How to cite this paper:

Namirah Fatmanissa & Kusnandi (2017). The linguistic challenges of Mathematics word problems: A research and literature review. *Malaysian Journal of Learning and Instruction (MJLI), Special issue on Graduate Students Research on Education*, 73-92.

THE LINGUISTIC CHALLENGES OF MATHEMATICS WORD PROBLEMS: A RESEARCH AND LITERATURE REVIEW

[1]Namirah Fatmanissa & [2]Kusnandi
Faculty of Mathematics and Science Education
Universitas Pendidikan Indonesia, Indonesia

[1]Corresponding author: namirahf@student.upi.edu

ABSTRACT

Purpose – Word problems are still considered challenging for students when compared to other type of mathematics problems. Many emerging findings regarding this issue highlight that the challenges are predominately caused by linguistic aspects. This article aims to present a review and synthesis of literatures regarding the linguistic challenges of mathematics word problems and recommend solutions to address these challenges.

Methodology – Systematic search was done and 35 articles from inside and outside Indonesia were selected. The linguistic challenges and recommended solutions found were analyzed using the main features constructing mathematics language: multiple semiotic system, particular features of vocabulary and grammar, and complex syntax.

Findings – The review shows various difficulties shown by students in each feature of mathematics language. The review also recommends the practice of mathematics teaching and learning in which language aspects are discussed and exercised both among students and between the students and the teacher in order to help students face their

linguistics challenges. It is also imperative for teachers to understand the structure and linguistic features involved in constructing word problems.

Significance – This review breaks down the difficulties of mathematics word problems from the perspective of linguistic features constructing them. The findings of this review offer teachers different point of view to deal with teaching word problems, which is by understanding word problem as an entity of language rather than only as an entity of mathematics. This review also provides some solutions to help teachers address the difficulty for each linguistic feature.

Keywords: mathematics, word problems, linguistic challenge.

THE LINGUISTIC CHALLENGES OF MATHEMATICS WORD PROBLEMS: A RESEARCH AND LITERATURE REVIEW

[1]Namirah Fatmanissa & [2]Kusnandi
Faculty of Mathematics and Science Education
Universitas Pendidikan Indonesia, Indonesia

[1]Corresponding author: namirahf@student.upi.edu

ABSTRACT

Purpose – Word problems are still considered challenging for students when compared to other type of mathematics problems. Many emerging findings regarding this issue highlight that the challenges are predominately caused by linguistic aspects. This article aims to present a review and synthesis of literatures regarding the linguistic challenges of mathematics word problems and recommend solutions to address these challenges.

Methodology – Systematic search was done and 35 articles from inside and outside Indonesia were selected. The linguistic challenges and recommended solutions found were analyzed using the main features constructing mathematics language: multiple semiotic system, particular features of vocabulary and grammar, and complex syntax.

Findings – The review shows various difficulties shown by students in each feature of mathematics language. The review also recommends the practice of mathematics teaching and learning in which language aspects are discussed and exercised both among students and between the students and the teacher in order to help students face their linguistics challenges. It is also imperative for teachers to understand the structure and linguistic features involved in constructing word problems.

Significance – This review breaks down the difficulties of mathematics word problems from the perspective of linguistic features constructing them. The findings of this review offer teachers

different point of view to deal with teaching word problems, which is by understanding word problem as an entity of language rather than only as an entity of mathematics. This review also provides some solutions to help teachers address the difficulty for each linguistic feature.

Keywords: mathematics, word problems, linguistic challenge.

INTRODUCTION

In Indonesia, many findings have shown that word problems are considered a difficult type of problem compared to other types of problems in mathematics. Some were evidenced through the low performance of students in solving word problems (e.g. Huda & Kencana, 2013; Rindyana & Chandra, 2012; Sutarni, 2011). Some others were shown through survey conducted by PPPPTK for Mathematics, Center for the development and empowerment of teachers and educational staff in Indonesia, which stated that over 50% of Indonesian teachers had complaints about the difficulties of students in solving word problems (Raharjo, 2008).

Like adding fuel to the fire of the difficulty, word problems are a part of the Indonesian National exam and several international tests such as PISA and TIMSS. In TIMSS, solving problems in context is one of the domains assessed (Martin & Mullis, 2013). In PISA mathematics framework, domains such as solving problems set in a context and formulating situations mathematically are expressed through word problems (OECD, 2013). In National examination, word problems are found, too. Based on 2014 National examination report by the Education Assessment Center (*Pusat Penilaian Pendidikan*), word problems were included in national examination and categorized as a "good" question, one level above "fair" in terms of difficulty (Badan Nasional Standar Pendidikan, 2014). The existence of word problems in several testing platforms should be paid careful attention.

