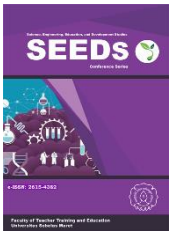

Science, Engineering, Education, and Development Studies (SEEDS): Conference Series

Journal Homepage : https://jurnal.uns.ac.id/seeds/index

CREATING WORD PROBLEM BASED ON THEMATIC MATHEMATICAL STORIES THROUGH COLLABORATIVE ACTION RESEARCH

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Article Info :

Available online 24/11/2021

Keywords:
word problem
thematic
mathematical stories
collaborative action research

Abstract

This research aims to improve the classroom practices of rural primary teachers in developing mathematics word problem through collaborative action research. The cooperation between fourth grade teachers and researchers from university focused on examining the results of the implementation of the two activities within the action plans, 'Creating word problems communicatively based by teachers' and 'Solving word problems easily by students'. From the analysis of qualitative data (interviews with students, observation and journal entries) and quantitative (tests and questionnaires) seen a significant improvement of the results of teacher in word problem creating and students in word problem solving. Developing word problem based on thematic mathematical stories enabled students to guide in using storytelling as a tool for understanding word problems

INTRODUCTION

Among the achievements of some elementary school students in Indonesia in various international math competitions, the quality of the majority of students in mathematics education is still of concern. At least that is reflected in the results of the 2015 Trends in International Mathematics and Science Study (TIMMS), which provides information that the ability of elementary students in mathematics is ranked 45th out of 50 countries, or below the international average. The achievement is not much different from the result of TIMSS in 2011, which is ranked 38 out of 42 countries, also the same as in previous years (Media Indonesia, December 15, 2016).

From various research results found that one source of difficulty in Mathematics is the solution of word problem. For example, the results of the experiments Sukamto and Ilmiyati (2004) obtained the fact that math word problems in the form of fewer done right than non-wprd problem (average 57% compared to 88%). The results of other studies show the ability of elementary school students to do the word problem rightly only reaches 30% - 80% of all, while the non-word problem reaches 70% -100% (Mastur, 2007). This suggests there are more miscalculated results in working out the word problem than the non-word problem.

The word problem is a matter of delivery in the form of symbols and mathematical notations. The non-word problem solving step is simpler than the word problem and that is what distinguishes the word problem from non- word problem. To solve non-word problem, students directly calculate the results of mathematical equations. As for the word problem, the student must translate the language about the story into a mathematical equation, then calculate the result.In fact, solving the word problem can be used as a vehicle to

train elementary students in solving problems. Students must be able to solve the word problem for success in math lesson (Moschkovich, 2012). This can be attributed to more word problem than the non-word problem in mathematics. More importantly, if associated with its function, the word problem is the use of mathematical science in everyday human life (Roux, 2008). Therefore, the ability to solve the problem of low resulted in addition to the low mathematical achievement, as well as the low ability of students to solve problems in daily life.

Regarding the causes of difficulties in word problem, Budiyono argues (2004: 131) that the first step in solving it is to write mathematical sentences and students often make mistakes in this step because it does not understand the purpose of the problem. It was in line with some research results identify problem solving constraints. Ballew and Cunningham (in Suryanto, 2001: 171), find the main source of error solving a mathematical word problem is misinterpreting the purpose of the question. The same thing was found by Sriati (1994: 11) that one of the causes of the mistake of solving the word problem is that students make mistakes in translating the probelm into mathematical equations. This type of mistake ranks second of 8 types of errors, ie after a strategy error.

Suharjo's findings above are relevant to the conclusion of Suryanto (2001) which identifies one of the causes of failed students in translating word problem related to the problem of understanding the use of language on the problem. As according to Zan (2010), in addition to language factors, the complexity of the story is also influenced by storytelling factors so that researchers termist the story as a story problem rather than word problem as the term used by other researchers. This suggests the source of the difficulty of understanding the word problem lies in the factor of language usage (the component in the text) and its narrative (the component in the context).

Judging from the language and storytelling factor, the fourth grade grade teachers in Tawangmangu who belongs to the rural area sees many word problems from textbooks that his students do not qualify as a good problem. The teachers see it as a student struggling to understand the word problem to be made into a mathematical sentence or mathematical equation. Students often ask the meaning of words and sentences, even the intent of the whole section of the word problems. However, the results of the solution remain much wrong. In fact, in working on non-word problem, they easily run mathematical operations in terms of addition, subtraction, multiplication, and division. Students are able to find the exact calculated results on most of them. Therefore, students become unhappy and scared when given a word problem, even making them unhappy and afraid of Mathematics lessons.

