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Mathematical Word Problem Solving in Students Elementary School: Is Schema-Based Instruction (SBI) or Cognitive Strategy Instruction (CSI) Used?

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Abstract

The type of problem solving of mathematical words is a mathematical domain that is quite difficult for learners in primary school. This is due to learners are not only adept to the ability of numbers and counting, however, as well as related to the understanding of the text on the word problem. Schema based instruction and cognitive strategy instruction is an explicit instructional approach applied to solving word problems, especially for learners who have difficulty in the area. Both of these instructional approaches are discussed in this article along with examples of problem solving of mathematical words which are the results of previous research by experts.

Keywords: Mathematical word problem solving, schema based instruction, cognitive strategy instruction

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1. Introduction

Mathematical problem solving or mathematical problems is a domain different from others. It is necessary to understand the meaning of words and sentences, in addition to the knowledge of numbers in order to find the appropriate solution. The results showed that in addition to knowledge of numbers and counting, it is necessary to understand the word in word solving text [1, 2].

Students in primary school strengthen the problem-solving skills of mathematical words as a basis for studying algebra in high school [3]. However, the problem solving of words at the school level is also considered difficult by students even for elementary school teachers. Some of the difficulties found are related to understanding the meaning in the story while for teachers have difficulty implementing appropriate word-solving

strategies for learners [4]. Experts based on the research find that some of the factors that cause difficulty solving the problem of mathematical words, those are (1) reading comprehension and spatial ability [5]; (2) mental representation [6]; (3) language skills and numbers [1]"; (4) understanding of the text [7]; (5) difficulty in understanding the unfamiliar context of problems and the use of inappropriate mathematical problem-solving strategies [8]. The use of mathematical word problem solving strategies is an important issue since certain strategies have less dominant characteristics in other strategies. In addition, since the mathematical problem-solving content exists prioritizing the semantic mastery of the text in which case paraphrasing skills are required, so word-solving content also exists in favor of visual and spatial representation capabilities.

Schema-based instruction (SBI) and cognitive strategy instruction (CSI) are two types of explicit instruction and by experts have done much research both on mathematical problem solving [9-11]. These two instructions each has characteristics that contribute to the problem solving of mathematical words. Even though, both have similarities in some respects (to be discussed next).

Below is a brief description of the two explicit instructional approaches commonly applied to solving mathematical word problems.

Table 1: Schema-based instruction and cognitive strategy instruction on word-solving.

Schema based instruction [12, 13]	Cognitive strategy instruction [14, 15]
Explicit instruction provides students to use metacognitive	Explicit instruction approach provides students to use cognitive strategy and self-regulation or metacognitive
FOPS strategy (Find the problem type, Organize the information in the problem using diagram, Plan to solve the problem, Solve the problem)	Solve It Strategy consists of 7 stages (Read, Paraphrase, Visualize, Hypothesize, Estimate, Compute, Check)
Regular strategy	Regular strategy
Developed based on schema theory	Developed based on Vygotsky social development theory

Based on the description in the table 1, in general, schema based instruction and cognitive strategy instruction (solve it) have several similarities. However, both approaches stem from two different theories. Both approaches of instruction cannot be applied to non-routine word problem solving, i.e. no need for cognitive stratification strategy, because it prioritizes visual representation. One of the results of expert research on word problems, [16] found that visual type representation, especially in accurate visual-schematic representation, strongly supports the success of solving word problems in primary school students. Conclusion [16]" explains that the success of solving word problems is by grasping the items and representing visually accurately and spatially,

not how to understand semantically. If it is seen that the type of problem the researcher aimed is non-routine in which the subject represents it visually (externally) and mentally (with and without gesture). One example of word problem according to the researcher that is:: “A ballon first rose 200 meters from the ground, then move 100 meters to the east, then dropped 100 meters. It then traveled 100 meters to the east, and finally dropped straight to the ground. How far was the ballon from its original starting poin?”

Discussion

Solving the problem does not require either a schema based instructional approach and cognitive strategy instruction both of which are routine strategies.

[17] in his research which favored mental representation skills in word-solving problems, also placed an important role in reading comprehension. Experimental study conducted on 80 elementary school students who have low ability and high on the word problem solving. [17]” concluded that reading comprehension should be given during the Realistic Math Education (RME) instruction, both for successful learners and less successful on standardized math tests, but both have low ability to comprehend reading. Furthermore, [17]” recommended instruction that optimizes mental representation and reading comprehension, i.e. schema-based instruction and solve it (cognitive strategy instruction).

The instance of inconsistent word problem: At the grocery store, a bottle of olive oil costs 7 euro. That is 2 euro *more than* at the supermarket. If you need to buy seven bottles of olive oil, how much it will cost at the supermarket?