The existence of word problems in these tests is actually in line with Indonesian content standard (*Standar Isi*) no. 21 as stated in the regulation of Ministry of Education and Culture (*Permendikbud*) as part of the new 2013 curriculum (Kemendikbud, 2016). It is stated

that students should be able to identify whole or partial information from daily life problems (p.112) and use strategies to solve daily life problems (p.114).

Encouraged by its difficulties, its existence in high-stake tests, or the statement of government regulation, several studies of teaching word problem have been conducted in Indonesia (e.g. Junaidah, 2016; Marlina, 2013; Poerwanti, 2014; Raharjo, 2008; Sutarni, 2011). However these studies focused on investigating the effect of a particular strategy or media to improve students' ability in solving word problems, examples of which include: mind-mapping (Sutarni, 2011), Polya steps (Marlina, 2013), Think-talk-write strategy (Poerwanti, 2014), and Problem-posing strategy (Junaidah, 2016). Most of them are studies driven by linguistic difficulties experienced by students in solving word problems, yet they rarely addressed this specific difficulty through the media or strategy but rather addressed the improvement of students' solving ability.

Some other studies focus on the analysis of errors or difficulties faced by students during word problems solving (e.g. Huda & Kencana, 2013; Mulyadi, Riyadi, & Subanti, 2015; Rindyana & Chandra, 2012). Interestingly, those studies maintained that the difficulties caused by linguistic aspects were predominant. However, they discussed this dominant difficulty in a "fair" portion with other difficulties regardless of its great frequency in being experienced by students, and do not propose any solution specific to linguistic difficulty.

On the other hand, several studies outside Indonesia reported difficulties in understanding word problems and they highlighted the difficulties caused by linguistic aspects. The linguistic difficulties were varied, for example, difficulty in identifying key words, identifying irrelevant information, defining vocabularies, analyzing lengthy sentences, and understanding written context (Gafoor & Sarabi, 2015; Seifi, Haghverdi, & Azizmohamadi, 2012).

Taking those into account, it is imperative to understand the linguistic challenges as challenges made by the language characteristics of word problems and thus the exploration of this language aspect will help us to suggest solutions that are closer to the targeted problems. Understanding linguistic aspects of word problems leads

to the understanding of helping students facing their challenges of it. The purpose of this article is to review and synthesize literature regarding the linguistic challenges of mathematics word problems and then recommend solutions based on those.

THEORETICAL FRAMEWORK

Word problems are simply problems situated in a real life context (Verschaffel, Van Dooren, Greer, & Mukhopadhyay, 2010); it is this characteristic that differentiates them from other types of problems. This context requires students to read and understand in order to solve the problem while at the same time incorporate their mathematical understanding. As word problems are not given in a "plain" mathematical expression, they require complex steps to solve (i.e. reading, comprehending, transforming into mathematical expression, processing the mathematics, interpreting result to context given, and evaluating the result) (Reys, Lindquist, Lambdin, & Smith, 2008; Ryan & Williams, 2007; Verschaffel et al., 2010). Despite their real life context, the context of word problems is "situated" or encoded into syntax and diction familiar to mathematics (Reed, 1999). The role of students in reading and comprehending the words in word problems thus are affected by this mathematically-situated context.

Regarding this mathematically-situated context, O'Halloran (2005) added that word problem was constructed by its own language system. This language system organizes choices of language function, mathematical symbol, and visual display. Failure in understanding this system will lead to failure in understanding word problems due to its linguistic features. Thus, in order to address linguistic difficulties in solving word problems, it is appropriate to explore linguistics features constructing them. Literatures have described several linguistic features or aspects that construct mathematics language. The work of Schleppegrell (2007) and O'Halloran (1998, 2005) provided a thorough exploration of linguistic features of mathematics language. The works used linguistics perspective to elaborate the system and categorize the features of mathematical discourse. They formulated three main features of mathematical discourse i.e. multiple semiotic systems, vocabulary, and grammar and syntax. In accordance with them, the work of Lee (2005)

highlighted the features of mathematics language specifically for assessment and instructions. The work mentioned the naming power, a power of particular word or phrase to awaken related concepts in mind, besides vocabulary and syntax as the main features of mathematical language. Although these studies categorized mathematical language into three similar features, Lee focused more on the role of word and syntax while the first two did more on multiple semiotic systems feature. Abedi and Lord (2001) added more by focusing on the use of mathematics language especially in written tests, including word problems. This work contributed to the feature of written instructional language inside word problems. All these references complete each other and are used to give the most accurate picture of linguistic difficulties in mathematics word problems.