Seeing the difficulties of students in their classes in solving word problems, teachers reflect on ways that can assist students in developing the ability to solve them. They consider questions such as: what are the obstacles facing students in understanding the word problem?; what teaching strategies might be useful? which activities can help students in this particular case?; which skills should students develop to be able to solve word problems? The teachers shared these questions and concerns with us, researchers about the story at the Faculty of Teacher Training and Education at Sebelas Maret University - Surakarta. Later, we recommend jointly developing a collaborative action research project to answer these questions.

Collaborative action research is the joint research between two or more teachers, or between university faculty and teachers. They collaborate and influence changes in the curricular approach and focus mainly on practical problems or individual teachers (Vula & Berdynaj, 2011). “Collaboration” is encouraged in teacher action research to bring co-researchers into an inter-subjective dialogue intended to open and refine different ways of knowing (Pine, 2009). Peer-observation and professional buddying or mentoring systems are used widely in action research to promote collaboration. The prerequisite for a successful collaboration is mutual trust between professionals and common beliefs about what constitutes good teaching in their subject (Norton, 2009).

Collaboratively we performed a review of existing research studies and discovered that many mathematics teachers shared similar difficulties in helping students learn to solve word problems (Sharma, 2001; Van De Walle, 2007). Researchers have studied the role of communicative aspect, like mathematical vocabulary and narrative unsure, and its impact in students’ achievements in mathematics and word problem solving (Brethouwer, 2008; Kranda, 2008; McConnell, 2008). It is not enough for students to learn mathematics only by solving tasks that require computations or memorizing concepts and operations. Students should be able to solve problems that encourage and develop thinking and logic skills. Problem solving is a skill that is required by life in general.

The research literature on improving students’ abilities to solve word problems in mathematics pointed us to two important classroom interventions: vocabulary and formative assessments. Our research questions

were “What is the impact of teaching mathematical vocabulary and storytelling based on themes on students’ abilities to solve word problems?”

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RESEARCH METHODOLOGY

Research was conducted collaboratively, with the researchers working together with primary school teachers. Participants in the research were three forth teachers in six primary schools in Tawangmangu, Central of Java which using Javanese as a fisrt language and Indonesia as a second language.

Students were tested on their ability to solve word problems by translating said problems into mathematical notations and mathematical equations, then finding the correct solution. However, the focus of this research was the translation produced by students, as this step represents the "key" to recognizing the extent to which students understood the language of the word problem. In other words, increases in students' ability to correctly translate word problems into mathematical notation indicates increased understanding of the problem.

Here, the phrase teacher-made word problems refers to word problems made as examples and as practice, as well as word problems used on tests at the end of each cycle. These problems were developed based on three types of communicative competences: students' linguistic, sociolinguistic, and discursive competences. These word problems were made by teachers working together with researchers and following a guidebook that had been developed through previous research. The criteria for developing word problems with communicative language (Sumarwati, 2014) include:

1. The word problem should based on a theme and use familiar and common words (unfamiliar or uncommon words should be replaced, such as "container")
2. Each sentence of the word problem should contain 3–9 words.
3. Each word problem should contain 3 - 12 sentences
4. Conditional compound sentences (i.e. those using the conjunctions *if*, *whether*) should be replaced with simple sentences.
5. Abstract vocabulary should be more concrete
6. All three word problem components (i.e. the initial situation, event, and question components) should be present in their entirety.
7. The initial situation should provide clear context and draw students' interest (include actors, place and time settings).
8. Each word problem should use objects that are familiar to students (i.e. objects that are unknown to students, such as hamsters, should not be included).
9. The language used must not refer to ethnic, racial, or religious issues, violence, pornography, abuse, gender bias, etc., which may disturb or negatively influence students.

To reduce teachers' difficulty in formulating word problems and avoid complicating their other materials, word problems were based on materials from textbooks. In other words, teaching material for the word problems was taken from the textbooks.

