62 results were retrieved. The titles were screened to determine if they referred to teaching numeracy, quantitative literacy, or mathematical literacy in a class or course, and the full text of all such articles was obtained for further evaluation. The author also did backward and forward searches to expand the searching process.

Fourth, each article was screened for quality and eligibility to determine whether it should be included in the data extraction and analysis. The abstracts were reviewed to evaluate the quality and eligibility and to remove unsuitable articles. The author then applied the content criteria for inclusion: as the research question relates to supporting students in becoming numerate in the classroom, only articles related to numeracy and numeracy learning are included. The number of articles was thus reduced to 35.

Fifth, quality assessment of the literatures acted as a fine sieve to improve the full-text articles and prepare them for data extraction and synthesis. This is also a crucial step for reviews aiming for generalization. Ranking the literatures based on a checklist is used for quality assessment in this study. The data extraction process in this article involves coding. The articles were classified according to their themes of numeracy and numeracy problems; examples of numeracy classes or courses; and teachers' roles in numeracy learning.

In step 7 (analysis and synthesis of the data), the data was explored qualitatively and distilled into analytic themes, as described in step 6: numeracy and numeracy problems; examples of numeracy classes or courses; and teachers' roles in numeracy learning. Lastly, this article describes opportunities and directions for further research, such as guidelines to enhance students' numeracy competence.

3. RESULTS

3.1. Conceptualizing numeracy

In general, numeracy can be described as an essential skill needed to engage in life situations involving mathematical elements [2], [4]. Numeracy involves how people deal with the demands of mathematical elements in adult life [18]. Prior to this arose from the demand for the characteristics of problems that adults may encounter [19]. Even though in some literature, numeracy is described as numbers and computation performance, it is not the term this article used. The consequence of the transformation of knowledge, social structures, work practices and technology are the transformation of how we see numeracy skills [6], [20].

A numeracy model containing the dimensions of numeracy-the capabilities needed to meet the challenges of life in the 21st century has been introduced in the prior study [21]. Figure 1 is the 21st-century numeracy model, which involves considering real-life contexts, using mathematical knowledge, positive dispositions towards mathematics implementation, using representational, physical, and digital tools, and critical orientation as the dimensions [21]. Next, these dimensions will be explored more, especially in a mathematics classroom.

3.1.1. Dimension context

Because numeracy is highly related to everyday situations, it requires consideration of context to be effective [4]. In addition, understanding numeric information and its use is crucial when making decisions on an issue [8], for instance, making informed decisions about healthcare or the value of polling data. Furthermore, these are the general situations which demand numeracy [6]: i) At home, numerous activities at home require numeracy. For instance, cooking involves the measurement of quantities and time, comparing prices and estimating money value when shopping, or keeping and predicting scores when playing or watching team sports; ii) At work, all jobs require numeracy [6], even the low-skilled [22]. In addition, numeracy practices are specific to each work context; and iii) In community and civic life.

Being a critical citizen requires numeracy, because almost without exception, the public issue depends on data for constructing arguments to inform, persuade or build decision-making. Uncritical citizens might accept a survey's numerical findings without questioning its design and sampling strategy. The situations which demand numeracy, or in other words, context, are the critical things that should be offered to students in order to support them to become informed and intelligent citizens [23], [24], which is the intention of becoming numerate [6]. Related to the context of the problem in real-life situations, it is not the primary goal of numeracy to understand mathematical concepts better. Instead, to understand how to use mathematical ideas in struggles to improve the world [25].

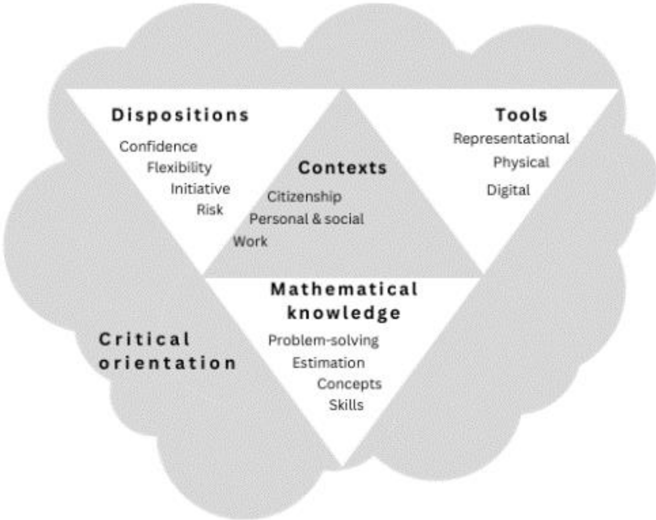


Figure 1. 21st century numeracy model [21]

3.1.2. Dimension mathematical knowledge

One of the characteristics of a numerate person is mathematical knowledge [21]. An understanding of mathematical knowledge is needed to reason mathematically, solve problems, and interpret situations in real-life contexts [5]. This is because using mathematics to solve real-life situations problem requires personal mathematical knowledge relevant to a particular situation, and this mathematical knowledge lies on mathematical strand, which numeracy demand [6]. Table 1 presents the numeracy demand of mathematical knowledge based on the organization for economic cooperation and development (OECD), trends in international mathematics and science study (TIMSS) and some high achievers' countries on program for international student assessment (PISA) mathematical literacy.