Table 1

Linguistic Features of Mathematics Language

Feature	Sub-feature
Multiple semiotic system	Symbol Oral language Written language Graphs and visual
Vocabulary	Same meaning words Math-specific words (technical words) Different meaning words
Grammar & complex syntax	Metaphorical (implicit) meaning Dense noun phrases Passive voice Conditional clauses Relative clause

Table 1 summarizes features, together with sub-features of each, based on the work of Schleppegrell (2007), O'Halloran (1998, 2005), Lee (2005), and Abedi and Lord (2001). The features shown in Table 1 are used to present this review by classifying challenges found in the literature based on linguistic feature contained in them. The detailed explanation of each feature is presented together with the findings of challenges to give better picture of how the feature related to the challenge.

METHODOLOGY

A systematic literature search was done for articles and other published sources (books and textbooks) on word problems in the field of mathematics education inside and outside Indonesia. Although the concern of this study was the difficulties faced by Indonesian students, it is still relevant to also take lesson from studies done outside Indonesia regarding linguistic challenges of mathematics word problems. The difference of language as the setting of word problems was discussed and analyzed respect to the context of Indonesian language using Kridalaksana (1986) and Purwo (1984).

The search term "word problem" was used in combination with one or more of the following terms: mathematics, challenge, difficulty, language, register, error, vocabulary, discourse, and analysis. The search terms included the Indonesian translations of those. Google scholar, ERIC, Academic full text were searched for articles and published sources.

To be included into the review, the articles and sources should be available fully for reading, means articles should be available in full text (and peer-reviewed) and written sources should be published (for books). After being collected, the sources were coded based on the linguistic aspects given in Table 1. Sources with more than one code were given multiple codes to expand understanding on challenges found.

RESULTS AND DISCUSSION

After reading the titles, abstracts and the full papers, the articles were narrowed down to 35 research and review articles. Next, the researcher coded each article using the code given in Table 1 and organized it in the Excel spreadsheet. The thorough reading and analysis were done in order to code each article into an appropriate code. The studies analyzed were conducted either in Indonesia ($n = 16$) or outside Indonesia ($n = 16$), and some others are review ($n = 3$). The publication year span from before 2000 until present. The word problems given in the studies were varied from arithmetic, algebra, geometry, and probability, but mostly were combination of those topics. The details can be seen in Table 2.

The research and review focus and article's code based on its linguistic challenge were recorded in Table 3. Articles with more than one appropriate code were included to each code, thus the sum of the numbers did not add up to 35.

Table 2

Numerical Data on Studies Collected

Research setting & number of reviews	Number of studies
Indonesia	16
Outside Indonesia	16
*Review	3
Publication Year	Number of studies
Before 2000	2
2000-2005	5
2005-2010	5
2010-present	23
Topic of Mathematics	Number of studies
Combination of several math topics	20
Arithmetic	5
Algebra	3
Geometry	6
Probability	1

Table 3

Focus and Code of Articles Collected

Research & review focus	Number of studies	Linguistic Challenge	Number of studies
Linguistics aspects of Mathematics	6	Multiple Semiotic System	14
Error analysis of students' work	10	Vocabulary and Grammar	10
Strategy to improve word problem solving ability	7	Complex Syntax	10
Others	12	Others	3

The role of books was to complete the analysis of linguistic challenges for theoretical analysis, while the articles were for empirical analysis. Explaining each linguistic feature (i.e. multiple semiotic systems, vocabulary, grammar, and complex syntax) together with sources correspond to it, then constructing recommended solutions for linguistic challenges of word problems were the purposes of the following sections.

Multiple Semiotic Systems

The meaning of multiple semiotic systems in mathematics word problems can be described as follow.

> The discourse in mathematics word problems is constructed by language, mathematical symbol, and visual representation. … The functions of language, the symbolism and the visual image may be summarized as follows. Patterns of relations are encoded and rearranged symbolically for the solution to the problem. The symbolism has limited functionality, however, so that language functions as the meta-discourse to contextualize the problem, to explain the activity sequence which is undertaken for the solution to the mathematics problem, and to discuss the implications of the results which are established. Visual images in the form of abstract and statistical graphs, geometrical diagrams, and other types of diagrams and forms of visual display, such as those generated through computer graphics, show the relations in a spatio-temporal format which involve multi-dimensional time-frames (O'Halloran, 2005, p. 158).

The intertwining function of these three elements, i.e. language, mathematical symbol, and visual representation, creates multiple semiotic systems. For example in a word problem explaining a height of an arrow shot vertically into the air with a given function of $s(t) = -16t^2 + 80t$, t is the time in seconds (O'Halloran, 1998). To understand the problem completely, the student has to understand that the symbolism given, $s(t) = -16t^2 + 80t$, can have the same meaning in its visual representation as a curve and also can have the same meaning in an explanation using language regarding the

movement of the arrow. Therefore, to understand word problems, students have to understand how symbols, language, and visual representations create meaning.