RESULT AND DISCUSSION

The final test results showed the positive impact of actions in developing students’ abilities in word problem solving. Average of final test score is 16.68 (91.75% of maximum score). From the analysis of the results of four tests we saw positive changes in student performance. There was an increase in the number of problems solved correctly by students and in the average score for each test. The action plans have shown positive effects on students’ performance, after every action plan students results improved and the number of students who solved problems correctly increased. The actions in this research helped develop students’ abilities in word problem solving. It iwas done because not all the word problems in the text book easily understood students in aspects of the use of vocabulary and the contents of the story. For example as follows: *Tukang jahit hendak membuat 120 baju pesanan seragam siswa SD. Sehari dapat membuat 6 baju seragam. Berapa hari yang dibutuhkan supaya selesai?* ‘A tailor will make 120 shirts for school uniforms. In one day, he can make 6 uniform shirts. How many days does he need to finish his order?’ In the above word problem, which consists of three sentences, the initial situation component can be found in the sentence "*A tailor will*

make 120 shirts for school uniforms". As such, this component tells students that the actor in the story is a tailor. The event component which transforms the situation is found in the sentence "*In one day, he can make 6 uniform shirts*". The final sentence, "*How many days does he need to finish his order?"*, represents the question component.

Ema berusia 8 tahun lebih muda dari Erna yang sekarang usianya 13t ahun. Berapa umur Ema sekarang? 'Emais 8 years younger than Erna, who is now 13 years old. How old is Ema now?' This word problem consists of only two sentences, which includes all three components of the word problem discourse (the initial situation, event, and question). The initial situation and eventcomponents are combined into one sentence. The initial situation component is the phrase "*Erna, who is now 13 years old*". The question component, meanwhile, is the sentence "*How old is Ema now*?" Meanwhile, word problem was modified by techers as follows: *"Ema has an older sister. Ema is two years younger than her sister is. Her sister is 13 years old. How many years old is Ema?"* As such, information was used the social environment thema (and subtheme about family) and added about the actor, thereby making the context clearer and helping students' follow the events of the story. As a result, most of the students in the class enjoyed the modified problems more than the textbook ones.

From observation of the learning process, as well as interviews with students and teachers, it is apparent that this is caused by students' difficulty solving mathematical equations and understanding Indonesian-language texts. As such, some teachers attempted to translate the texts into Javanese. Other teachers made problems that used the names of students in their classes,as this would directly tie the problems with their environment. In these cases, the majority of students were capable of correctly translating the modified word problems into mathematical equations. This indicates that, with a clearer context, students could more easily understand the problem.

Examining and comparing the students who were capable of translating word problems into mathematical equations and also capable of finding the correct solution, There are a positive correlation between students' ability to translate problems into mathematical notation and their ability to find the correct answer. This can be linked to students' achievements, as measured by these two indicators. the number of students capable of consistently finding the correct solution to problems was lower than the percentage of students consistently able to translate word problems correctly into mathematical notation. The difference between these two activities shaped similar patterns among students. As such, it may be concluded that the more students are capable of translating word problems into mathematical equations, the more students are able to successfully solve the problem. This means that students who are capable of accurately converting word problems into mathematical notation are also capable of accurately solving said problems.

Linguistically, teachers' simplification of word problems focused predominantly on vocabulary and narrative unsure to make the probelm with themes of Curriculum 2013. Teachers attempted to use words, particularly verbs, that were already familiar to students or that referred to common activities but remained variative (i.e. were not repeated in multiple word problems).As such, the words used were words that were commonly used by students and that had specific meanings. For instance, the word *involve* in the textbook problems was replaced with the word *use*, the word *calculate*was replaced with the word *count*. Teachers also sought variety, to ensure that students were not bored by the problems. For example, the word *buy* was replaced in some problems by the words *donate*, *send*, and *order*. In their structures, the sentences in teacher-written word problems were short (maximum of twelve words) simple sentences.This reflects Verhaar's argument that simple sentences that are short can be more readily parsed than lengthy compound or complex sentences (1995:74–75). Furthermore, research by Carrell(1986) has indicated that lengthy sentences that are difficult to understand can be more easily parsed when they are divided into several shorter sentences. As such, in making word problems teachers often modified the sentences in the textbook word problems. For instance, the compound sentence *Jika dalam satu minggu Ema menabung Rp5.000,00, berapa tabungannya selama 24 minggu?* 'If Ema saves Rp 5,000.00 each week, how much can she save in 24 weeks?' was divided into two sentences: "Every week, Ema saves Rp 5,000.00. How many rupiahs are in her savings after 24 weeks?"