Based on Table 1, we can see that numbers, measurement, data and probability, geometry, and algebra are the intersection of the mathematical knowledge that numeracy demands. This is in line with Goos *et al.* [6] who stated that the five strands of mathematical knowledge demands are exploring, analyzing, and modeling data; numbers; measurement; patterns and algebraic reasoning; and spatial sense and geometric reasoning. In addition, mathematical knowledge, as mentioned before, is the crucial content of mathematics.

Geometry studies provide the development of mathematical thinking, logical thinking, intuition and developing spatial orientation and acquaintance with the environment [30]. They can successfully bring the student to study a higher level of mathematics [31]. Hoogland [3], based on his observation, stated that the most numeracy demand in the PISA study and Dutch literacy and numeracy framework (LaNF) was on numbers. For measurement, based on Smith *et al.* [32] prior works reported it as a binding domain for students, including vocational education and various use in occupations and workplaces. He also stated that weak learning in this domain would impact students' ability to learn and understand more advanced mathematics and scientific content and, therefore, students' access to essential kinds of skilled work.

Furthermore, due to a large amount of information and decision-making competency based on data analysis, there is an increasing need for teaching-learning probability and statistics [33], [34]. Data and probability are also essential parts of mathematics curricula in school [35]. Lastly, algebra is a crucial field of learning [36]. Learning algebra helps a lot in order to understand mathematics [37], even considered a critical milestone in learning mathematics [38], as well as playing a significant role in students' opportunities to pursue many different types of education in the current society [39].

Table 1. Numeracy demand of mathematical knowledge

Sources	Mathematical strands/domains
OECD [5]	Quantity: Understanding magnitudes, counts, measurements, relative size, indicators, unit, also numerical trends and patterns. Uncertainty and data: Perceiving and comprehending the role of variation in processes, along with acknowledging measurement uncertainty and mistake, understanding chance, and formulating, interpreting, and assessing findings obtained in situations where uncertainty is key. Change and relationships: Gaining knowledge of fundamental categories of change to employ appropriate mathematical models for describing and forecasting change, representing the change and connections using suitable functions and equations, and proficiently interpreting and converting between symbolic and graphical representations of relationships. Space and shape: Analyzing patterns, objects' characteristics, their positions and orientations, ways of representing objects, decoding and encoding visual information, and navigating and interactively engaging with real shapes and their representations.
TIMSS 2015 [26]	Number: Understanding of whole numbers, fractions and decimals, and expressions, simple equations, and relationship (4^{th} grade); Understanding of whole numbers, fractions, decimals, integers, ratio, proportion, and percent (8^{th} grade) Geometric shapes and measures (4^{th} grade): Understanding measurements, coordinate plane, lines, and angles; and two- and three-dimensional shapes. Geometry (8^{th} grade): Expanding understanding of shapes and measurements by examining the attributes and properties of various two- and three-dimensional objects and demonstrating proficiency in geometric measurement, including perimeters, areas, and volumes. Data display (4^{th} grade): Understand graphs and charts. Data and Chance (8^{th} grade): Understanding of characteristics of data sets, data interpretation, and chance. Algebra (8^{th} grade): Understanding of operations and expressions, equations and inequalities, also relationships, and functions.
Mathematics curriculum of Japan [27]	Numbers and calculations (primary school): Hundred million-unit and trillion-unit, notation of decimal positional, approximation numbers, fractions meaning and notation, operations of fractions and decimal. Numbers and algebraic expressions (lower secondary school): Square roots of natural number, multiplication of monomials and polynomials, polynomial division by monomial, expanding and factorizing simple algebraic expressions, and quadratic equations. Quantities and measurements (primary school): Understanding area and measuring in simple cases, size of an angle and as an amount of rotation. Geometrical figures: Grasping the concepts of basic geometric shapes, such as isosceles and equilateral triangles, understanding angles concerning these shapes, and comprehending the center, diameter, and radius of circles and spheres, including their respective diameters (primary school level). Familiarity with the conditions for triangle similarity, properties of parallel lines, segment proportions, and the Pythagorean theorem (lower secondary school level). Quantitative relations: Describing and inspecting the relationships between two changing quantities, investigating the quantitative relationship using: table and broken-line graph, understanding expressions of operations or parentheses, understanding the concept of formula, and also gathering, classifying, and arranging data (primary school). Function and ratio change in the values (lower secondary school).
Mathematics curriculum in Korea [28]	Number and operations: Understanding the operations involving integers and rational numbers, prime factorization of natural numbers, integers, and rational numbers, recurring decimals, square roots, and real numbers. Letters and expressions: Expressions with letters and calculations, linear equation solution, monomial and polynomial computation, and radical sign computation. Functions: Topics include understanding functions and their graphs, solving simultaneous equations, linear and simultaneous inequalities, linear functions and graphs, the relationship between linear functions and linear equations, polynomial factorization, and quadratic equations. Probability and statistics: Table of frequency distribution and its graph, meaning and computation of probability, representative value and dispersion Geometry: Key concepts covered are fundamental shapes, their construction and congruence; properties of polygons, circles, and sectors; polyhedral and solids of revolution; surface area and volume calculations for solid figures; properties of triangles and rectangles, the Pythagorean theorem and its applications, trigonometric ratios and their applications, circles and straight lines, and angles at the circumference.
Primary school mathematics curriculum in Netherland [29]	General mathematical insights and abilities: Effectively employ mathematical language to solve real-life and formal mathematical problems, articulate their reasoning, and evaluate and justify solution strategies. Numbers and operations: Comprehending the structure and interconnections between whole numbers, decimal numbers, fractions, percentages, and ratios, and applying them in practical scenarios; performing mental calculations and rapid operations with whole numbers up to 100, having fluency in addition and subtraction within 20, and memorizing multiplication tables; making estimations and approximate calculations, and utilizing a calculator effectively and intelligently. Measurement and geometry: Resolve basic geometric problems and perform measurements and calculations using appropriate units of measurement.

