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METAPHORICAL THINKING LEARNING AND JUNIOR HIGH SCHOOL TEACHERS' MATHEMATICAL QUESTIONING ABILITY

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Abstract

This control-group posttest-only experimental design study aims to investigate the role of learning that teaches metaphorical thinking in mathematical questioning ability of junior high school teachers. The population of this study was mathematics junior high school teachers in West Java province. The samples were 82 mathematics junior high school teachers selected using random purposive sampling for experimental class and control class. It was concluded that: 1) the teacher's mathematical questioning ability who received metaphorical thinking learning is better than those who received conventional learning; 2) learning factors and KAM (*Kemampuan Awal Matematis* = Prior Mathematical Ability) affect the achievement of teachers' mathematical questioning ability; there is an interaction effect between learning and KAM in developing teachers' mathematical questioning ability; 4) teachers' mathematical questioning ability does not reach optimal for submitting non-routine and open-ended questions indicator.

Keywords: KAM, Mathematical Questioning Ability, Metaphorical Thinking

Abstrak

Studi ini dirancang dalam bentuk eksperimen dengan disain kelompok kontrol dan postes saja yang bertujuan menelaah peranan pembelajaran yang mengajarkan berpikir metaforik terhadap kemampuan bertanya matematis guru SMP. Populasi dalam penelitian ini adalah guru SMP mata pelajaran matematika di Provinsi Jawa Barat, sedangkan sampel penelitian ini adalah 82 orang guru SMP mata pelajaran matematika yang ditetapkan secara purposif kemudian ditetapkan secara acak yang termasuk ke dalam kelas eksperimen dan kelas kontrol. Berdasarkan hasil dan pembahasan diperoleh kesimpulan: (1) Kemampuan bertanya matematis guru yang memperoleh pembelajaran *Metaphorical Thinking* lebih baik daripada yang memperoleh pembelajaran biasa; (2) Faktor pembelajaran dan KAM masing-masing mempengaruhi ketercapaian kemampuan bertanya matematis guru. Selain itu, terdapat efek interaksi antara pembelajaran dan KAM secara bersama-sama dalam mengembangkan kemampuan bertanya matematis guru; (3) Ketercapaian penguasaan kemampuan bertanya matematis guru masih belum tercapai dengan baik pada indikator pengajuan permasalahan berupa pertanyaan non-rutin dan pertanyaan terbuka.

Kata kunci: KAM, Kemampuan Bertanya Matematis, *Metaphorical Thinking*

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The ability to pose questions in mathematics is the ability the students need to have in order to solve problems in mathematics, because in fostering students' understanding of mathematic skills, we need to improve their reasoning skill which appears when they are able to answer the questions posed by themselves or by the teachers in the form of problems that must be solved. Students' success in learning mathematics is not only based on their work on the problems or tests given. Elder and Paul (2002: 3) stated that thinking without questioning is not intellectual thinking. Students are considered to have substantial understanding of mathematical problems if they can argue statements beginning with a question based on the data, warranties, ideas and even claims in the

matter correctly. The relationship between understanding of mathematical problems and the ability to bring up the question can be seen from the ability to explain mathematical concepts in accordance with what the students understand.

Rahman (2013), in his study, argued that the quality criteria of the mathematical problems posed by students are categorized into 5 (five) ratings, which are: *very low*, *low*, *medium*, *high*, and *very high*. These criteria explains the indicators of posing mathematical problems quality submitted by the students, such as: (1) the suitability of the problems posed and the information given; (2) the relationship of problems presented semantically; (3) syntactically speaking, whether or not the issues raised contain the elements of supposition; (4) the clarity of sentences that can be understood and focused on a problem that can be solved; and (5) if presented in chart form, the sentences can be interpreted properly and quickly.

Hendriana (2012) suggested that in the learning and teaching process, students simply model and write how to solve an exercise item done by the teacher. If students are given a problem different from the exercise, they will be confused because they do not know where to start to finish it. It is in line with the study by Minarni, Napitupulu, and Husein (2016) who stated that the students' ability of mathematical understanding and representation are still considered low. To anticipate problems in teaching and learning process that the students have, teachers should pose problems by submitting mathematical problems to support the improvement of students' mathematical ability. This is in line with Rahman (2013) who argued that, in submitting mathematical problems, there is mathematical activities students can initiate by raising issues as the beginning stage before entering the troubleshooting steps. Such activities are the process that must be done the students in learning mathematics.

Hindarto and Anwar (2007) suggested that processing proficiency indicators in learning by the students include the ability to ask or respond questions from the teacher or other students. So, the students' questioning ability in mathematics learning is a process that is considered necessary to support their achievement of mathematical abilities in general.