The simplification of discourses involves making the discursive structure of word problems more easy to understand, involving each of the three discourse components (initial situation, event, and question) separately and wholly. This reflects the findings of Gerofsky (1996: 41), who writes that the combination of these components will create discourses that are either too long or semantically ambiguous. As such, ideally these three components should be realized through different syntactic structures; as such, every discourse should contain a minimum of three syntactic structures. However, teachers and problem writers frequently ignore the initial situation component, as they often consider this component not part of the mathematical

equation.This can also be connected to the word problems made by the teachers. Their lengthy word problems, which wholly and separately presented the initial situation, event, and question components, were enjoyed by students more than the textbook problems. This is because most of the textbook word problems do not offer students an introduction/describe the initial situation.

In modifying the word problems, most teachers considered the spesific contexts of the students related to a theme that they use, particularly their interests, in describing the actors and settings of the word problems. This eased students' understanding of the word problems. As the event component of a word problem depends on the presence and skills of its actors, such stories—no matter how short—must include actors.

From interviews with students, it was gathered that they prefer animal actors from fairy tales and other stories, such as *kancil* (mouse-deer). This reflects the findings of Stein (1997), who shows that primary school students favor animal and fairytale characters. As such, the teachers used characters such as mouse-deer, crocodiles, monkeys, tigers, rabbits, and eagles in their stories. Likewise, teachers also used their students' names as well as the names of people around the school when creating actors. One example is as follows: "Lutfi is a student at Randu Primary School. During a social event, Lutfi donates some eggs he has collected. He donates 6 boxes of eggs. Each box contains 15 eggs. How many eggs has Lutfi donated?"

Aside from actors, teachers also accommodated students through other narrative elements (i.e. the natural environment settings and themes). This was sufficient to motivate students to read the problems carefully. Among the word problems made by teacher was a mixed operations (addition and subtraction) problem that drew on an animal tale (of the mouse-deer and tiger). The problem developed by the teacher along these lines was as follows:

> *Kancil tiba di suatu tempat. Ia melihat hari mau sedang tidur. Pelan-pelan kancil menghampiri harimau. Ia berjalan 23 langkah. Kemudian ia mundur 6 langkah karena harimau bergerak. Setelah harimau tenang, ia berjalan lagi 12 langkah. Sekarang, berapa langkah posisi kancil dari tempat semula?*
>
> 'A mouse-deer arrives in the forest. It sees a sleeping tiger. Slowly the mouse-deer approaches the tiger. It takes 23 steps. It then takes 6 steps back after the tiger moves. When the tiger stops, it moves another 12 steps forward. How many steps is the mouse-deer from his starting point? '

The maximal use of narrative elements in these word problems was capable of drawing students' interest. This was shown by interviews with the students, who stated that they enjoyed the word problems more when actual stories (real or fictional) were included. Such a storytelling approach, aside from providing students with more context, is also suited to children's love of stories. This reinforces the findings of Peter-Koop (2005:459), who writes that, even if they do not notice the numbers in the word problem, children will still follow the narrative story itself. Likewise, Philips (2002:20) writes that student-written word problems include not only the events that they have experienced, but also the events that accessed or even considered. Caldwell & Godin (2005:332), meanwhile, identify word problems with contexts built through the narrative processas being preferred by younger students than problems that rely on real experiences but are frequently repeated in problems.

It may be concluded here that the modification of vocabulary and story elements of the word problems allows them to be more easily understood by students, and therefore more easily translated into the correct mathematical equation. Accurately translating a problem allows students to more easily find the correct solution. As such, by giving students word problems that are more communicative (more easily understood), teachers offer their students the opportunity for greater academic achievement. Furthermore, the use of problems that are easily understood, translated, and solved motivates students to become more active in the learning process. As shown by Greenwood, Delguard, and Hall (Borich, 1996:267), there is a strong positive correlation between students' active response and their academic achievement, a finding that this research reinforces. Likewise, while they were trained how to write word problems, teachers provided feedback regarding how the language used could be simplified, thereby easing students' understanding of the problems. Based on similar experiences, Greenwood, Delguard, and Hall recommend that students spend 75% of their time providing active responses (in Borich, 1996: 269).