3.1.3. Dimension disposition

Furthermore, another characteristic of numerate is the dispositional elements such as eagerness and persistence when facing challenges in working with real-life problems, attitude, prior beliefs, and habits [6], [40]. In addition, based on the results of Kamid *et al.* [41] which highlight the relationship between disposition and mathematics ability, the students' cognitive aspects are also good by having an excellent affective aspect. Hence, these means dispositional elements support an individual to be numerate and have a good mathematical ability.

3.1.4. Dimension tool

Moreover, real-world problems generally contrast with textbook problems, which require different problem-solving tools [42]. There were two reasons: real problems are often more confusing and take longer to solve. Hence, planning the approach is critical to understand the problem well. Second, it is uncommon for the real-world problem to seek the answer in the form of a number instead a better device, a modeling process, or interpreting the data, and this is consistent with the statement of Goos *et al.* [6] to form a judgment about the result. The dimension of the tool is connected to the last dimension of the 21st-century numeracy model, which is critical orientation.

3.1.5. Dimension critical orientation

Critical orientation, as the last dimension, considers the aspects of numerate individuals, which are interpretative, evaluative, and analytical [6]. This dimension supports the individual to be preventive about increasing the utilization of mathematical information in social, political, and national or international issues [20], [43]. In a nutshell, numerate means using mathematical information to generate decisions, and perceptions, supporting and assessing an argument [44]. Furthermore, he also highlights an approach for the teacher to emphasize critical orientation in the learning; request students provide evidence for their conjectures, and supervisory them to back to their data when they form speculation.

3.2. Characteristics of numerate

Being numerate, or in other words having numeracy competencies, involves more than mastering basic mathematics [2], [6], [7]. Numeracy needs mathematical knowledge and the ability to apply it in real-world contexts [45]. Numeracy also is viewed as an essential outcome of school [18], and being numerate is students' right after completing compulsory school [6]; this is because numeracy is a foundational skill for every individual [2].

Gal *et al.* [18] characterized numerate as an individual who knows some or a lot of mathematics and statistics and is able to apply that mathematics within a real-world context. Specific to the health context, Heilmann [46] described four numeracy levels: i) Basic, incorporates number identification and quantitative data comprehension, such as the quantity of prescriptions and the time and date of medical appointments; ii) Computational, includes computing and doing simple manipulations, e.g., calculating fees; iii) Analytical, entails making sense of information and comprehending quantities and percentages, as well as comprehending simple graphs and comparing the benefits of various treatments; and iv) Understanding statistical concepts and probability statements, critically assessing information, comprehending and interpreting complex graphs, comprehending treatment ramifications, and making risk-based decisions are all part of the job.

In addition to possessing advanced mathematical skills and being able to apply in non-mathematical situations, numeracy also encompasses problem-solving abilities and critical judgment [6]. Numeracy extends beyond the mathematics classroom and involves skills, knowledge, and attitudes related to understanding and utilizing specific statistical information [8]. For instance, numeracy competencies include the ability to interpret and critically analyze data in various contexts. In economic situations, this could involve evaluating the terms of buying or selling a house, assessing loan options for potential predatory practices, or understanding how interest rate changes impact daily life. In scientific or medical contexts, numeracy entails using medical information to make informed decisions about the risks associated with certain medications. In civic life, numeracy involves understanding polling data and posing critical questions about the statistical methodology employed in polls. Hoogland [3] classified a way we can use to observe the numerate behavior of students. First, responding to mathematical ideas that may be expressed in multiple ways. Furthermore, the activation of a range of enabling knowledge, factors, and processes.