In raising questions done by students to teachers or other students, it needs necessary stimulus from teachers or other students can respond. This is in line with Slavin (2000) who argued that learning is the interaction between stimulus and response. A person can be said to have learned if there is a change of behavior experienced by him/her. Stimulus is what teacher gives to students, while response is students' reaction or response to stimulus provided by teacher. However, when it comes to practical implementation, teachers have difficulties to get expected responses although they have given diverse stimulus. This is consistent with the results of the study by Widodo (2006) which suggests that majority of teachers' questions regarding the material are mostly closed-ended questions requiring short answers and memorization and comprehension. Japa (2014) suggested that teachers should give more open-ended questions in the learning process. It was intended to make the students

issued an opinion in the form of a statement or a question (as a form of stimulus), which is expected to build a response from other students who may be used as an alternative solution.

The ability to pose question which is considered good in mathematics includes the aspects of quality, relevance, language and frequency. This is in line with Widodo (2006), which suggests that analyzing the questions is based on certain considerations, including: (1) the question of academic and non-academic questions. The academic questions are related to the subject matter, whether they are being discussed or have been discussed, while the non-academic questions are related to the social, organizational, and material that is classified as non-academic; (2) closed-ended and open-ended questions. Closed questions require limited response, and usually straight to the conclusion, while the open-ended questions are questions that invite a number of the answer; (3) questions related to cognitive processes which belong to the Bloom's taxonomy, which are: to memorize (*remember*), comprehend (*understand*), apply (*apply*), analyze (*analysis*), evaluate (*Evaluation*), make (create).

Based on pilot study by Hendriana (2014), the ability to pose mathematical question is a person's ability to convey the problems of a given statement by paying attention to: (1) the relationship of the questions and their contexts, (2) the classification of routine or non-routine questions (3) the scope of closed or open-ended question. So, based on the results of the study, the formulation of categories of the ability to pose mathematical question is as follows:

1. The ability to pose mathematical question is considered *very low* if the question submitted does not fit the context of a given statement and it is a routine question and included into a closed-ended question.
2. The ability to pose mathematical question is relatively *low* if the question submitted does not fit the context of a given statement and it is routine question and belongs to the open-ended question.
3. The ability to pose mathematical question is considered *medium* if the question submitted is in accordance with the context of a given statement, but it shows the routine question and a closed-ended question.
4. The ability to pose mathematical question is considered *high* if the question submitted is in accordance with the context of a given statement but it belongs to non-routine questions and show a closed-ended question.
5. The ability to pose mathematical question is considered *high* if the question submitted is in accordance with the context of a given statement but it belongs to non-routine question and showed an open question.

Quigley (2011) explained that mathematics is a discipline that starts with methods of analysis in solving practical problems. It resulted in many practical problems which are common and can be solved, so there appeared process of abstraction in solving the problems globally and gradually and developed into a systematic discipline. In addition Bardini, Pierce, Vincent dan King (2014) also

stated that mathematics scholars have the skills without understanding conceptual comprehension which they have.

Results of preliminary research conducted by Hendriana (2013) about the communication skills in growing mathematics teachers' ability to pose a question towards students' learning outcomes in elementary schools in Bandung shows that the teachers whose communication skills in terms of asking belong to the category of *low* likely produce the results of student learning that pertained *low*, while the teachers whose communication skills in terms of asking belong to the categories of high likely produce the results of student learning that pertained *good*. Basically, both teachers and students already have the ability to ask, but it is not untapped well. Therefore, to motivate the students to develop the ability to ask in mathematics, it needs strategies that must be done by teachers in providing learning support, so that students can be motivated to learn independently, at least in submitting problems encountered in the form of questions or statements. One of the strategies is to teach students to think metaphorically (*metaphorical thinking*).

The relationship between learning process that teaches students to think metaphorically (*metaphorical thinking*) and the ability to pose mathematical question include: (1) students are able to connect the problems of a given statement into a question posed in order to get deeper information, (2) the students are able to find new concepts like a conjecture that is expected to become the basis of the question, (3) the students are able to create creative ideas that come from the problems faced, and (4) the students are able to apply the results of their thinking into questions of statements which are given. This is in line with Hendriana (2012) who argued that metaphorical thinking in mathematics is used to clarify train of thought of those who are connected with mathematical activities. Abstract concepts that are organized through metaphorical thinking are expressed in concrete things based on structures and ways of reasoning based sensory-motor system called conceptual metaphor. The metaphorical conceptual form includes: (1) *grounding metaphors* that are the basis for understanding mathematical ideas connected to everyday experiences; (2) *linking metaphors* that build relationship of two things, which are to choose, emphasize, give freedom, and organize the characteristics of the main topics to be supported by additional topics in the form of metaphorical statements; (3) *re-definitional metaphors* that redefines the metaphors and choose the most suitable to the topics that will be taught.

