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Investigating of Students' Methaporical Thinking in Solving Algebra Problems

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Abstract

This research aims to describe the students' metaphorical thinking in solving algebraic problems especially in view of differences in their mathematical abilities. Metaphorical in this study refers to metaphorical thinking with Connect, Relate, Explore, Analyze, Transform, and Experience (CREATE) criteria. This research uses descriptive research with a qualitative approach. The subjects of this study consisted of three VII grade students of Al-Falah Surabaya Middle School with one subject from each category of high, medium and low mathematical abilities. Data collection is done by written assignments and interviews. To test the credibility of the data is done by time triangulation. At different times the tasks and interviews are given with problems that are equivalent to the previous tasks. The results showed that students with high mathematical abilities can reveal all CREATE criteria, students with moderate abilities can already check by writing down the steps in making models, operating and completing them. In addition, students did not reveal the criteria for transform, when in fact he had done it in the previous stage. Furthermore, students with low ability only re-read metaphors and their compatibility with the problem. These students did not reveal the criteria to relate, explore, analyze and experience.

Keywords: Metaphorical Thinking, Algebra Problem Solving, and Mathematical Ability.

Abstrak

Penelitian ini bertujuan untuk mendeskripsikan berpikir metaforis siswa dalam memecahkan masalah aljabar khususnya dilihat dari perbedaan kemampuan matematika mereka. Metaforis pada penelitian ini mengacu pada berpikir metaforis dengan kriteria *Connect, Relate, Explore, Analyze, Transform*, dan *Experience* (CREATE). Penelitian ini menggunakan penelitian deskriptif dengan pendekatan kualitatif Berpikir. Subjek penelitian ini terdiri atas tiga siswa kelas VII SMP Al-Falah Surabaya dengan satu subjek dari setiap kategori kemampuan matematika tinggi, sedang dan rendah. Pengumpulan data dilakukan dengan tugas tertulis dan wawancara. Untuk menguji kredibilitas data dilakukan dengan triangulasi waktu. Pada waktu yang berbeda diberikan tugas dan wawancara dengan masalah yang ekuivalen dengan tugas sebelumnya. Hasil penelitian menunjukan bahwa siswa dengan kemampuan matematika tinggi dapat mengungkap semua kriteria CREATE, siswa dengan kemampuan sedang sudah dapat memeriksa dengan menuliskan langkah-langkah dalam membuat model, mengoperasikan dan menyelesaikannya. Selain itu, siswa tidak mengungkap kriteria *transform*, padahal sebenarnya dia sudah melakukan pada tahap sebelumnya. Selanjutnya, siswa dengan kemampuan rendah hanya membaca kembali metafora dan kesesuaiannya dengan permasalahan. Siswa ini tidak mengungkap kriteria *relate*, *explore*, *analyze* dan *experience*.

Kata kunci: Berpikir Metaforis, Pemecahan Masalah Aljabar, dan Kemampuan Matematika.

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Introduction

Mathematical learning activities are teaching and learning activities that are intentionally done to help students construct mathematical concepts or principles with their own abilities through the process of internalization (Schleppegrell, 2007). The concepts are related to measurement (including calculation), forms, patterns and structures, and logical reasoning that is developed deductively. Therefore, learning mathematics requires meaningful learning for students (Goldman & Hasselbring, 1997).

Meaningful learning has several characteristics that distinguish it from rote learning (Gazali, 2016). Riadi & Ferita (2016) said that the characteristics of meaningful learning were the incorporation of new knowledge substances in students 'cognitive structures, deliberate efforts to combine knowledge with higher concepts in students' cognitive structures, learning related to experiences both in the form of events or existing events around, and commitments about attitudes related to new knowledge before entering into the material to be studied.

One branch of mathematics that is compatible with meaningful learning is algebra (Prianto, 2014). Algebra is a mathematical communication language. There are two things teachers must focus on in order to increase students' understanding of algebra (Asquith, 2007). First, students must acquire algebraic manipulation skills that are supported by conceptual understanding. Second, students are able to use algebraic language to generalize patterns, students are able to use algebraic language as a problem solving tool, using mathematical modeling to solve everyday problems. With this material students can improve understanding of students' thinking concepts by practicing skills and generalizing patterns.