3.3. How do we support student to become numerate?

Enhancing numeracy in students means a shift from emphasizing mathematics education on mathematical procedures against attention to problem-solving and creating a problem-solving attitude in students [3]. Mathematics education in school can serve students learning to understand concepts, confidence and adaptive thinking to apply their knowledge in a wide range of contexts [6], [47]. This is in line with the statement of Frankenstein [25], the primary goal of numeracy is not to understand mathematical concepts better. Instead, to understand how to use mathematical ideas in struggles to make the world better.

Specifically for social studies, educators should consider where basic numeracy is to help prepare students to become a member of the citizenry [8]. By serving students with numeracy learning, the teacher could make the activities in the classroom contain these two characteristics of numeracy, which are [4]: i) Modelling: formulating issues, finding patterns, and constructing conclusions; detecting interactions in complicated systems; comprehending linear, exponential, multivariate, and simulation models; comprehending the consequences of varying rates of growth; and ii) Chance: Understanding that seemingly unlikely coincidences are not unusual, estimating risks from existing evidence, and understanding the significance of random samples.

To produce numerate students, more than a sufficient mathematical education is needed; in other words, to become critical citizens, learning requires the promulgation of democratic values and attitudes [48]. However, numerous mathematics teachers must be made aware that they teach mathematics and values. Changing the perception is one of the biggest obstacles to overcome. Changing the perception of learning can be done by avoiding instruction like "solve the equation…", "find the length of…" and "calculate the value of…" because it would dissociate students to be critical, meanwhile mathematics teaching should include activities that will encourage students to use mathematics as a thinking tool.

In his study, Hoogland [3] described the process of the classroom, first serving real problem as the starting point, continued by stipulating mathematizing: formulating the mathematical problem, modelling, and problem-solving, then calculating occurs: employing mathematical analysis, and working mathematically, last is interpreting the result of the mathematical activity and make sense of it in the perspective of the original problem: interpret, evaluate, communicate, validate, and expose. In addition, several areas where differences can be made in enhancing numeracy learning through mathematics class are i) adjusting the design of learning environments; ii) changing the tasks; iii) self-regulation training and cooperative learning with peers; iv) process-oriented feedback; v) teachers' emotions and enthusiasm in teaching mathematics, and vi) contextual factors, e.g., parental support and the composition of peer groups [22].

Moreover, Crowe [8] provided an example of how numeracy can be integrated into social studies classrooms. Teachers can provide students with various articles or information that contain numeric data, percentages, averages, graphs, and charts. To foster a deeper understanding, teachers can encourage students to ask probing questions about the data or the readings. They can initiate this process by posing critical questions, such as: i) what is the significance of the numbers; ii) how could the data be represented in alternative ways; iii) where might misunderstandings arise due to the author's use of numbers; iv) what information is missing; and v) would additional data enhance comprehension. These questions serve as guidance for students to establish connections between data and decision-making concerning a particular issue.

Besides that, in mathematics classrooms, the art of enclosing numeracy can be done by seeing the situations (or contexts) as having particular gaps concerning students. The gap can be described as the closest situation for students. Here is the list of the distance from the shortest to the furthest: students' personal life—school (educational) life—work (occupational) and leisure—local community and society—scientific situations. It might be possible to enlarge the distance domain as the age of students increases, but not in a strict way [24]. This is in line with the critical implication of Piaget's theory which is the adaptation of instruction to the student's developmental level [49]. Talking about numeracy tasks, the characteristics of numeracy problems are: i) real-world situations; and ii) involves the process of reading, interpreting, solving, and communicating mathematically [18]. In addition, mathematical concepts should be learned by solving problems in appropriate settings [24].