Several studies have been conducted on the existence of multiple semiotic systems affecting students' understanding of word problems. In algebra, Agustiawan, Uno, and Ismail (2013) found that 41% of participants fail to solve word problems due to factual error, or error in understanding what was actually given in the text. Ulu (2017) found similar challenge in his study that the participants failed to correctly interpret the meaning of number operator symbol. Interestingly, in this study when a student was given a word problem "In a farm with chickens and rabbits, there are 12 heads and 30 feet. How many rabbits are there in the farm?" A student was interviewed about his work of simply multiplying 12 by 30. When questioned why he made such step, it was just because it made sense. After deep interview, it was revealed that the student simply multiplied, added, and subtracted numbers without understanding why. The failure to relate the mathematical operator into its language or visual meaning is seen here.

The misinterpretation of symbol and visual image is also found in geometry. Huda and Kencana (2013), pointed out the challenge of understanding the meaning of cube and cuboid image and how it was translated into other representations such as symbol. The challenge due to multiple semiotic systems in geometry was also highlighted by Putra, Jaeng, and Sukayasa (2016). They found that it was difficult for students to transfer language into its geometric visual representation. Both studies in geometry hinted towards a low spatial ability of students, thus resulting in the difficulties in completely understanding the meaning of three semiotic elements.

In order to face the challenge of multiple semiotic systems, students' ability in each element should be fostered. As mentioned before, since the challenge of multiple semiotic systems lies in the intertwining functions of each element constructing mathematical discourse, it is imperative to allocate more time in class to discuss those elements with regards to given word problem. Hutahean, Sutawidjaja, and Susanto (2016) used Think-Pair-Share strategy to help students. Think-pair-share is a strategy in which students are given more time to think by themselves about word problem

without asking anyone. After a given time, students are allowed to ask or discuss the problem in pairs and finish the problem. The help from others is given only after "think" time. This allows students to really have time to read the problem and make sense of its possible meaning. Although challenge due to multiple semiotic systems is not directly addressed by giving more reading time, at least students are supported to exercise their reading and meaning-making skills.
Another strategy was shown by Sutarni (2011) by using mind-map. Sutarni made her students create mind-map for every word problem given. In her study, she gave students problem:

> Pak Beni membeli sepeda motor seharga Rp 12.000.000,00 setelah diperbaiki dengan menghabiskan biaya Rp 750.000,00 Pak Beni ingin menjualnya, dan Pak Beni ingin mendapat untung 22.5% walaupun secara diangsur dalam 1 tahun oleh pembelinya. Berapa Pak Beni menjual motornya? Berapa angsuran tiap bulan yang harus dibayarkan pembeli motor itu? (Sutarni, 2011, p. 28)
>
> (Mr. Beni buys a 12,000,000 rupiahs motorcycle. He repairs this motorcycle with the cost of 750,000 rupiahs. Mr Beni wants to sell this motorcycle and he wants to get 22.5% profit although being paid in credit per month for a year. How much is the selling price of the motorcycle? How much money should be paid each month by the buyer? [rupiah is Indonesian currency]).

Figure 1 shows the sample of student's mind-map. It is important to note that the mind-map was not only intended for students to translate the language to a visual representation of it, but also helped students to construct several equivalent meanings of information given. The main information; "Mr. Beni buys a 12,000,000 rupiahs motorcycle", which means that the purchasing price (*harga pembelian*) of the motorcycle is Rp 12,000,000; was put as the center of the mind-map (as seen in Figure 1). In the four branches of the picture, all the information was gathered from the problem including selling (*penjualan*), repairing (*perbaikan*), and profit (*laba*). The mind-map, with information gathered in it, becomes a tool to show all equivalent representations of the word problem. This mind-mapping activity is able to make students exercise their skill in making meaning from information given.

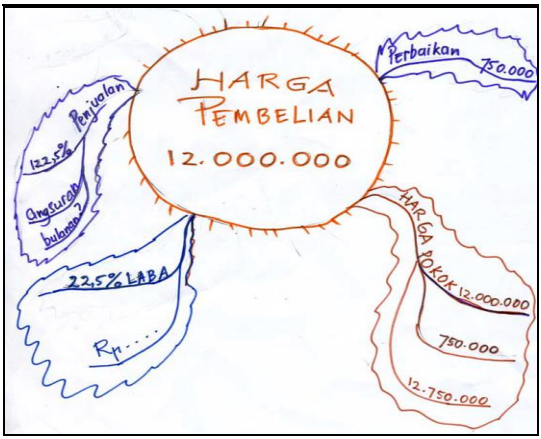

Figure 1. Example of a mind-map (Sutarni, 2011, p.29)**.**

A similar practice was recommended by Powell (2011) using schema. Figure 2 shows a sample of schema using vertical lines to classify information given in the word problem of "Maya wants to buy two bags of pencils for $3 each, four notebooks for $2 each, and six folders for $1 each. How much will Maya spend?". This schema helps students to interpret language into arithmetic symbol and thus create solution.