In addition it needs to be supported by the concept of thinking that emphasizes the relationship between mathematics and real phenomena that exist around according to Carreira (2001), among others, is metaphorical thinking. Carreira (2001) said that methaporical thinking has metaphors as a basic concept in thinking. As a result of a number of mathematical concepts learned based on the experience possessed, students can easily build a mathematical model with an accurate interpretation (Hendriana, 2009). With the metaphorical thinking, students are expected to be able to metaphorize mathematical problems especially algebra in a form that is better understood.

In solving mathematical problems, students have diverse abilities, including in terms of understanding the problem (van Garderen et al, 2013). Students have varied initial knowledge, the more knowledge they have, the easier it is for students to understand a problem by making connections between objects that will be understood by objects in the student's cognitive system. So that, high ability students have more initial knowledge than low ability students, it is possible that high ability students will more easily understand algebra problems, so that later students can think metaphorically in solving these algebra problems.

Based on Setiawan (2016), metaphorical thinking begins with making models in accordance with the situation at hand and interpreted from a semantic point of view (the science of the meaning of words). The use of models aims to improve communication in conveying mathematical meanings (Lai, 2013). In this case, the profile of metaphorical thinking can be described through a metaphorical process by using the acronym CREATE which means "connect, relate, explore, analyze, transform, experience" (Sanchez-Ruiz et al, 2013). According to Sunito (2013), Create namely connect is connecting two or more things that are different both objects and ideas; Relate is to link a difference between objects and ideas to things that are already known or known, starting with observing the similarities; Explore is exploring similarities: drawing ideas, building models and describing those models; Analyze is an analysis of things that have been thought of. Therefore, it is necessary to outline the ideas and models that already exist to find the relationship between these ideas and models; Transform is recognizing or discovering something new based on connection, exploration and analysis of the image, model or object created; and Experience is to apply these images, models or discoveries to as many new contexts as possible. This means, starting the creative process all over again.

Based on this problem, the researcher wants to uncover the students' metaphorical thinking in solving algebra problems viewed from differences in students' mathematical abilities.

Method

The method in this study is a descriptive research with a qualitative approach with aims to describe the profile of students' metaphorical thinking in solving algebraic problems. Besides that, this descriptive research also is to describe or give a description of the object under study in a systematic, factual, and accurate sample or population data. The approach used is a qualitative approach because in this study using qualitative data that describes a deep and detailed picture of the profile of students' metaphorical thinking in solving algebraic problems.

This research was conducted in grade VII students at SMP AL-Falah Surabaya. Grade VII are selected as research subjects because the class students have gotten class VII algebra material. Every class such as 30 students. Researcher choose one class randemly, and choose 3 students based on entrance test from school before. They are 1 high ability student, 1 moderate ability student, and 1 low ability student. In addition, researchers also take a personal approach to students to ask for their willingness to be research subjects.

The research instrument developed was a matter of mathematical ability test (TKM), a problem solving task (TPM) and interview guidelines. For the TKM question, it was adopted from the National exam (UN) for the 2008/2009 school year to 2013/2014. The task of solving mathematical problems (TPM) consists of 2 similar questions, this is intended for the purpose of triangulation. The interview in this study used a task-based interview technique. Task-based interviews mean interviews conducted

using interview guidelines that contain an outline of the questions. Interviews in this study use the basic questions set by the researcher but can be developed with other questions according to the existing conditions, so that each research subject has the same opportunity to answer the same questions. So that no information is missed and the data obtained is guaranteed its validity, then the interview is recorded with a tape recorder or the like. Besides that, data analysis to reveal the profile of Metaphorical Thinking in this study was carried out by reducing data, presenting data, and drawing conclusions or verification.

