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Exploring Prospective Teacher's Beliefs about Nature of Mathematics

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Abstract: This study discusses the beliefs of prospective teachers about nature of Mathematics with descriptors including: definition of Mathematics, relationship of Mathematics with daily life and view of the Mathematics knowledge development. The 172 prospective teachers answered to an open questionnaire and a series of semi-structured interviews. The research result showed that most students who had instrumentalist beliefs believed that Mathematics was an exact science consisting of a set of unchanging rules, proved true not interrelated but useful in life and Mathematics knowledge was predicted to remain, unchanged. Others believed that Mathematics was dynamic, creative and always developed.

Key words: Prospective teachers, beliefs and nature of Mathematics, predicted, developed, unchanged, true

INTRODUCTION

Understanding differences in beliefs about Mathematics is crucial in developing and ensuring the successful implementation of school Math program (Dossey, 1992; Purnomo, 2017). Cooper and Mc Gaugh (Leder and Forgasz, 2002) define beliefs as the attitude involving a number of cognitive structures. Belief is between the cognitive domain and affective domain, called the "twilight zone" (Pehkonen and Pietila, 2003). Belief is the basis of a person's motivation in behaving and understanding that the individual has for an event. Someone uses belief as a basis to predict what will happen. Teacher's beliefs about different Mathematics result in different Mathematics learning practices in the classroom (Thompson, 1992). Teacher's belief in Mathematics influences his learning practices (Siswono *et al*., 2016). This shows how important the belief in Mathematics, so that, the teacher plays an important role in building student's beliefs. Further Siswono *et al*. (2017a, b) explain that teacher's beliefs have a strong relationship with the teacher's knowledge of problem solving. In particular, the beliefs of instrumental teachers are consistent with their insufficient knowledge of problem solving while platonist teacher's beliefs and problem solving are consistent with their knowledge of content and pedagogical problem solving. When students are asked, "what is Math?" their answer is taken to show a view of the nature of Mathematics which can be called a belief (Presmeg, 2002). What students believe is largely based on the experience gained during learning Mathematics. Therefore, Mathematical beliefs relate to how one behaves towards an object and believes about the existence of the object. There is a cyclic relationship between faith and learning (Spangler, 1992). Learning experiences tend to contribute to one's beliefs about the meaning of Mathematics learning. In turn, beliefs about Mathematics tend to influence how they approach a new knowledge of Mathematics. The belief in Mathematics is an individual understanding of the world of Mathematics, while identifying Mathematical tasks together (Muhtarom *et al*., 2017a). It means that one's beliefs are influenced by the self and the environment. Teacher's belief in Mathematics has an impact on how his role in teaching Mathematics. It implies that one's beliefs can change because every time each person experiences the formation, alteration or reinforcement of his or her beliefs. There are three aspects that simultaneously influence Mathematical beliefs, namely the objects of Mathematics education, the context of the class and themselves (Op't-Eynde *et al*., 2002) interrelating in shaping Mathematical beliefs in students. Knowing the importance of Mathematical beliefs, a teacher as well as prospective Mathematics teachers must have positive beliefs in Mathematics. Without such a belief, it is likely that Mathematics teachers will further strengthen the picture of Mathematics as a very difficult lesson for some students.

Research on beliefs in Mathematics has attracted much attention from educators (Ernest, 1989; Thompson, 1992; Grigutsch *et al*., 1998; Swan, 2007; Zakaria and Musiran, 2010; Felbrich *et al*., 2012). Grigutsch *et al*. (1998) learn Mathematics teacher's beliefs using questionnaires consisting of 75 statements about the nature of Mathematics, Mathematics teaching and learning. Felbrich *et al*. (2012) investigate teacher's beliefs

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to teach Mathematics in elementary level, explore whether and to what extent beliefs about the nature of Mathematics are influenced by cultural factors and individualism/collectivism towards the formation of beliefs about the nature of Mathematics. In general, Mathematicians in researching beliefs follow Ernest's opinion which focuses on the views of respondents on Mathematical definitions. Ernest (1989) states that beliefs in Mathematics are divided into three categories: the view that Mathematics is a collection of facts, rules and skills that are useful but unrelated (instrumentalist), Mathematics as a static, yet, integrated knowledge, consisting of structure and truth which are interrelated. Mathematics is a monolith an immutable product that is unchanged, invented and not created (platonist) and Mathematics as an ever-evolving human investigation and the result remains open to revision (problem solving/constructivist). A person who is instrumentalist views Mathematics as a given body of knowledge and standard procedures and someone with problem solving views Mathematics an interconnected body of ideas which the teacher and the student create together through discussion (Swan, 2007; Muhtarom *et al*., 2017b).

Other researches on belief in Mathematics (Presmeg, 2002; Buehl and Fives, 2009; Amirali and Halai, 2010; Beaudette, 2012; Viholainen *et al*., 2014) investigating beliefs in Mathematics that not only focus on Mathematical definitions. For example, Presmeg (2002) views student's views of Mathematics and Mathematical relationships with daily life (Amirali and Halai, 2010) investigate the views of Mathematics, the relationship of Mathematics to daily life and the view of the development of Mathematics knowledge. Thus, it is necessary to investigate the beliefs of prospective teachers toward Mathematics with research descriptor including: view of Mathematics, the relationship of Mathematics with daily life and view on the development of Mathematics knowledge. This is necessary in order to expand the theory of prospective teacher's beliefs towards Mathematics.