3.4. Numeracy problem

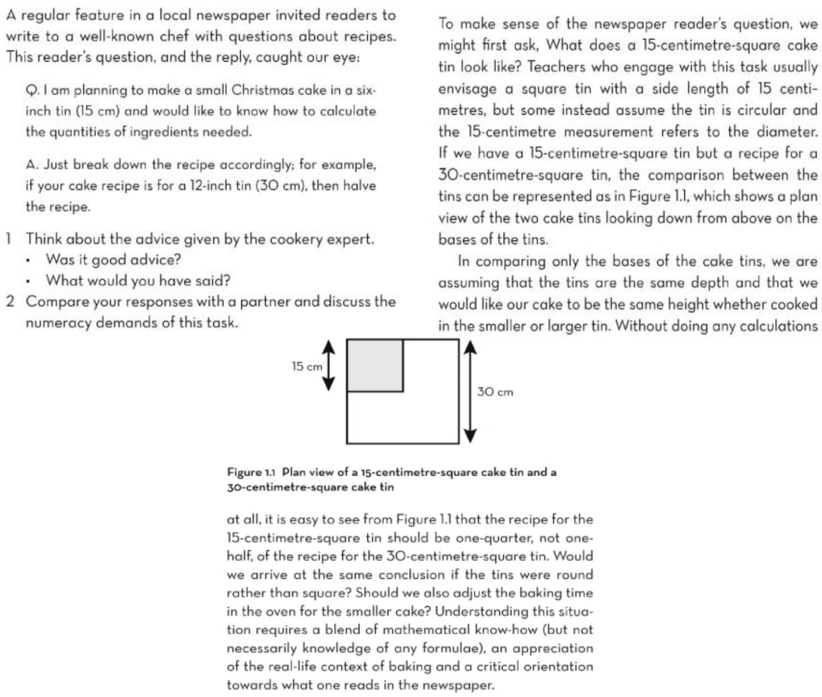
Numeracy skill is closely related to mathematical elements in real-life settings that occur in a broad context, integrated with another knowledge of the world [25]. Hence, proficiency is needed to recognize numeracy demands in real-life settings to effectively develop students' numeracy capabilities [6]. Furthermore, they gave some examples of everyday situations that demand numeracy, as seen in Figure 2.

4. DISCUSSION

Numeracy is an essential skill to have in this century [4], [6], [8]. It is because it promotes individual competencies to solve a problem which includes mathematical elements [6]. However, taking many mathematics classes does not imply that students will have better numeracy skills or become numerate [8]. It is because numeracy involves more than mastering basic mathematics [6]. Table 2 provides abilities included as numeracy.

In order to prepare students to become numerate, teachers can serve students numeracy learning. Numeracy learning does not mean it only can be done by mathematics teachers in mathematics classrooms, and it also can be embedded in numerous subjects [4], [8]. The core point of numeracy learning is the understanding of the teachers about the implications of mathematics in real situations. Furthermore, Table 3 provides the activities which can be used to implement numeracy learning.

In addition, since the use of everyday situations is crucial to numeracy learning, there is one learning approach that is expectantly able to support numeracy learning. Realistic mathematics education (RME) is one of its principles, of the reality principle, which is attached to the goal of mathematics education of students' ability to apply mathematics in solving "real-life" problems [51]. This principle aligns with the aim of numeracy learning [52], [53].



A regular feature in a local newspaper invited readers to write to a well-known chef with questions about recipes. This reader's question, and the reply, caught our eye:

Q. I am planning to make a small Christmas cake in a six-inch tin (15 cm) and would like to know how to calculate the quantities of ingredients needed.

A. Just break down the recipe accordingly; for example, if your cake recipe is for a 12-inch tin (30 cm), then halve the recipe.

1 Think about the advice given by the cookery expert.
  - Was it good advice?
  - What would you have said?
2 Compare your responses with a partner and discuss the numeracy demands of this task.

To make sense of the newspaper reader's question, we might first ask, What does a 15-centimetre-square cake tin look like? Teachers who engage with this task usually envisage a square tin with a side length of 15 centimetres, but some instead assume the tin is circular and the 15-centimetre measurement refers to the diameter. If we have a 15-centimetre-square tin but a recipe for a 30-centimetre-square tin, the comparison between the tins can be represented as in Figure 1.1, which shows a plan view of the two cake tins looking down from above on the bases of the tins.

In comparing only the bases of the cake tins, we are assuming that the tins are the same depth and that we would like our cake to be the same height whether cooked in the smaller or larger tin. Without doing any calculations

15 cm

30 cm

Figure 1.1 Plan view of a 15-centimetre-square cake tin and a 30-centimetre-square cake tin

at all, it is easy to see from Figure 1.1 that the recipe for the 15-centimetre-square tin should be one-quarter, not one-half, of the recipe for the 30-centimetre-square tin. Would we arrive at the same conclusion if the tins were round rather than square? Should we also adjust the baking time in the oven for the smaller cake? Understanding this situation requires a blend of mathematical know-how (but not necessarily knowledge of any formulae), an appreciation of the real-life context of baking and a critical orientation towards what one reads in the newspaper.

Figure 2. Numeracy demand example

Table 2. Numeracy abilities

Categories	Ability
Mathematics Knowledge	Understanding the crucial concept of mathematics topic, including numbers, measurement, data, probability, geometry, and algebra [6], [50].
Context-related	Including perceiving a data, and making sense of information
Problem-solving	Including being critical about the data or the information, applying the correct mathematics in the appropriate context, making decisions, and interpreting the results.

Table 3. Numeracy learning

Learning phase	Activity
Planning	Preparing a lesson plan that contains numeracy problems: situated in real-life settings involves the process of reading, interpreting, solving, and communicating mathematically [18] and allows students to formulate problems, seek patterns, draw conclusions (modeling), evaluate risks, recognize coincidences, understanding the value of random samples (chance) [4].
The learning	Avoid to give direct instruction instead pose critical questions Giving process-oriented feedback
Assessment	The problem characteristics used in the assessment are: i) situated in the real world; ii) involves the process of reading, interpreting, solving, and communicating mathematically [18]; iii) in the form of modeling and chance [4].