Result and Discussion

Description of metaphorical thinking of high ability students (KMT)

The KMT metaphorical thinking profile in solving algebraic problems at the reading and digging stages in the KMT connect criteria finds metaphors of problems. He described problems such as the scales in a balanced state. He only found the only scale as a metaphor for the problem. In the relate criteria, KMT explains the relationship between the scales metaphor with the problem, where the keywords of the metaphors used in the problem are balanced. Next to the explore criteria, KMT also explains about the information and things that are asked of the problem. In the analyze criterion, KMT also examines the initial idea with the metaphorical scales created by checking the suitability of the problem and KMT also explains the material related to the problem. In the transform criteria, KMT reiterates the idea of the scales metaphor for the problem and in the KMT experience criteria is able to explain the problem in its own language.

At the stage of making a plan, the KMT connect criteria determine how to use the scales metaphor as a basis for solving problems. In the relate criteria, KMT also makes relationships that apply to the metaphor of the scales and also to the problem. In explore criteria, he plans to make a mathematical model using certain variables as an example. Next to the analyze criteria, KMT explains the types of arithmetic operations and the methods that will be used in solving problems, especially part b. on the transform criteria, KMT explains the steps that will be taken in completing part b by using the scale metaphor as the basis. In the experience criteria, KMT has not been able to describe the final results to be obtained later.

At the stage of carrying out the plan, the KMT summarizes and explains the exact metaphors of the problem using the scales metaphor. The KMT also makes metaphorical statements that apply to both metaphors and problems. It can be doing, because based on Hendriana (2009), with the metaphorical thinking, high ability students are expected to be able to metaphorize mathematical problems. He also made a mathematical model by using certain variables as an example. Then KMT explained that it carried out the process according to the plan and the steps that had been planned. KMT also explains the steps taken in solving problems, especially part b. KMT explains the interpretation of the final results obtained and explains the new problems created in

accordance with the mathematical model of the problem.

In the re-checking stage, KMT decided to re-examine the results of its work. He reexamined the metaphors used by re-reading the suitability of the metaphor with the problem. In addition, he also reviewed the metaphorical statements made. KMT explained that he re-examined the mathematical model by looking at the suitability of the variables, the numbers used with the existing problems. KMT also checks the steps that have been done from the beginning. Then to check the truth of the results obtained, KMT substitutes the initial mathematical model, so that it is proven that the left segment is the same as the right segment. The final step, KMT checks the suitability of the new problem with the mathematical model by examining the final results obtained. He thinks that the new problem is appropriate because the end result is the same.

Description of students' ability to think metaphorically (KMS)

The profile of KMS metaphorical thinking in solving algebraic problems in the reading and digging stages in the KMS connect criteria found a metaphor for the problem. He found the scales and the seesaw game as a metaphor for the problem. The principle used is the same, namely the scales or the seesaw game in a balanced state. In relate criteria, he makes the relationship between the scales, the tipping game with the problem. As for the explore criteria, KMS explains information (things) that are known and also explains questions a, b and c. Then for the analyze criteria, KMS re-checks the suitability of the metaphor with the problem, checks the information that is known and explains the material related to the problem. In the transform criteria, he explains the properties contained in the metaphor and also applies to the problem. As well as the experience criteria, KMS explained again the metaphor that will be used for the problem and also reiterated KMS's understanding of the problem.

At the stage of making a plan, in the connect criteria, KMS makes a completion plan using the seesaw game metaphor as the basis. In the relate criteria, he explained again the characteristics that apply to the seesaw game and also applies to the problem. Next, explore criteria, KMS explains the plan to build a mathematical model based on the example made, which is y for one adult, or in problem for one bag of marbles or apples. For the criterion of analyzing, he plans to use add (+), subtract (-) and calculate operations in completing the mathematical model. While on the transform criteria, KMS explains the steps to be taken in completing questions a, b and c. In the experience criteria, it cannot describe the possibility of the end result obtained from determining the contents of 1 bag.