Therefore, further more specific research about the ability to pose question of junior high school mathematics teachers in West Java Province is really needed. In this study, the ability to pose a question is defined as the ability of mathematics teachers in connecting, discovering, creating and applying mathematical concepts of a statement given to produce an issue raised in the form of questions in line with context, routine and non-routine question, as well as close or open-ended questions.

Based on that situation, the problems and the purposes of this research are to investigate and examine the followings: (1) is the ability to pose mathematical questioning of teachers who acquire

metaphorical thinking learning better than teachers who receive conventional learning? (2) is there effect of interaction between learning and KAM (early mathematical ability) in developing mathematics teachers' ability to pose mathematical questioning? (3) How is the achievement of teachers' ability to pose mathematical questioning?

METHOD

This study is designed in the form of experiment with the design of control group and posttest only aimed at investigating the role of learning that teaches metaphorical thinking in improving junior high school teachers' mathematical questioning ability. The population of this study was junior high school teachers of mathematics in West Java province and the samples were 82 junior high school teachers of mathematics set purposively and randomly to be included into the experimental class and control class. Mathematical questioning proficiency tests in this study were compiled to refer to the characteristic of questioning ability and the guidelines of good test formulation. Data is analyzed by using statistical tests of Two-Way Annova to see the differences and the effect of interaction between the learning and KAM in generating teachers' ability to pose mathematical questioning.

RESULTS AND DISCUSSION

Findings regarding teacher's ability to pose mathematical questioning are presented in Table 1.

Table 1. Mathematical Questioning Ability

Prior Mathematical ability	**Mathematical Questioning Ability**			
	MT Class (n = 39)		**Conventional Class (n = 43)**	
	Mean	**SD**	**Mean**	**SD**
Good	8,33 (83,30 %)	1,11	7,08 (70,80 %)	1,52
Moderate	7,76 (77,60 %)	0,28	7,00 (70,00 %)	0,69
Low	6,73 (67,30 %)	1,00	5,98 (59,80 %)	0,79
Total	7,24 (72,40 %)	1,08	6,50 (65,00 %)	1,10

Notes: Ideal Score is 10

Based on the results of the above description, the obtained interpretations are as follows:

1. Overall, there are differences between the ability to pose mathematical questioning of teachers who acquire *metaphorical thinking* learning and conventional. The ability to pose mathematical questioning of teachers in the metaphorical thinking classroom is considered *high*, while in the conventional class, the ability to pose mathematical questioning is *moderate* (72.40%> 6.50% of the ideal score).

2. In addition, based on the level of Early Mathematics Ability (KAM), the ability to pose mathematical questioning of teachers who acquire *metaphorical thinking* is better than teachers in conventional class. The ability to pose mathematical questioning of *good* and *moderate* level both learning (MT and Conventional) belongs to the *high* category (83.30%> 70.80% and 77.60%> 70.00%), while for the low level belongs to the *moderate* category (67.30%> 5.98%).
3. In terms of factors which affect the ability to pose mathematical questioning, so, based on the description in Table 1, it shows that both factors (learning and KAM) affect the ability to pose mathematical questioning. In addition, there is no interaction effect between learning and KAM jointly in developing teachers' ability to pose mathematical questioning.

To support the description of teachers' ability to pose mathematical questioning, there is data analysis about teachers' ability to pose mathematical questioning by using statistical tests of mean differences. After normality test of data distribution about teachers' ability to pose mathematical questioning is done, then, it is found that the data have normal distribution. Based on these findings, then, the test of the ability mean difference is done by using Two-Way Annova (See Table 2).

Table 2. Summary of Two-Way Annova Test of Developing Teachers' Ability to Pose Mathematical Questioning Based on Factors of Learning and KAM

SOURCE	JK	dk	RJK	F^{hit}	Sig
Learning Approach (A)	19,709	1	19,709	19,110	0,000
KAM (B)	10,647	2	5,324	5,162	0,008
A x B	7,767	2	3,883	3,765	0,028
Inter	78,383	76	1,031		

(Taken from output SPSS. 22)

1. Learning Approach

   H_0 : $\mu_e = \mu_k$

   H_A : $\mu_e \neq \mu_k$

   Criteria of Testing:

   If *sig* > 0,05 then H_0 is accepted

   Based on Table 2, it was obtained that score of *sig* = 0,000; or in other words *sig* <0.05. It can be concluded that, at the significance level of 5%, there are significant differences between the ability to pose mathematical questioning of teachers who acquire metaphorical thinking *learning* and the ability of teachers with conventional class.