The example of consistent word problem: At the grocery store, a bottle of olive oil costs 7euro. At the supermarket, a bottle of olive oil costs 2 euro more than at the grocery store. If you need to buy 7 bottles of olive oil, how much will you pay at the supermarket?

The illustration of marked word problem: At the grocery store, a bottle of olive oil costs 7 euro. At the supermarket, a bottle of olive oil costs 2 euro *less than* at the grocery store. If you need to buy seven bottles of olive oil, how much will you pay at the supermarket?

Example of unmarked word problem: At the grocery store, a bottle of olive oil costs 7 euro. That is 2 euro less than at the supermarket. If you need to buy seven bottles of olive oil, how much will it costs at the supermarket?

Based on the example of the word problem, subjects who excelled in word-solving problems in the study [17]” demonstrated a low ability in the text of word problems that contained the feature of a complex language in a semantic (marked inconsistent text); whereas less favorable subjects in word-solving have lower scores on both simple

linguistic semantics (especially in marked and unmarked inconsistencies) and complex word issues. Reading comprehension plays an important role in all types of explicit instruction on solving mathematical problems. Especially for learners who have low ability to solve mathematical problems, then explicit instruction also trains semantic abilities in both simple and complex language.

Discussion

Explicit instruction is the forefront of both a schema-based instructional approach and a cognitive strategy instruction. In the example of the word problem in question the researcher is more emphasis on the semantic aspects of language, than visual. Strategies applied in the research that is, Realistic Math Education instruction approach (RME) is similar to the instruction-based scheme and instruction cognitive strategy. Both are explicit instructional approaches that train reading comprehension while working on solving mathematical word problems.

[18] through his research entitled *The use of bar model drawing to teach word problem solving to students with mathematical difficulties*. This experimental study applies the use of bar drawing model, which is the method of training elementary school students who have difficulty solving the problem of mathematical words. The method is an instruction that combines two explicit instructions and is often used in problem solving words, namely schema based instruction (SBI) and cognitive strategy instruction (CSI). The instructions use four cognitive strategies, namely (1) paraphrasing, for example by rewriting questions in response; (2) visualizing, e.g. constructing a bar model; (3) hypothesizing about problem solutions, i.e. manipulating the model bar; and (4) checking work, i.e. writing the answer in the written answer statement and ensuring it made sense). The results show that the use of bar drawing model is an effective strategy to improve the accuracy of primary school students on problem solving of mathematical words and ability to use cognitive strategies in problem solving. Below is an example of a mathematical problem solving problem used in the study:

> Olivia ate three cookies after lunch and two more cookies after dinner.
>
> How many did she eat all together (addition).
>
> Sam had nine pencils, but he gave two away. How many did he have left? (substraction).
>
> Avery, Jackson, and Hayden each have 32 baseball cards. How many cards do they have in all? (multiplication).

[18]" further explaining that SBI also uses the application of a cognitive strategy at the outset of solving a math word problem, such as restructuring the question being asked into an answer statement and leaving a blank for the answer, supports the student in paraphrasing the problem and thinking about how the problem needs to be answered, structured, organized, and computed. It may train students to thoughtfully form their own procedural foundation for successfully solving the problem.

Discussion

The mathematical problem-solving instruction approach used in the research is to combine schema-based instruction and cognitive strategy instruction. A model bar applied by researchers also adopts the cognitive strategy instruction found in Solve It. Solve It! which consists of 7 routine strategies, and one of them is paraphrase. Paraphrasing on Solve It! used by learners by interpreting the word-solving text using their own language.

2. General Discussion

The explicit instructional approach applied to word-solving is a focused approach for students who are less able or less skilled at solving mathematical problems. Such learners have less efficient knowledge and utilize cognitive knowledge during the work on solving mathematical word problems. For primary school students, one application of cognitive strategy instruction that has been proven through research to improve problem solving skills is Math Scene Investigator (MSI) [19]

Mathematical word problem-solving content types are varied, some are routine so use the cognitive strategy instruction approach. However, there are also non-routine ones which do not require explicit instruction and practice cognitive strategies. This type of word problem puts great emphasis on mental representation with a primary focus on both visual and visual thinking.

3. Conclusion

The schematic-based explicit instructional approach (SBI) and cognitive strategy (CSI) are both applied in solving mathematical word problems in primary schools, especially for learners who have difficulty with word problems. Both of these routine instructions train students to direct cognitive strategies during the work on solving mathematical word problems.

References

[1] Dacrozy, G., Wolska, M., Meurers, W. D., & Nuerk, H. C. Word problems: A review of linguistic and numerical factors contributing to their difficulty. Frontiers in Psychology, 6: 348, (2015). doi: 10.3389/fpsyg.2015.00348.