5. CONCLUSION

One crucial thing about numeracy is using mathematics elements in numerous contexts, which means using context when serving numeracy learning is crucial. With that understanding, the teacher can prepare the problem or readings or public information as the learning material to be disposed to students. Furthermore, this learning material can be discussed in depth to deepen students' understanding and make them more critical. Teacher can exemplify by questioning everything, and students will, unconsciously, start to question everything critically. Combining all those aspects can provide an opportunity for students being numerate.

ACKNOWLEDGEMENTS

The authors thank to Ministry of Education, Culture, Research and Technology Republic Indonesia through HIBAH PMDSU 2022-2024 main contract 142/E5/PG.02.00PT/2022 with derivative contract no. 0146.04/UN9.3.1/PL/2022.

REFERENCES

[1] J. O'Donoghue, "Numeracy and mathematics," *Irish Mathematical Society Bulletin*, vol. 0048, pp. 47–56, 2002, doi: 10.33232/BIMS.0048.47.56.

[2] M. Niss and E. Jablonka, "Mathematical literacy," in *Encyclopedia of Mathematics Education*, Dordrecht: Springer Netherlands, 2014, pp. 391–396, doi: 10.1007/978-94-007-4978-8_100.

[3] K. Hoogland, "Images of numeracy: Investigating effects of visual representations of problem situations in contextual mathematical problem solving," Ph.D. dissertation, Technische Universiteit Eindhoven, Eindhoven, Netherlands, 2016.

[4] D. Hains, M. Intindola, D. Lepisto, and B. Wagner, "Scrimmage! Teaching quantitative literacy through a multidimensional simulation," *The International Journal of Management Education*, vol. 17, no. 1, p. 119, 2019, doi: 10.1016/j.ijme.2019.01.002.

[5] Organisation for Economic Co-operation and Development (OECD), "PISA 2022 Mathematics Framework (Draft)," 2018.

[6] M. Goos, V. Geiger, S. Dole, H. Forgasz, and A. Bennison, *Numeracy across the curriculum: Research-based strategies for enhancing teaching and learning*. Routledge, 2018.

[7] D. Tout and I. Gal, "Perspectives on numeracy: Reflections from international assessments," *ZDM*, vol. 47, no. 4, pp. 691–706, Jul. 2015, doi: 10.1007/s11858-015-0672-9.

[8] A. R. Crowe, "'What's math got to do with it?': Numeracy and social studies education," *The Social Studies*, vol. 101, no. 3, pp. 105–110, Apr. 2010, doi: 10.1080/00377990903493846.

[9] V. Geiger, M. Goos, and H. Forgasz, "A rich interpretation of numeracy for the 21st century: A survey of the state of the field," *ZDM*, vol. 47, no. 4, pp. 531–548, Jul. 2015, doi: 10.1007/s11858-015-0708-1.

[10] J. Engel, "Statistical literacy and society: What is civic statistics?" *Stochastik in der Schule*, vol. 39, no. 1, pp. 2–12, 2019.

[11] P. Liljedahl, "Numeracy task design: A case of changing mathematics teaching practice," *ZDM*, vol. 47, no. 4, pp. 625–637, Jul. 2015, doi: 10.1007/s11858-015-0703-6.

[12] R. Prince and V. Frith, "An investigation of the relationship between academic numeracy of university students in South Africa and their mathematical and language ability," *ZDM*, vol. 52, no. 3, pp. 433–445, Jun. 2020, doi: 10.1007/s11858-019-01063-7.

[13] G. A. Nortvedt and E. Wiese, "Numeracy and migrant students: A case study of secondary level mathematics education in Norway," *ZDM*, vol. 52, no. 3, pp. 527–539, Jun. 2020, doi: 10.1007/s11858-020-01143-z.

[14] A. Asrijanty, *AKM and its implications on learning*. Pusat Asesmen dan Pembelajaran, Kementerian Pendididkan dan Kebudayaan (in Indonesian), 2020.

[15] *Inspiration of numeracy-enhancing learning*. Direktorat Jenderal Pendidikan Anak Usia Dini, Pendidikan Dasar dan Pendidikan Menengah (in Indonesian), 2021.

[16] R. McClure and S. Sircar, "Quantitative literacy for undergraduate business students in the 21st century," *Journal of Education for Business*, vol. 83, no. 6, pp. 369–374, Jul. 2008, doi: 10.3200/JOEB.83.6.369-374.

[17] Y. Xiao and M. Watson, "Guidance on conducting a systematic literature review," *Journal of Planning Education and Research*, vol. 39, no. 1, pp. 93–112, Mar. 2019, doi: 10.1177/0739456X17723971.

