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Status of Use of Model Drawing Method in Basic level Mathematics Textbook

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Abstract: *This topic entitled 'Application of Model drawing Method in Basic level Mathematics Textbook' is intended to explore the status of the model drawing method in basic-level mathematics textbooks. It is a case study approach in which I have selected the two textbooks grade five and eight published by the government of Nepal, Curriculum Development Center. The model drawing method is a strategy also called the Singapore math strategy to solve mathematical problems by drawing bars in different ways. I found that basic-level mathematics textbooks incorporated model drawing methods to solve problems related to basic operations. Part-part-whole models are more common in a textbook rather than comparison models and parallel bar models. The use of models in arithmetic leads in frequency with comparison to other content areas of the curriculum. The training and workshop for the writer to incorporate model drawings seems necessary for betterment. For proper mathematization and solving different mathematical contextual problems we should develop textbooks form each sector we should incorporate different models of model drawing.*

Keywords: *models drawing, textbook, pedagogy, problem solving, school mathematics*

Introduction

Mathematics is one of the most important and central subjects at the school level as well as at the university level. Different technical and general faculties and institutions of universities have been teaching mathematics in different forms both applied and pure form (Cross et al., 2009). We have to introduce apply and incorporate different methods of teaching, new and effective technologies as well as the strategies in mathematics textbooks. In Nepal, different types of textbooks are in existence. Both the government level and private sectors are publishing the textbooks. From government level, Curriculum Development Center (CDC) is responsible for not only the developing the curriculum but also writing textbooks of different levels of school. Furthermore, the textbooks from private publications have been implementing after approving by CDC. The Janak Education Material Center (JEMC) was formally established in 1978 and taken responsibility of printing textbooks for public schools for decades. The books which are printing by JEMC have been developing by Curriculum Development Center (CDC) which established in 1971 AD (Aryal, 2021).

Most of the textbooks in mathematics present content knowledge such as mathematical concepts, principles, theorems, proofs, and models in a verbal manner with a focus on what is mathematics and the proving of facts (Badru, 2008; Sunday, 2014). The applied nature of mathematics focuses on how to teach and how to use mathematics in real life. Many problems are presented in mathematics textbooks. The problems such as numerical problems, real-world problems, word problems, etc. We can use different methods and models to solve mathematical problems (Intaros et al., 2014). The activities designed help to improve the students' problem-solving ability with conceptual and procedural abilities (Fülöp, 2015). According to Shield & Dole (2013) the majority of teachers plan and implement different activities of teaching and learning by using prescribed textbooks. So, mathematics textbooks should incorporate different techniques and methods of instruction and problem-solving. Textbooks are crucial artifacts that play an important role in shaping both the students' as well as the teachers' roles and linking the intended and implemented curriculum (Rezat & Straesser, 2014).

In this paper, I have tried to explore to what extent the model drawing techniques of problem-solving are incorporated in basic-level mathematics textbooks from the government and private levels.

The textbooks of different publications have been using different format and patterns of presentation. They have been using different methods in presenting the concepts and content and problem solving in mathematical problems. The methods used in books not only guide the students to solve listed problems but also to acquire the conceptual knowledge of mathematics on them (Morina, 2022; Parker, 1995). The problem solving in textbooks are varied by country and as well as the philosophical basis of textbook writing.

Textbooks have different styles of presentation such as didactic style, problem oriented as well as inquiry-based style, Narrative style, constructive style. (Palincsar & Brown, 1987; Polya, 2004). The Inquiry- based style aligns the presentation with constructivist learning theories for conceptual understanding and developing problem solving skills. They start the writing with contextual problems or mathematical puzzles to stimulate thought and discussions emphasizing critical thinking and justification. The teachers and the students need more time for engagement and guidance and scaffolding. In similar way, the stories, historical anecdotes, or contextual problems are used to enumerate mathematical concepts in narrative style of textbook writing (Schoenfeld, 2016). The activity-based style promotes experiments and activities with manipulatives which is highly effective for developing deeper understanding and active learning of mathematical concept. It requires careful design with specific materials to achieve goals. Its main focus is discovery as well as conceptual development through activities (Pakpahan & Saragih, 2022; Vygotsky, 1978). (Brown et al., 2014) explained clarity, presenting information in highly condensed format with spare text, heavy definitions, formulae, and examples in organized way assuming a certain level of prior knowledge. Since it lacks scaffolding, and activities for conceptual understanding, it is supposed less applicable for school textbooks.