This research showed an increase in the number of students capable of correctly translating 70% of the word problems written by their teachers into mathematical equations over the course of three cycles. As such, it may be stated that teacher-made word problems were easier for students to understand. In making these word problems, teachers preferred to paraphrase and analogize when making problems during training and post-tests. In paraphrasing, teachers transform non-word problems into word problems. Meanwhile, in

analogizing, teachers write new word problems based on existing problems (in their students' textbooks). Using these two methods for preparing word problems allows teachers to consider their students' linguistic competence by using the simplest language possible; their students' discursive competences by wholly presenting the three discourse components in their entirety; and their students' sociolinguistic competences by selecting contexts that are relevant to their experiences, thereby easing their understanding and correct translation of the problems.

Interviews with teachers indicate that this occurred both because more word problems were available for teachers and because more of the word problems in their textbooks met the criteria, particularly in terms of their structures. Meanwhile, the problems found in textbooks for students were structurally inappropriate for students' written language competences. Their sentences contained too many words and used textual elements that had not been taught to students (including capital letters and clusters of consonants). Meanwhile, in textbooks, most problems presented all three discursive components wholly and separately, and as such without modification they could be considered structurally appropriate for students. Teachers' modifications focused predominantly on the problems' linguistic and sociolinguistic aspects.

According to the teachers interviewed, the different characteristics of the textbook word problems influenced the method they used to modify or create entirely new word problems. Among these teachers, the most commonly used of the several approaches to making word problems were paraphrasing and analogizing.Of these two methods, teachers of Third Year students were required to paraphrase more frequently as they modified the word problems' discursive structures, linguistic elements, and sociolinguistic contexts; most of the textbook problems failed to meet recommended guidelines in these three aspects. However, teachers also used analogizing when the considered the textbook word problems relatively acceptable. Meanwhile, teachers tended to emphasize the analogy approach. Most of the textbook word problems met the criteria for discursive structures, and teachers were thus only required to modify these problems' linguistic elementsand sociolinguistic contexts.

An example of modifications to word problems for second year students involving vocabulary and narrative aspects follows: *Umur Iwan 4 tahun lebih tua dari Budi. Jika umur Iwan 12 tahun, berapa umur Budi?* 'Iwan is 4 years older than Budi. If Iwan is 12 years old, how old is Budi?' Based on social environment and the guidelines developed by the researchers above, this problem has the following characteristics: (1) it uses the semantic structure "older" but involves subtraction, (2) uses family relationships, ie brother and little brother, (3) the event and question components are combined, and (4) there are no clear units used in the question component. Such problems are relatively difficult for second year students. One modification made by a teacher follows: *Iwan adalah siswa kelas 4. Ia mempunyai seorang adik. Umur Iwan 4 tahun lebih tua dari adiknya. Umur Iwan saat ini 10 tahun. Berapa tahun umur adik Iwan?* 'Iwan is a fourth year student. He has a little brother. Iwan is 4 years older than his brother is. Now Iwan is 10 years old. How many years old is Iwan's brother?'

The modification of the second actor (the co-actor) was made because the vocabulary "older"and "younger" often cause difficulty for students, as they must identify the relevant mathematical expression. This is particularly problematic as there is an inconsistency between the vocabulary "older" and the mathematical calculation subtraction; as understood by students, the vocabulary should refer to addition. To ease students' understandings, the actor and co-actor have been attributed with a familial relationship: younger and older brother. Modifications to the narratiive aspects of the problem were also made by adding more information: Iwan is stated as being a fourth year student, as with the students solving the problem, who are generally ten years old. Furthermore, the structure of the discourse has been modified. The event and question components have been separated and units have been included to ease students answering the problem.

CONCLUSION

Implementation of collaborative action research has proved to be very efficient for changing teacher practice in learning word problem and developing students' skills in word problem solving. Implementation of action plan conducted by teacher with university researcher in every action research cycle resulted in the achievement of research objectives and answering research questions. The results of this study indicate that there is a direct relationship between problem solving and understanding of vocabulary and storytelling based on themes. After understanding the contents of the story on the subject, "students have higher math test

scores". This study shows that the development of theme-based vocabulary and storytelling contributes to allowing students to better understand the mathematical arithmetical operations they must use in the making of mathematical sentences. Understanding arithmetic operations impacts the word problem results.

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