[2] Tolar, T. D., Fuch, L., Cirino, P., Fuchs, D., Hamlett, C. L., & Fletcher, J. M. Predicting development of mathematical word problem solving across the intermediate grades. Journal of educational psychology, 104(4): 1083-1093, (2012). doi: 10.1037/a0029020. (2012).

[3] Roy, S., & Roth, D. Solving general arithmetic word problems. Proceedings of Conference on Empirical methods in Natural Langiage Processing, 1743-1752, (2015).

[4] Siregar, N. R. Teacher's and students's perception on mathematical word problem solving. (Reports of Survey, not published), (2017).

[5] Boonen, A. J. H., Wesel, F. van., Jolles, J., & Schoot, M. van der. The role of visual representation type, spatial ability, and reading comprehension in word problem solving: an item level analysis in elementary school children. International Journal of Educational Research, 68: 15-26, (2014). https://doi.org/10.1016/j.ijer.2014.08.001.

[6] Thevenot, C. Arithmetic word problem solving: Evidence for the construction of a mental model. Acta Psychologica, 133(1), 90-95, (2010). https://doi.org/10.1016/j.actpsy.2009.10.004.

[7] Fuchs, L. S., Geary, D. C., Compton, D. L., Fuchs, D., Hamlett, C. L., & Seethaler, P. M. Do different types of school mathematics development depend on different constellation of numerical versus general cognitive abilities?. Developmental Psychology, 46(6), 1731-1746, (2010). doi: 10.1037/a0020662.

[8] Seifi, M., Haghverdi, M., & Azizmohamadi, F. Recognition of students' difficulties in solving mathematical word problems from the viewpoint of teachers. Journal of Basic and Applied Scientific Research, 2(3), 2923-2928, (2012).

[9] Griffin, C. C., Gagnon, J. C., Jossi, M. H., Ulrich, T. G., & Myers, J. A. Priming mathematic word problem structures in a rural elementary classroom. Rural Special Education Quarterly, 1-14, (2018). doi: 10.1177/8756876510772164.

[10] Jitendra, A., Dipipi, C. M., & Perron – Jones, N. An exploratory study of schema-based word problem solving instruction for middle school student with learning disabilities. An emphasis on conceptual and procedural understanding. The Journal of Special Education, 6(1), 23-38, (2002). https://doi.org/10.1177/00224669020360010301.

[11] Zhu, N. Cognitive strategy instruction for mathematical word problem-solving of students with mathematics disabilities in China. International Journal of Disability,

Development and Education, (2015). https://doi.org/10.1080/1034912X.1077935.

[12] Jitendra, Asha K., and Jon R. Star. 2011. Meeting the needs of students with learning disabilities in inclusive mathematics classrooms: The role of the schema-based instruction on mathematical problem-solving. Theory Into Practice, 50, no. 1: 1219.

[13] Jitendra, A. K., Rodriguez, M., Kanive, R., Huang, J-P., Church, C., Coroy, K. A., & Zaslofsky, A. Impact of small group tutoring interventions on the mathematical problem solving and achievement of third grade students with mathematical difficulties. Learning Disability Quarterly, 36(1): 21-35, (2013). doi: 10.1177/0731948712457561.

[14] Krawec, J., & Montague, M. Cognitive strategy instruction. Current Practice Alerts, 19, 1–4, (2012). Retrieved from http://TeachingLD.org/Alerts/

[15] Montaque, M., Krawec, J., Enders, C., & Dietz, S. The effects of cognitive strategy instruction on math problem solving of middle-school students of varying ability. Journal of Educational Psychology, 106(2): 469-481, (2013). doi: 10.1037/a0035176

[16] Boonen, A. J. H., Wesel, F. van., Jolles, J., & Schoot, M. van der. The role of visual representation type, spatial ability, and reading comprehension in word problem solving: an item level analysis in elementary school children. International Journal of Educational Research, 68: 15-26, (2014). https://doi.org/10.1016/j.ijer.2014.08.001.

[17] Boonen, A. J. H., de Koning, B. B., Jolles, J., & van der Schoot, M. Word Problem Solving in Contemporary Math Education: A Plea for Reading Comprehension Skills Training. *Frontiers in Psychology*, *7*, 191, (2016). http://doi.org/10.3389/fpsyg.2016.00191

[18] Morin, L. L., Watson, S. M. R., Hester, P., & Raver, S. The use of a bar model drawing to teach word problem solving to students with mathematics difficulties. Learning Disability Quarterly, 40(2), 91-104, (2017). https://doi.org/10.1177/0731948717690116.

[19] Pfannenstiel, K. H., Bryant, D. P., Bryant, B. R., & Porterfield, J. A. Cognitive strategy instruction for teaching word problems to primary – level struggling students. Intervention in School and Clinic, 50(5), 291-296, (2015). doi: 10.1177/1053451214560890.