The international research community has been focusing and textbook review and analysis the evaluation of mathematics textbooks should be based on the standard of textbooks along with the use of recent and global techniques and Technology. The pedagogical intentions and the learning app percentage for the mathematical tax also be noted and incorporated in textbooks (Fan, 2013; Rezat & Sträßer, 2015). According to TIMSS (Trends in International Mathematics and Science Study) and the Program for International Students Assessment; (Schmidt et al., 2014), Singapore has performed top rank in international assessment of mathematical performance out of 36 countries. The translation of story problems of mathematics into visualized form by using bars to represent the values of variables is called the model drawing method (Pozo & Espinoza, 2025). A pentagonal figure represents Singapore's national mathematics framework. The center is occupied by mathematical problem solving, which is flanked by five sides: 1) attitudes (beliefs, interest, appreciation, confidence, perseverance), 2) metacognition (self-regulation of learning, monitoring one's thinking), 3) processes (reasoning, communication and connections, thinking skills and heuristics, application, and modeling), 4) concepts (numerical, algebraic, geometrical, statistical, probabilistic, and analytical) and 5) skills (numerical calculation, algebraic manipulation, spatial visualization, data analysis, measurement, mathematical tool usage, estimation (Thiyagu, 2013). Along with this, these activities help students in developing higher order thinking skills through engaging among the peer groups and cooperative skills in mathematization(Acharya et al., 2025) .

The model drawing method in mathematics is also called Singapore math approach that bridges between concrete manipulation and abstract algebraic reasoning as critical pedagogy. It uses rectangular bars for known and unknown quantities, students can materialize mathematical relationship through concrete pictorial abstract (CPA) sequence (Özalp, 2024). Particularly, this method helps the learners to visualize the part whole and comparison types of complex word problems without the immediate cognitive load of formal variables (Jahudin & Siew, 2024). Gradini et al. (2025) shows that bar model

not only visualize the arithmetic problems but also enhance the higher order thinking skills in students with providing a systematic framework for algebraic transformation and reduces the mathematics anxiety and improve accuracy of diversified learners with fostering a deeper mental model of mathematical logic, leading to higher proficiency in non-routine problem solving. The model drawing method is one of the strategies of Singapore mathematics that uses bar models to visualize the problem (Phillips et al., 2010; Sharp & Shih Dennis, 2017; Thiyagu, 2013). Sharp & Shih Dennis (2017) explained that the model drawing packages are effective for teaching and learning word problems of fractions for learners with learning disabilities. Bar modeling is an effective strategy that helps students to increase accuracy as well as the ability to use mental activities in solving story problems of mathematics (Morin et al., 2017)

The visualization of the mathematical problem is crucial for a better understanding of the mathematical problems. Also, among different visualization tools the bar drawing model is that which the peoples easily understandable and economical to all (Gracin & Matić, 2016; Viholainen et al., 2015). That is why I intend to review the basic level textbook based on the model drawing method.

Method

The provision of different methods of teaching and learning in mathematics textbooks is explored by analyzing the basic-level mathematics textbooks of the Government of Nepal. Furthermore, the main focus of the study was the implementation and provision of different methods of visualization of the problems to solve them. The government of Nepal, Ministry of Education, Science and Technology, Curriculum Development Center is an authorized institution for textbook development and publication from the government level. (CDC, 2076 BS). In Nepalese context, grade 5 and grade 8 are the terminal classes of second stage and third stage of basic level education (CDC, 2021). Since I intended to examine the model drawing methods in basic-level mathematics textbooks, so, I have selected the textbooks of grade 5 and Grade 8 for the study. The selected books were analyzed based on a theory of model drawing and identified the examples and the methods those used in developing textbooks. I have snapped the part or problem, both in Nepali as well as English language as the textbook available in both medium, from textbook and analyze according as the different types of the model drawing. Also, I have presented snapped part in analysis and discussion on the article. The data were analyzed in descriptively with identifying the perception and status of the model drawing methods used in developing such books.

Finding and Discussions

The structure of school education in Nepal is basic and secondary. Within the basic level, there are three stages; first (grade 1-3), second stage (grade 4,5), and the third stage (grade). The curriculum and the areas of content are also different for each level. For grades 4 and 5 there are five subject areas; geometry, arithmetic, measurement, statistics, and algebra. In grades 6 to 8, the sets are additional with grades 4 and 5(CDC, 2076 BS).