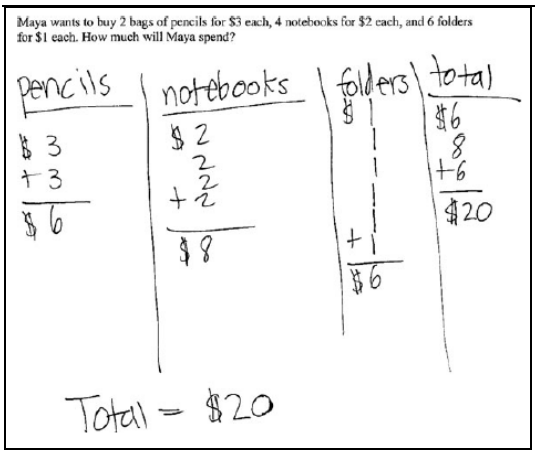

Figure 2. Example a schema (Powell, 2011, p. 102)**.**

Vocabulary

Mathematics discourses, and thus word problems, have specific vocabulary. Lee (2005) mentioned the classification of these vocabularies as same-meaning words, math-specific words (technical words), and different meaning words. Same meaning words are words whose meaning in real life and mathematics is the same. For example *panjang* in both Indonesian daily language and mathematical language has meaning of length or being long. Some other words are specific or technical words only exist in mathematics. For example *koefisien* (coefficient) and *hipotenusa* (hypothenuse) only exist in mathematics language, they are not used in daily Indonesian language conversation. The last type of words is words that are used in both daily conversation and mathematics discourse but have different meaning in each. For example *fungsi* (function) is used in both daily conversation and mathematics, but in Indonesian daily conversation it means the use or function, while in mathematics it means a mapping of a set to another. *Ganjil* in daily Indonesian language means strange or odd while in mathematics it means "not even", or a number that is not a multiplication of two.

The understanding of the meaning of vocabulary as it exists in mathematics word problems is an important point of attention. Some studies (Rindyana & Chandra, 2012; Seifi et al., 2012) found that students failed to solve word problems because they could not define the vocabulary in it. The word problems in these studies were given in students' mother language thus the challenge is not due to translation, but due to how students make meaning from vocabulary. Interestingly, some studies showed how students even neglected the meaning of vocabulary in word problem. This issue was addressed in the study by Verschaffel, Greer, and de Corte (2000) and Verschaffel et al. (2010). When given a word problem, students are more likely to pay attention to only the numbers or symbols rather than the vocabulary. An extreme example was students came up with a numerical answer when given the problem "There are 13 boys and 15 girls in a class. How old is the teacher?". This shows that to vocabulary, students still have lack attention, let alone make meaning from it.

Riccomini, Smith, Hughes, and Fries (2015) suggested a possible strategy to make students exercise their vocabulary in mathematics word problems. The strategy, called vocabulary teaching, used explicit vocabulary instruction, mnemonic strategies, and multiple

exposures on vocabulary, game-like activities, and technological applications to promote mathematical vocabulary. For example, a mnemonic strategy to introduce term "parallel lines" is to associate the phrase "parallel lines" with a "pair of elves" who cannot intersect (see Figure 2). This mnemonic strategy helped students understand the concept of parallel lines in an interesting and memorable fashion. The strategy is not new in and of itself, yet it was sometimes not utilized by teachers due to technicalities (lack of time, no proper training, etc) regardless its effectiveness.

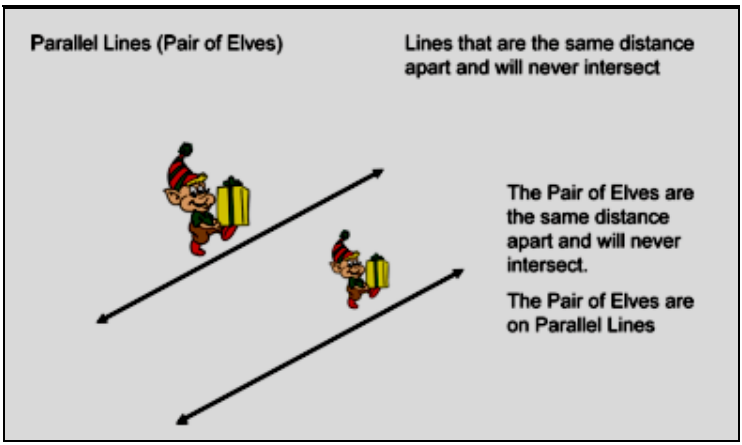

Figure 2. Example of mnemonic strategy (Riccomini et al., 2015, p. 243)**.**

In relation to multiple semiotic systems, the challenge created by characteristics of mathematic vocabulary is in understanding each term independently, regardless of the sentence in which it is put, while in multiple semiotic systems, the challenge is in how students can relate the meaning of a representation (be it language, symbols, or visual representation) to another. It should be understood that the challenges created by the two can be seen as both separated and inter-related at the same time, when considering linguistic challenges in mathematics word problems.