[18] I. Gal, A. Grotlüschen, D. Tout, and G. Kaiser, "Numeracy, adult education, and vulnerable adults: a critical view of a neglected field," *ZDM*, vol. 52, no. 3, pp. 377–394, Jun. 2020, doi: 10.1007/s11858-020-01155-9.

[19] A. Bakker, M. Wijers, V. Jonker, and S. Akkerman, "The use, nature and purposes of measurement in intermediate-level occupations," *ZDM*, vol. 43, no. 5, pp. 737–746, Oct. 2011, doi: 10.1007/s11858-011-0328-3.

[20] E. Jablonka, "The evolvement of numeracy and mathematical literacy curricula and the construction of hierarchies of numerate or mathematically literate subjects," *ZDM*, vol. 47, no. 4, pp. 599–609, Jul. 2015, doi: 10.1007/s11858-015-0691-6.

[21] M. Goos, V. Geiger, and S. Dole, "Transforming professional practice in Numeracy Teaching," in *Transforming Mathematics Instruction*, Cham: Springer International Publishing, 2014, pp. 81–102, doi: 10.1007/978-3-319-04993-9_6.

[22] H. Liu, "Low-numerate adults, motivational factors in learning, and their employment, education and training status in Germany, the US, and South Korea," *ZDM*, vol. 52, no. 3, pp. 419–431, Jun. 2020, doi: 10.1007/s11858-019-01108-x.

[23] P. Cohen, L. Cuban, W. J. Ellis, P. Ewell, D. Hallett, and D. Kennedy, *Mathematics and democracy*. The Woodrow Wilson National Fellowship Foundation, 2001.

[24] J. De Lange, "Mathematics for literacy," *Quantitative Literacy: Why Numeracy Matters for Schools and Colleges*, pp. 75–89, 2003.

[25] M. Frankenstein, "Developing a criticalmathematical numeracy through real real-life word problems," in *Words and Worlds*, BRILL, 2009, pp. 111–130, doi: 10.1163/9789087909383_008.

[26] M. Hooper, I. V. S. Mullis, and M. O. Martin, *TIMSS 2015 context questionnaire framework martin*. TIMSS & PIRLS International Study Center, 2013.

[27] M. Koyama, "Mathematics curriculum in Japan," in *Reforms and Issues in School Mathematics in East Asia*, BRILL, 2010, pp. 59–78, doi: 10.1163/9789460912283_005.

[28] H. Lew, "Current mathematics curriculum of South Korea and its embodiment into textbooks," in *School Mathematics Curricula*, Singapore: Springer Nature Singapore Pte Ltd, 2019, pp. 127–150, doi: 10.1007/978-981-13-6312-2_7.

[29] M. van den Heuvel-Panhuizen and M. Wijers, "Mathematics standards and curricula in the Netherlands," *Zentralblatt für Didaktik der Mathematik*, vol. 37, no. 4, pp. 287–307, Aug. 2005, doi: 10.1007/BF02655816.

[30] D. Patkin and I. Levenberg, "Geometry from the world around Us," *Learning and Teaching Mathematics*, vol. 13, pp. 14–18, 2012.

[31] P. van Hiele, "Begin wit," *Teaching Children Mathematics*, vol. 6, pp. 10–16, 1999.

[32] J. P. Smith, M. van den Heuvel-Panhuizen, and A. R. Teppo, "Learning, teaching, and using measurement: Introduction to the issue," *ZDM*, vol. 43, no. 5, Oct. 2011, doi: 10.1007/s11858-011-0369-7.

[33] A. P. de O. Júnior, P. R. Zamora, L. A. de Oliveira, and T. C. de Souza, "Student's attitudes towards probability and statistics and academic achievement on higher education," *Acta Didactica Napocensia*, vol. 11, no. 2, pp. 43–56, 2018, doi: 10.24193/adn.11.2.4.

[34] C. Batanero, E. J. Chernoff, J. Engel, H. S. Lee, and E. Sánchez, *Research on teaching and learning probability*. Cham: Springer, 2016, doi: 10.1007/978-3-319-31625-3_1.

[35] J. Ingram, "Randomness and probability: Exploring student teachers' conceptions," *Mathematical Thinking and Learning*, vol. 26, no. 1, pp. 1–19, Jan. 2022, doi: 10.1080/10986065.2021.2016029.

[36] S. Şengül and F. Erdoğan, "A study on the elementary students' perceptions of algebra," *Procedia - Social and Behavioral Sciences*, vol. 116, pp. 3683–3687, Feb. 2014, doi: 10.1016/j.sbspro.2014.01.823.

[37] C. Kieran, "Algebra teaching and learning," in *Encyclopedia of Mathematics Education*, Dordrecht: Springer Netherlands, 2014, pp. 27–32, doi: 10.1007/978-94-007-4978-8_6.