2. KAM (Prior Mathematical Ability)

   H_0 : $\mu_b = \mu_s = \mu_k$

   H_A : at least, there is one significant KAM different from another KAM

   Criteria of Testing:

   If *sig* > 0,05 then H_0 is accepted

Based on Table 2, it was obtained that *sig* = 0,008; or in other words, if *sig* <0.05; it can be concluded that, at significance level of 5%, at least there is one particular group of KAM whose ability to pose mathematical questioning is significantly different from another KAM. To find out which KAM different significantly, then, Scheffe test is conducted. The results of the calculations are presented in Table 3.

Tabel 3. Scheffe Test of Developing the Ability to Pose Mathematical Questioning Based on KAM

KAM(I)	KAM(J)	Mean Difference (I – J)	Sig	Interpretation
Good	Moderate	0,350	0,585	Not Different
Moderate	Low	0,396	0,343	Not Different
Good	Low	0,746*	0,047	Different

(Taken from output SPSS.22)

Based on the Table 3, it is concluded that, significance level of 5%, there are significant differences between the ability to pose mathematical questioning on *Good* & *Low* KAM compared to *Good* & *Moderate* KAM with *Moderate* & *Low* KAM. This implies that teachers' ability to pose mathematical questioning on *Good* & *Low* KAM is more developed than on Good & Moderate KAM with *Moderate* & *Low* KAM.

3. Effect of Interaction between Learning Approach and KAM

   H_0 : There is no effect of interaction between learning approach and KAM

   H_A : There is at least a significant deviation different from another deviation.

Based on Table 2, it was obtained that sig = 0.028 less than 0.05; it can be concluded that, at the 5% significance level, there is a significant interaction effect between learning approach (MT, and Basic) and KAM to produce teachers' ability to pose mathematical questioning.

Based on the findings in the field, the achievement of teachers' ability to pose mathematical questioning has not been achieved as what is expected. The achievement of the results is attached in Table 4.

Table 4. The Achievement of Mathematical Questioning Ability

Indicators of Mathematical Questioning Ability	KAM	MT Class	Conventional Class
Raising issues connected to the statement contexts given	Good	100%	100%
	Moderate	100%	100%
	Low	88%	100%
	Total	96%	100%
Raising issues in the form of non-routine questions of statements given	Good	71%	59%
	Moderate	66%	55%
	Low	54%	56%
	Total	63%	57%
Raising issues in the form of open-ended questions of statements given	Good	68%	64%
	Moderate	65%	60%
	Low	63%	60%
	Total	66%	62%

The results, shown in Table 4, conclude that, on the indicator *raising issues in the form of non-routine and open-ended questions of statements given*, the achievement of teachers' mathematical questioning ability has not been reached well. Based on the observation, the constraints faced by junior high school mathematics teachers who have difficulties in arranging non-routine questions and expect open-ended answers from students are as follows:

1. The cultural climate of the learning atmosphere in the classroom in applying the learning activities that leads students to think abstractly caused by the initial conditions of students who are accustomed to only receive learning material without thinking of the material context in more depth.
2. Teaching experience makes the teachers feel redundant to keep up-to-date with the current development of education, so, they still use monotonous models, methods and strategies.
3. Demands of the curriculum in realizing learning atmosphere in accordance with the development of mathematical ability to ask are caused by the necessity of conformity plans and targets in implementing the curriculum.
4. Output of student learning outcomes is more oriented towards quantity rather than quality in the form of understanding subject matter.

Based on the constraints experienced by these teachers, it needs a good effort such as innovative teaching aimed at improving students' mathematical questioning ability. These obstacles are in line with Hendriana (2012) who argued that students still have difficulty making a mathematical

model in solving mathematical problems because teachers practice monotonous learning method (not students-centered learning method).

CONCLUSION

Based on the results and discussion, it can be concluded that: (1) The ability to pose mathematical questioning of the teachers who acquire metaphorical Thinking learning is better than teachers with conventional class. Overall, the ability of mathematical questioning of teachers who acquire metaphorical learning Thinking belongs to *high* category while the ability of mathematical questioning of teachers who obtain conventional class belongs to *moderate* category. However, based on the ability of Early Mathematics (KAM), teachers who acquire metaphorical Thinking (Good, moderate, and Low) fall into the category of *high*, while on *Good* and *Moderate* KAM, teachers who acquire conventional class fall into the category of high, and on Low KAM, teachers fall into the category of *moderate*. (2) Factors of learning approach and KAM affect the achievement of teachers' mathematical questioning ability. In addition, there is the effect of the interaction between the learning approach and KAM in developing teachers' mathematical questioning ability. (3) On the indicator *raising issues in the form of non-routine and open-ended questions*, the achievement of teachers' mathematical questioning ability still has not been reached well. To solve this problem, it needs an effort in the form of innovative learning such as *metaphorical Thinking* method that can be applied from elementary to secondary education, so that both teachers and students will be accustomed to think more comprehensively from all directions of thought in solving problems of mathematics education.

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