Grammar and Complex Syntax

Mathematical discourse also has its own grammar system, a system of rules of words, phrase, and clauses structure in a text;

and syntax, study of construction of a sentence. Mathematical word problems sometimes are constructed without personal reference and use passive voice (Lee, 2005). Typical word problem for the area and perimeter of a rectangle showed the complexity of syntax in Indonesian word problem: "Seorang petani mempunyai sebidang tanah berbentuk persegi panjang. Lebar tanah tersebut 6 meter lebih pendek daripada panjangnya. Jika keliling tanah 60 meter, tentukan luas tanah petani tersebut" (Rahmania & Rahmawati, 2016, p. 169). (A farmer has a rectangular land. The width of the land is 6 meters shorter than the length. If the perimeter of the land is 60 meter, determine the area of the land.)

The sentence "*Lebar tanah tersebut 6 meter lebih pendek daripada panjangnya*" (The width of the land is 6 meters shorter than the length) is constructed to give the meaning that the length is longer than the width, however since the word "*lebih pendek*" (shorter) is given after the word "*lebar*" (width), students tend to understand this as width subtracted by 6 is the length. This error is indeed due to the syntax of the problem.

Some studies have shown that the more complex the syntax of the word problems, the more difficult they are to understand. Martiniello (2008) compared the work of students with similar mathematical ability on two word problems, one with more syntax complexity than the other. The result was that the problem with more complex syntax was more difficult to solve. Sumarwati, Subroto, Pujosudarmo, and Nurkamto (2014) supported the idea with a different study. By comparing Indonesian elementary school textbooks across grade levels, they found that as the grade level increased, the syntax was more complex, and students were less interested in solving the word problem as it got harder to comprehend. The phrases became denser as conjunctions were omitted, the sentence shortened, and personal reference decreased e.g. "*usianya setengah usia Ani*" (his/her age is half of Ani's age) is more complex than "*usia Indah adalah setengah dari usia Ani*" (Indah's age is half of Ani's age). In this case, the word *Indah* in the second sentence, which works as a personal reference, is changed into a pronoun "*-nya"* in *usianya*; and *dari* as a conjunction in the second sentence is omitted.

As challenges due to grammar and complex syntax demands comprehension of the whole text of word problems rather than a part

of the information, the strategy suggested to face it is related more closely to the way the word problem is delivered and discussed. Wijaya (2015) recommended a consultative teaching approach, an approach with more consultation and dialogue time. This study recommends that teachers should believe that investing time in discussion between teacher and students and among students is necessary. This study shows that many teachers habitually explain word problems directly without even giving students time to read, explain the word problem without giving students chance to think about it first, or give specific instruction regardless the context given in the problem. Consultative teaching approach is the exact opposite of those, and is proven to be effective in helping students face problems with complex syntax. Similar to the think-pair-share strategy mentioned before, the Think-talk-write strategy also had been proven successful in helping students facing problems with complex syntax (Poerwanti, 2014) as it facilitates students to talk or discuss more and write the information obtained from the word problem accordingly.

The linguistic challenges investigated from three features of mathematical language i.e multiple semiotic systems, vocabulary, and grammar and complex syntax are the main focus of this article. However, it cannot be denied that other stream of investigations are appropriate to be included to give better and thorough understanding of the challenges. The work of Wijaya, van den Heuvel-Panhuizen, and Doorman (2015) focused on teachers' belief and how it affected the way they teach word problems. The study revealed that most Indonesian teachers believed that giving specific instruction to solve word problems is the most important thing in helping students solve word problems. This is reflected in the class when the teacher mostly provides easy word problems even with specific additional instruction to solve it. Teachers' belief that word problem should be discussed as an abject of language is still lacking.

Another finding related to linguistic challenges of word problems is that it is very important for teachers to understand the structure of word problems and how they are constructed. The study of Roche reported the types of word problems based on how they were constructed and how they should be understood by teachers (Roche, 2013). By understanding the types of word problem, teachers can avoid giving inappropriate instructions or even make their own word

problem correctly. Supporting this idea, Adams (2003) highlighted the teaching skill of making students read mathematics both its words and its symbols. The study recommended teachers to thoroughly prepare the lesson not only in terms of mathematical procedures but also terms, symbols, and language that would be used in it. The discussion that happens in the word problem session should not only focus on the word problem itself translated to mathematical symbols, but also on the reading of the symbols obtained.