Most of the mathematics books in our context are loaded with pure mathematical content. Some of them are in deductive form and some of them are in inductive forms according to the nature of topic and writers' orientation regarding the curriculum developed by curriculum development center (Curriculum Development Center [CDC], 2019). The textbook of grade 5 included different methods presentation. The book included the review first for anticipation of the students. The review portion intended to acquire the student's prior knowledge based on the new lesson and that is followed by the inductive way of content presentation (Acharya et al., 2023).

The arithmetic and number sense are the fundamental areas of basic-level mathematics. The concepts of counting, comparison, and basic operations are included in arithmetic. In grade 4 and 5 a large number of concepts with their operation is included. The first example stated in figure 1 alongside shows that the model part to the whole model drawing method is used to calculate the total expenditure. In second problem, two-part bar is used for calculation. This example of subtraction is solved by using the parallel bar model to compare the total with the parts. So, in general, in basic operation we can use both part to whole model and parallel bar models to visualize the problem.

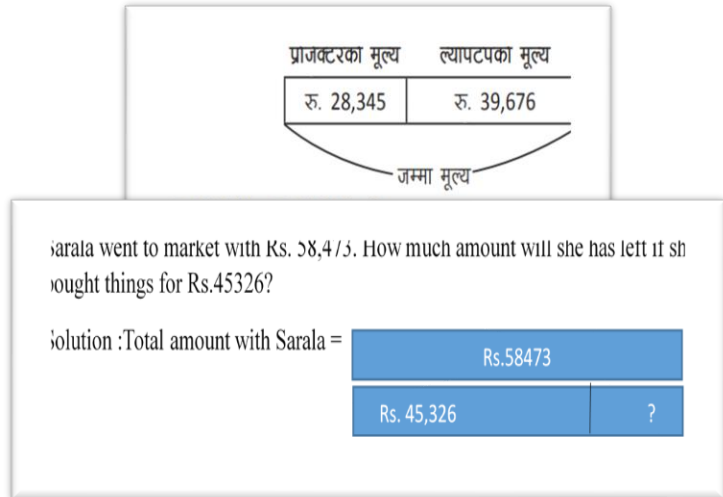


Figure 4: Bar model used in addition and subtraction.

The ratio and proportion are the fundamental concept for the unitary method and other higher arithmetic. The figure 2 presented showed that the bar model is used to easily visualize the concept of ratio. Similar types of problems are solved in the textbook to familiarize the method. Also, examples relating the ratio of more quantities and arithmetic operations to the model drawing methods are included in the textbook at the basic level.

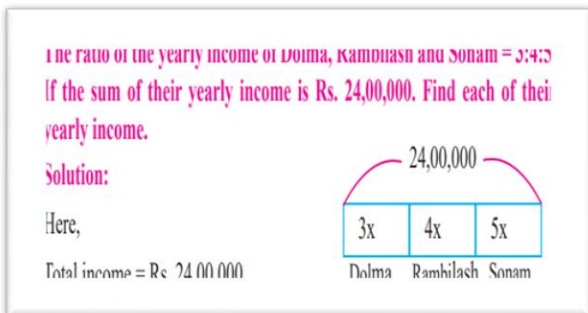
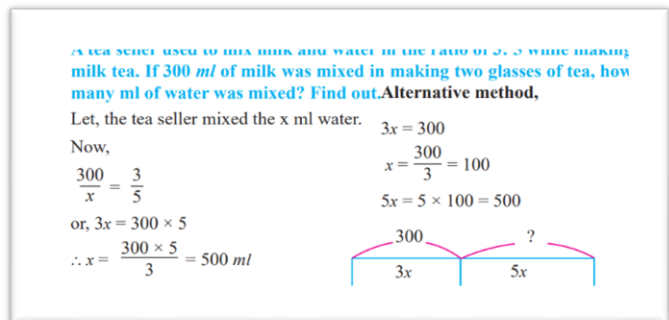


Figure 5: Bar model for problem on ratio



The fraction and decimal are also major content areas of school mathematics basically in basic level. The sample example showed in figure 3 showed the example using bar model in problem-solving on the topic fraction of grade 5 textbook. This bar model is using parallel bar model and visualize the parts of two different fractions. This type of visualization helps the students to develop the conceptual understanding about the fractions and their parts with basic operations. This helps to logically reasoning by using bar model.