[38] X. Wang, "The literature review of algebra learning: Focusing on the contributions to students' difficulties," *Creative Education*, vol. 6, no. 2, pp. 144–153, 2015, doi: 10.4236/ce.2015.62013.

[39] L. S. Grønmo, "The role of algebra in school mathematics," in *Invited Lectures from the 13th International Congress on Mathematical Education*, 2018, pp. 175–193, doi: 10.1007/978-3-319-72170-5_11.

[40] I. Gal, M. van Groenestijn, M. Manly, M. J. Schmitt, and D. Tout, "Adult numeracy and its assessment in the ALL survey: A conceptual framework and pilot results," in *Measuring adult literacy and life skills: New frameworks for assessment*, 2005, pp. 2731–2745.

[41] K. Kamid, N. Huda, W. Syafmen, S. Sufri, and S. Sofnidar, "The relationship between students' mathematical disposition and their learning outcomes," *Journal of Education and Learning (EduLearn)*, vol. 15, no. 3, pp. 376–382, Aug. 2021, doi: 10.11591/edulearn.v15i3.17604.

[42] A. Draganov, *Mathematical tools for real-world applications a gentle introduction for students and practitioners*. Cambridge, MA: The MIT Press, 2022.

[43] M. Rosa and D. C. Orey, "A trivium curriculum for mathematics based on literacy, matheracy, and technoracy: An ethnomathematics perspective," *ZDM*, vol. 47, no. 4, pp. 587–598, Jul. 2015, doi: 10.1007/s11858-015-0688-1.

[44] V. Geiger, "Using mathematics as evidence supporting critical reasoning and enquiry in primary science classrooms," *ZDM*, vol. 51, no. 6, pp. 929–940, Nov. 2019, doi: 10.1007/s11858-019-01068-2.

[45] D. Tout, "Evolution of adult numeracy from quantitative literacy to numeracy: Lessons learned from international assessments," *International Review of Education*, vol. 66, no. 2–3, pp. 183–209, Jun. 2020, doi: 10.1007/s11159-020-09831-4.

[46] L. Heilmann, "Health and numeracy: The role of numeracy skills in health satisfaction and health-related behaviour," *ZDM*, vol. 52, no. 3, pp. 407–418, Jun. 2020, doi: 10.1007/s11858-019-01106-z.

[47] Y. P. Sari, Z. Zulkardi, and R. I. I. Putri, "The development of numeracy problems using light rail transit context," *Jurnal Elemen*, vol. 9, no. 1, pp. 227–245, Jan. 2023, doi: 10.29408/jel.v9i1.6923.

[48] M. S. Aguilar and J. G. M. Zavaleta, "On the links between mathematics education and democracy: A literature review," *Pythagoras*, vol. 33, no. 2, Aug. 2012, doi: 10.4102/pythagoras.v33i2.164.

[49] B. Lefa, "The piaget theory of cognitive development : An educational," *Educational Psychology*, vol. 1, no. 1, pp. 1–9, 2014.

[50] E. E. Indefenso and A. D. Yazon, "Numeracy level, mathematics problem skills, and financial literacy," *Universal Journal of Educational Research*, vol. 8, no. 10, pp. 4393–4399, Oct. 2020, doi: 10.13189/ujer.2020.081005.

[51] M. van den Heuvel-Panhuizen and P. Drijvers, "Realistic mathematics education," in *Encyclopedia of Mathematics Education*, Cham: Springer International Publishing, 2020, pp. 713–717, doi: 10.1007/978-3-030-15789-0_170.

[52] M. S. Aguilar and A. Castaneda, "What mathematical competencies does a citizen need to interpret Mexico's official information about the COVID-19 pandemic?" *Educational Studies in Mathematics*, vol. 108, no. 1–2, pp. 227–248, Oct. 2021, doi: 10.1007/s10649-021-10082-9.

[53] M. Goos, V. Geiger, and S. Dole, "Auditing the numeracy demands of the middle years curriculum," *PNA. Revista de Investigación en Didáctica de la Matemática*, vol. 6, no. 4, pp. 147–158, Jun. 2012, doi: 10.30827/pna.v6i4.6138.

BIOGRAPHIES OF AUTHORS

Viona Adelia is a doctoral student of mathematics education in Sriwijaya University, Palembang, South Sumatra, Indonesia. Her research interests lie in the numeracy, realistic mathematics education, and design research. She can be contacted at email: viona.adelia1999@gmail.com.

Ratu Ilma Indra Putri is a professor of mathematics education in Sriwijaya University, Palembang, South Sumatra, Indonesia. Her research interests lie in the numeracy, lesson study, realistic mathematics education, and design research. She can be contacted at email: ratuilma@unsri.ac.id.

Zulkardi is a professor of mathematics education in Sriwijaya University, Palembang, South Sumatra, Indonesia. His research interests lie in the numeracy, PISA task, realistic mathematics education, and design research. He can be contacted at email: zulkardi@unsri.ac.id.