CONCLUSION

Linguistic challenges of word problems are still an urgent matter to investigate. The trends of investigating word problems teaching through only experimenting with a strategy has been proven to be insufficient. Word problems are an entity of both mathematics and language. Understanding that word problems are constructed by multiple semiotic systems, vocabulary, grammar and complex syntax can help teachers and students deal with the challenges associated with word problems. The three features are not to be separated as they construct word problems side-by-side and thus they make them unique.

In dealing with mathematical word problems, teachers should understand word problems not only as a part of a mathematical test or task, but also as a language object that should be addressed from perspectives other than simply mathematical operations. By using this idea as the underlying framework, teacher may construct their own way to help students face their linguistic difficulties, for example by allocating more time and effort to help students exercise their reading and meaning-making skill as it has been proven to be a useful practice.

It is not claimed that all studies related to linguistic challenges of word problems are included in this article. Although the time frame of the included studies was long enough, from 1998 to 2017, the number of selected studies was quite limited, adjusting to the sources eligibility and online databases accessibility. Thus, the number of selected studies might be bigger, if the search was not limited to three online databases mentioned earlier or to the mentioned keywords only. Besides, the participants of the included studies were mostly

high school students. The included studies could be more diversified by including more studies with younger participants as it might be a meaningful information to learn about the linguistic difficulties of younger students.

Especially in the context of Indonesian language, the number of studies that investigated linguistic difficulties in mathematics word problem are still limited. Future studies could explore more about each feature constructing word problem and observe its trace in Indonesian students' word problem solving activity. Additionally, as some included studies in this article explore mathematics word problem solving of bilingual students, future research might also specifically address this issue in Indonesian student context.

Regardless its limitations, this article has tried to address linguistics challenges as much as possible. The article has tried to illustrate these issues in Indonesian context and discuss them together with other supporting ideas. It is believed that this article will help to emphasize the importance of investigating word problems in the context of Indonesian language and thus deepen the understanding of its challenges especially in the context of Indonesian education.

REFERENCES

Abedi, J., & Lord, C. (2001). The Language factor in mathematics tests. *Applied Measurement in Education, 14*(3), 219-234.

Adams, T. L. (2003). Reading mathematics: More than words can say. *The Reading Teacher*, *56*(8), 786-795.

Agustiawan, R., Uno, H. B., & Ismail, Y. (2013). Analisis kesalahan matematika siswa dalam menyelesaikan soal cerita pada pembelajaran sistem persamaan linier dua variabel. *KIM Fakultas Matematika dan IPA*, *1*(1).

Badan Nasional Standar Pendidikan. (2014). *Laporan hasil ujian nasional 2014*. Jakarta: Kemdikbud

Gafoor, K. A., & Sarabi, M. K. (2015). Relating difficulty in school mathematics to nature of mathematics: Perception of high school students from Kerala. *Proceedings of National Conference on Mathematics Teaching- Approaches and Challenges. Regional Institute of Education, Mysuru.*

Huda, N., & Kencana, A. G. (2013). Analisis kesulitan siswa berdasarkan kemampuan pemahaman dalam menyelesaikan soal cerita pada materi kubus dan balok di kelas VIII SMP Negeri 30 Muaro Jambi. *Prosiding SEMIRATA 2013*, *1*(1).

Hutahaean, L. G. D., Sutawidjaja, A., & Susanto, H. (2016). Upaya meningkatkan kemampuan siswa dalam menyelesaikan soal cerita melalui pembelajaran think pair share (TPS). *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *1*(4), 608-616.

Junaidah, M. S. (2016). Penerapan model pembelajaran problem posing tipe pre-solution posing untuk meningkatkan keterampilan menyelesaikan soal cerita tentang bangun datar dan bangun ruang. *Jurnal Didaktika Dwija Indria (Solo)*, *4*(8).

Kridalaksana, H. (1986). *Kelas kata dalam bahasa Indonesia*. Jakarta: Gramedia Pustaka Utama.

Lee, C. (2005). Language for learning mathematics: Assessment for learning in practice. New York: Open University Press.

Marlina, L. (2013). Penerapan langkah Polya dalam Menyelesaikan soal cerita keliling dan luas persegi panjang. *Jurnal Elektronik Pendidikan Matematika Tadulako*, *1*(1), 1-10.

Martin, M. O., & Mullis, I. V. (2013). TIMSS and PIRLS 2011: Relationships among reading, mathematics, and science achievement at the fourth grade - Implications for early learning. Boston: IEA.

Martiniello, M. (2008). Language and the performance of English-language learners in math word problems. *Harvard Educational Review*, *78*(2), 333-368.

Mulyadi, Riyadi, & Subanti, S. (2015). Analisis kesalahan dalam menyelesaikan soal cerita pada materi luas permukaan bangun ruang berdasarkan Newman's Error Analysis (NEA) ditinjau dari kemampuan spasial. *Jurnal Elektronik Pembelajaran Matematika, 3*(4), 370-382.