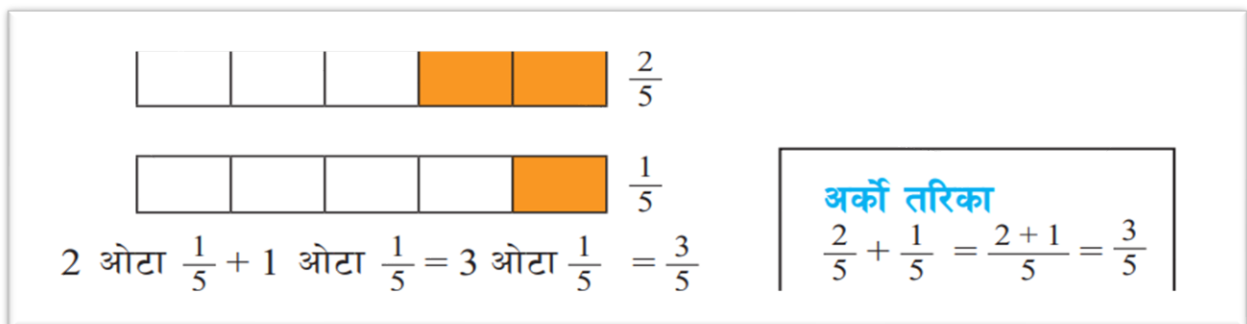


Figure 6: Bar model using in solving fraction problem

In similar ways, the Algebra is one of the mother stream in mathematics. Algebra in basic level has taken major space in school mathematics. We can use different forms of model drawing method in solving different types of algebraic problems with basic operations. The example on figure 4 given demonstrate the application of model drawing method in addition and subtraction of the algebraic expressions in basic level mathematics textbook. If we first count a total of 23 pieces and back to 5 pieces then we get the difference as 18 pieces.

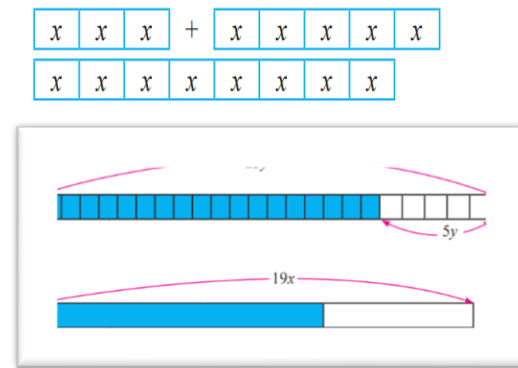


Figure 4: Bar model for algebraic expressions

Furthermore, the algebraic tiles and the models are also used in factorization as well as the multiplication of algebraic expressions (figure 5) as well as factorization. The operation of algebraic expressions can also be visualized by using the bar models.

Since mathematical problem-solving includes knowledge, skill, attitudes, and metacognition, we have to learn all the subject areas of mathematics with meaningful learning (Sharp & Shih Dennis, 2017). All content areas of mathematics at the basic level are crucial for daily life problem-solving. Among them, arithmetic problem-solving is directly linked with the day to day life. The textbooks from the government of Nepal, CDC tried to incorporate different visualized methods of teaching. The model drawing method can be useful not only the arithmetic operations but also in comparison and arrangement (Phillips et al., 2010).

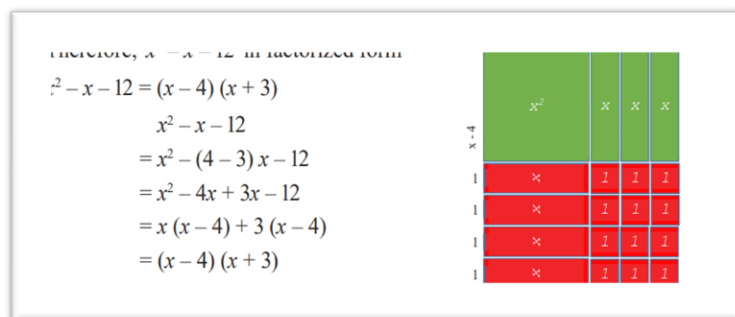


Figure 5: Bar model for factorization

Although the model drawing method can be incorporated into different fields like comparison of numbers, addition, multiplication, subtraction, and division of integers and fractions, the textbook is less focused and incorporates only some parts as alternative methods of solving the problems of related fields. Furthermore, the model drawing method not only helps to develop the conceptual understanding but also helps in developing skills of solving, reasoning, and analyzing the data, it is better to incorporate algebra together with measurement as well as algebra with statistics. I found that in the basic level second stage grade 5 book a few numbers of the algebraic problems are solved by using the model drawing method. It is said that algebra is a generalization of arithmetic and statistics is the application of arithmetic, so it is necessary to incorporate the model drawing method of problem-solving in algebra together with operations and spatial arrangement and calculation (Osman & Mohamad Nasri, 2023).