At the stage of implementing the plan, KMS summarizes the seesaw metaphor for the algebra problem. In addition, he also makes statements that apply to metaphors and also problems. In making mathematical models, KMS uses variables in making mathematical models, KMS uses variable y, to assume the contents of one bag of marbles (apples). Then, he also explained the steps that had been taken from the beginning of reading to completing a mathematical model. KMS also explained the

steps in determining the contents of one bag and he completed it according to the plan made. Finally, he interpreted the final results obtained and explained the new problems created.

In the re-checking stage, KMS conducts an examination of the metaphors that are made and checks their compatibility with the problem. For the metaphorical statements made, KMS only reviews again and matches the problem. For the mathematical model, KMS explains again and makes sure that the example is made correctly. Then to ensure that the steps taken are correct, KMS rechecks each of the steps. Meanwhile, to ensure that the final results obtained are correct, KMS has not been able to prove it. And to re-examine the new problem in accordance with the mathematical model, KMS tried it or by adopting the old problem, so that the same final result was obtained.

Description of students' low ability metaphorical thinking (KMR)

The KMR metaphorical thinking profile in solving algebraic problems in the reading and digging stages in the KMR connect criteria found a metaphor for the problem. He described problems such as the scales in a balanced state. He only found the only scale as a metaphor for the problem. In the relate criteria, KMR explains the relationship between the scales metaphor with the problem, where the keywords of the metaphors used in the problem are balanced. Next to the explore criteria, KMR also explained about the information and things that were asked of the problem. In the analyze criterion, KMR does not examine the initial idea in the form of a weighing metaphor and KMR also does not explain material related to the problem, nor does it examine information known from the problem. In the transform criteria, KMR explains the properties that exist in the scales and the KMR experience criteria explains the problem in its own language.

At the stage of making a plan, in the connect criteria, the KMR has not made a picture of the settlement using the scales metaphor, but only a few plans for completion. In the relate criteria, KMR explains the relationship (properties) of the scale metaphors that apply to the problem. Next, in the explore criteria, KMR has described a mathematical model by specifying a specific variable. Next, analyze, KMR explained that it would use undercount operations and divide it into mathematical models. In the transform criteria, KMR explains the steps in completing questions a and b, but in part c, it does not have a plan yet. In the experience criteria, KMR does not have a picture of the possible final results obtained.

At the stage of implementing the plan, the KMR summarizes and explains the exact metaphors of the problem by using the metaphor of the scales. The KMR was unable to make metaphorical statements. He made a mathematical model by using certain variables as an example. Then KMR explained the steps that had been done, but he did not know whether he had carried out according to plan. KMR also explains the steps taken in solving problems, especially part b. KMR explains the interpretation of the final results obtained, but not for all problems and KMR has not been able to create a new problem in accordance with the mathematical model of the problem.

In the re-checking stage, KMR decided to re-examine the results of its work. It is line with the

Vilianti et al (2018) study, which students' low ability metaphorical thinking also re-examine the results of the problem. They usually reread the metaphors used. KMR explained that he did not re-examine the mathematical model. KMR also does not check the steps that have been done from the beginning. Then, KMR also does not check the final results obtained following the appropriate steps. The final step, KMR does not check the suitability of the new problem with the mathematical model, because KMR does not create the new problem.

Conclusion

Based on the results and analysis above, the characteristics of high, medium, and high ability students are obtained: (1) For KMT; students reveal all the information that is known and asked in the problem by writing back on the answer sheet using a concise sentence and some algebraic symbols. Students find metaphors and their relationship to problems. At this stage students reveal all CREATE criteria. (2) For KMS; students reveal all the information that is known and asked in the problem by writing back on the answer sheet using a concise sentence and some algebraic symbols. But at this stage, students do not reveal the criteria for transform, when in fact he had done in the previous stage. (3) For KMR, students find metaphors and their relationship with problems. At this stage students do not reveal the criterion analyze, besides that students also do not reveal the criteria of relate, analyze and experience, because it is caused by students not being able to make interpretations properly and also not being able to create new problems.

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