OECD. (2013). *PISA 2012 Assessment and analytical framework: mathematics, reading, science, problem solving and financial literacy*. OECD Publishing

O'Halloran, K. L. (1998). Classroom discourse in mathematics: A multisemiotic analysis. *Linguistics and Education*, *10*(3), 359-388.

O'Halloran, K. L. (2005). Mathematical discourse: Language, symbolism and visual images. London: A&C Black.

Poerwanti, J. I. (2015). Penerapan strategi pembelajaran Think-Talk-Write (TTW) untuk meningkatkan keterampilan menyelesaikan soal cerita pecahan. *Jurnal Didaktika Dwija Indria (Solo)*, *3*(8), 1-7.

Powell, S. R. (2011). Solving word problems using schemas: A review of the literature. *Learning Disabilities Research & Practice*, *26*(2), 94-108.

Purwo, B. K. (1984). *Deiksis dalam bahasa Indonesia*. PT Balai Pustaka (Persero).

Putra, M. A. A., Jaeng, M., & Sukayasa, S. (2016). Analisis kesalahan siswa kelas VII SMP Al-Azhar Mandiri Palu dalam menyelesaikan soal cerita pada materi luas dan keliling bangun datar. *Jurnal Elektronik Pendidikan Matematika Tadulako*, *3*(3), 1-14.

Raharjo, M. (2008). Pembelajaran soal cerita berkait penjumlahan dan pengurangan di SD. Yogyakarta: PPPPTK Matematika.

Rahmania, L., & Rahmawati, A. (2016). Analisis kesalahan siswa dalam menyelesaikan soal cerita persamaan linier satu variabel. *JMPM: Jurnal Matematika dan Pendidikan Matematika*, *1*(2), 165-174.

Reed, S. (1999). Word Problems: Research and Curriculum Reform. London: Routledge.

Regulation of Ministry of Education and Culture (Permendikbud) no. 21 2016 about content standard.

Reys, R., Lindquist, M.. M., Lambdin, D.V., & Smith, N.L. (2008). *Helping Children Learn Mathematics.* New Jersey: John Wiley and Sons.

Riccomini, P. J., Smith, G. W., Hughes, E. M., & Fries, K. M. (2015). The language of mathematics: The importance of teaching and learning mathematical vocabulary. *Reading & Writing Quarterly*, *31*(3), 235-252.

Rindyana, B. S. B., & Chandra, T. D. (2012). Analisis kesalahan siswa dalam menyelesaikan soal cerita matematika materi sistem persamaan linear dua variabel berdasarkan analisis Newman (Studi Kasus MAN Malang 2 Batu). *Artikel Ilmiah Universitas Negeri Malang*.

Roche, A. (2013). Choosing, creating and using story problems: Some helpful hints. *Australian Primary Mathematics Classroom*, *18*(1), 30.

Ryan, J. & Williams, J. (2007). Children's Mathematics 4-15: Learning from Errors and Misconceptions. Berkshire: McGraw Hill.

Schleppegrell, M. J. (2007). The Linguistics challenges of mathematics teaching and learning: A research review. *Reading & Writing Quarterly, 23,* 139-159.

Seifi, M., Haghverdi, M., & Azizmohamadi, F. (2012). 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.

Sumarwati, Subroto, E., Pujosudarmo, S., & Nurkamto, J. (2014). The types of word problem discourse structure in mathematics textbook presented in Indonesian for primary school students. *Journal of Education and Practice, 5*(12), 151-162.

Sutarni, M. (2011). Penerapan metode mind mapping dalam meningkatkan kemampuan mengerjakan soal cerita bilangan pecahan. *Jurnal Pendidikan Penabur*, *1*(16), 26-33.

Ulu, M. (2017). Errors made by elementary fourth grade students when modelling word problems and the elimination of those errors through scaffolding. *International Electronic Journal of Elementary Education*, *9*(3).

Verschaffel, L., Greer, B., & De Corte, E. (2000). Making sense of word problems. *Lisse, The Netherlands*.

Verschaffel, L., Van Dooren, W., Greer, B., & Mukhopadhyay, S. (2010). Reconceptualising word problems as exercises in mathematical modelling. *Journal für Mathematik-Didaktik*, *31*(1), 9-29.

Wijaya, A. (2015). Context-based mathematics tasks in Indonesia: Toward better practice and achievement. (Doctoral Dissertation, Utrecht University, Netherlands). Retrieved from https://dspace.library.uu.nl/bitstream/1874/303951/1/Wijaya.pdf.

Wijaya, A., van den Heuvel-Panhuizen, M., & Doorman, M. (2015). Teachers' teaching practices and beliefs regarding context-based tasks and their relation with students' difficulties in solving these tasks. *Mathematics Education Research Journal*, *27*(4), 637-662.