Since learning of mathematics depends upon the continuous recursion of the task of concept and revision, the presentation of basic concepts helps in the mastery of problem-solving. The spiral way of problem-solving helps to reduce the difficulties of mathematics learning by visualization of mathematical concepts (Phillips et al., 2010). However, the textbook has tried to use the model drawing strategy in basically distinctly in topics. The progressive differentiation and integrative reconciliation promote mathematics learning with a basic understanding of problem-solving with connecting previously learned knowledge with the new knowledge (Roessger et al., 2018).

Mathematics is a technical subject which seeks different skills in students. The student who learn mathematics are expected to think logically and can solve different contextual problems with

innovative and appropriate methods of problem solving. The mathematics writers has been introduced different innovative methods like as structured problem solving, inductive and deductive methods and other cooperative strategies to fulfill the students' needs(CDC, 2021; Kuwar & Acharya, 2024) .

Conclusion

Identifying the status of model drawing in basic-level mathematics textbooks was the primary intention of this research. The model drawing method is important for conceptual development, books are used variously in textbooks. Mathematical concepts are not absolute and distinct within and between the grades and levels. Mostly, the model drawings are used to solve the word problems of comparison, and solving the story problems of basic operation to clarify the conceptual understanding. Although the model drawings are valuable tools for teaching and learning mathematics, there is a need for spiral ways of grade as well as concept-wise teaching and learning. The conceptual understanding, as well as content enrichment in students, will be obtained by using model drawings to introduce the concept, illustration, and problem-solving in all the content areas of mathematics at the basic level. To interconnect content knowledge and pedagogical knowledge the textbooks should incorporate the different problem-solving skills along with the model drawing techniques. The different types of model drawing should be included in textbooks form government as well as private sector those not only developed different conceptual understanding but also helps to mathematize contextual mathematics problems and enhances learners' mathematical thinking more clearly.

References

- Acharya, N. H., Nabaraj, P., Adhikari, J., Dhakal, R., & Yadav, D. (2023). *Mathematics; Grade 5 (First)*. Curriculum Development Center, Government of Nepal, Bhaktapur. <https://moecdc.gov.np/content/121/mathematics-class-5--english-translation/>
- Acharya, N. H., Pokhrel, T. R., & Kunwar, R. (2025). Practices of Mathematization by Basic Level Mathematics Teachers of Nepal. *Education and Development*, 34(1), 71–84. <https://doi.org/10.3126/ed.v34i1.80286>
- Aryal, K. (2021). *A Social History of the Printing Press in Nepal: Struggle and Advances in Breaking the Monopoly of Knowledge*. 156(1), 156–172.
- Badru, A. K. (2008). Effects of team-assisted visual instruction on students' learning outcomes in Mathematics in junior secondary schools. *Post-Field Research Report presented at ICEE. Institute of Education. University of Ibadan. Ibadan.*
- Brown, P. C., Roediger III, H. L., & McDaniel, M. A. (2014). *Make it stick: The science of successful learning*. Harvard University Press.
- CDC. (2021). *National Curriculum Framework* (p. 13). Curriculum Development Center, Government of Nepal, Bhaktapur.
- Cross, C. T., Woods, T. A., & Schweingruber, H. E. (2009). *Mathematics learning in early childhood: Paths toward excellence and equity*. The National Academies Press.
- Curriculum Development Center [CDC]. (2019). *Basic Level Curriculum* (pp. 85–89). Curriculum Development Center, Ministry of Education Science and Technology, Government of Nepal.
- Fan, L. (2013). Textbook research as scientific research: towards a common ground on issues and methods of research on mathematics textbooks. *ZDM*, 45(5), 765–777.
- Fülöp, E. (2015). Teaching problem-solving strategies in mathematics. *LUMAT: International Journal on Math, Science and Technology Education*, 3(1), 37–54.
- Gracin, D. G., & Matic, L. J. (2016). The role of mathematics textbooks in lower secondary education in Croatia: An empirical study. *The Mathematics Educator*, 16(2), 31–58.

- Gradini, E., Noviani, J., & Ulya, K. (2025). Fostering higher-order thinking skills in mathematics education: strategies, challenges, and classroom practices. *Prisma Sains: Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, 13(2), 135–163.
- Jahudin, J., & Siew, N. M. (2024). The Effects of Polya's Problem Solving with Digital Bar Model on the Algebraic Thinking Skills of Seventh Graders. *Problems of Education in the 21st Century*, 82(3), 390–409.
- Kuwar, R., & Acharya, N. H. (2024). Integrated curriculum: concept, characteristics and consideration for planning and designing. *ILAM इलाम*, 20(1), 176–196.
- Morin, L. L., Watson, S. M. R., Hester, P., & Raver, S. (2017). The use of a bar model drawing to teach word problem solving to students with mathematics difficulties. *Learning Disability Quarterly*, 40(2), 91–104.
- Morina, Q. (2022). *Word Problems in Kosova's mathematics Textbooks for Grade 8*. (September). <https://www.researchgate.net/publication/363350549%0AWORD>
- Osman, N. N., & Mohamad Nasri, N. (2023). Mastery Level of Higher – Order Thinking Skills (HOTS) High School Students in Mathematical Learning: Systematic Literature Survey. *International Journal of Academic Research in Progressive Education and Development*, 12(1), 998–1012. <https://doi.org/10.6007/ijarped/v12-i1/15484>
- Özalp, F. A. (2024). *Middle School Mathematics Teachers' Understanding of the Singapore Bar Model Method as a Problem-Solving Heuristic in Algebra Teaching*. Middle East Technical University (Turkey).
- Pakpahan, F. H., & Saragih, M. (2022). Theory Of Cognitive Development By Jean Piaget. *Journal of Applied Linguistics*, 2(2), 55–60. <https://doi.org/10.52622/joal.v2i2.79>
- Palincsar, A. S., & Brown, D. A. (1987). %J J. of learning disabilities. (1987). *Enhancing instructional time through attention to metacognition*. 20(2), 66–75.
- Parker, G. W. (1995). *Structured problem solving*. 139.
- Phillips, L. M., Norris, S. P., & Macnab, J. S. (2010). *Visualization in mathematics, reading and science education* (Vol. 5). Springer Science & Business Media.
- Polya, G. (2004). *How to Solve It: A New Aspect of Mathematical Method (Princeton Science Library) vol. 1*.
- Pozo, A. M. Q., & Espinoza, M. M. G. (2025). The Singapore method as a strategy for improving mathematics learning. *Sinergias Educativas*, 10(3), 76–108.
- Rezat, S., & Straesser, R. (2014). Mathematics textbooks and how they are used. *Master Class in Mathematics Education: International Perspectives on Teaching and Learning*, 51–62.
- Rezat, S., & Sträßer, R. (2015). Methodological issues and challenges in research on mathematics textbooks. *NOMAD Nordic Studies in Mathematics Education*, 20(3–4), 247–266. <https://doi.org/10.7146/nomad.v20i3-4.148710>
- Roessger, K. M., Daley, B. J., & Hafez, D. A. (2018). Effects of teaching concept mapping using practice, feedback, and relational framing. *Learning and Instruction*, 54, 11–21.
- Schmidt, W. H., Zoido, P., & Cogan, L. (2014). *Schooling matters: Opportunity to learn in PISA 2012*. OECD.
- Schoenfeld, A. H. (2016). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics (Reprint). *Journal of Education*, 196(2), 1–38.
- Sharp, E., & Shih Dennis, M. (2017). Model Drawing Strategy for Fraction Word Problem Solving of Fourth-Grade Students With Learning Disabilities. *Remedial and Special Education*, 38(3), 181–192. <https://doi.org/10.1177/0741932516678823>
- Shield, M., & Dole, S. (2013). Assessing the potential of mathematics textbooks to promote deep learning. *Educational Studies in Mathematics*, 82(2), 183–199.

- Sunday, A. S. (2014). Mathematics textbook analysis: A study on recommended mathematics textbooks in school use in southwestern states of Nigeria. *European Scientific Journal*.
- Thiyagu, K. (2013). Effectiveness of Singapore math strategies in learning mathematics among fourth standard students. *Vetric Education, 1*, 1–14.
- Viholainen, A., Partanen, M., Piironen, J., Asikainen, M. A., & Hirvonen, P. E. (2015). *The role of textbooks in Finnish upper secondary school mathematics: theory, examples and exercises*.
- Vygotsky, L. (1978). *Mind in Society: The Development of Higher Psychological Processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press Cambridge, Massachusetts London, England.