MATERIALS AND METHODS

Type of research: This research was the qualitative one based on open questionnaires and semi-structured interviews. The criteria used to assess the instruments developed are validity and reliability (Kemp, 1977, 1994; Popham, 1995). An instrument is said to be valid if the instrument can measure what is thought to have been studied (owned) accurately, the research is to meet the characteristics to know the prospective teacher's beliefs of Mathematics. Reliability refers to the consistency of assessment procedure of what should be measured (Popham, 1995) using an internal consistency type, namely to see whether the question items can work in a homogeneous way to identify the prospective teacher's ideological beliefs toward Mathematics.

Data collection: Subjects in this study were the prospective teachers in a university in Semarang that were motivated as Mathematics teachers. First, prospective teachers completed questions from open questionnaires, where they are asked to explain their beliefs on Mathematics. The questions in the following:

- According to your beliefs, what is Math?
- According to your beliefs is there any relationship between Mathematics topics and daily life? Give the reason!
- According to your beliefs, is Mathematics knowledge the same throughout the world and remain the same in the future? Give the reason!

The 172 prospective teachers gave answers to the open questionnaires about their beliefs in Mathematics. The result showed that 122 prospective teachers tended to have instrumentalist beliefs, 34 prospective teachers tended to have platonist beliefs and 16 prospective teachers tend to have constructivist beliefs. Semi-structured interviews were conducted to deepen the subject's beliefs in Mathematics and selected three subjects representing each category of beliefs to analyze the data on the results of the study. The interview was conducted twice with different times, then the first interview data and the second interview in triangulation to obtain valid subject data. Semi-structured interviews provided that: the questions asked should not be the same but contain the same core issues, if the students have difficulty with a particular question, the students will be encouraged to reflect or be given a simpler question without losing the point, the interviewer is allowed to ask additional questions, depending on the answer of the interviewee and the interview process is audio visually recorded and transcribed.

Analysis: Data analysis of interview result was done by: data reduction that was activity which referred to election process, attention concentration of abstraction simplification and raw data transformation in field. If there were invalid data, then the data were collected separately and might be used as verification or other by-products. Data validation had already begun when data collection, namely by time triangulation by examining the results of data from a subject by taking different time data

(Bogdan and Biklen, 1998; Moleong, 2007), data exposure including classification and data identification namely writing organized and categorized data so making it possible to draw conclusions from the data and drawing conclusions from the data collected and verifying conclusions about prospective teacher's beliefs on Mathematics.

RESULTS AND DISCUSSION

DPW's beliefs: Subject DPW believed that Mathematics was an exact science whose truth could not be changed, from the beginning when Mathematics existed, until the concept from the past until now the concept has not changed. This opinion reflected the existing Mathematical view from the beginning to the present, that Mathematics is a set of tools (concepts, rules) used to find answers to specific tasks, as well as solving Mathematics problems. The subject asserted that what was believed to be the definition of Mathematics had never changed. Obviously Table 1 shows that, subject DPW had a belief that Mathematics was used in everyday life such as those associated with social arithmetic. Although, subject DPW said that there were some Mathematical materials that were not related to everyday life such as trigonometry but at the end of the interview subject DPW actually knew that it was used in engineering. It means the subject had a 'belief on the relationship of Mathematics with everyday life that has never changed because from the beginning until now Mathematics is used and applied in everyday life'. The subject had a belief that knowledge of Mathematics was still the same from time to time because Mathematics itself was an exact science that was certainly unchanged. Although, from written work of subject DPW, he wrote that the knowledge of Mathematics was continuous and progressing every time the students 'came up to the next class'. Nevertheless this opinion implied that Mathematics knowledge was predicted absolute, fixed and unchanging; the different was the scope of Mathematics material in elementary, junior and senior high school because Mathematics learning was adjusted the level of learner's development.

DP's beliefs: It is obvious that, Table 2 shows subject believed Mathematics was an integrated knowledge, having a material context that was interconnected each

Table 1: Analysis of DPW's beliefs

Reduction and presentation of data	Categories	Conclusion
Researcher; According to DPW, what is Math? Subject; Mathematics is an exact science that is already and is still the same as it used to be Researcher; The definition of science can certainly be explained further? Subject; The exact science is the truth. It certainly cannot change So, from the beginning of Mathematics existence, the concept from the past until now has not changed	View of Mathematics	Mathematics is an exact science consisting of a set of rules that are unchanged, proved true not interrelated but useful in life
Researcher; Is there any relationship between Mathematics and everyday life? Subject; Yes, there is (nod) Researcher; The explanation? What kind of relationship? Subject; The reason is from the word 'there is' means not all can be used in everyday life Researcher; This means that some can be utilized in everyday life Subject; Only the abstracts that are not used. Maybe social arithmetic is the one used in everyday life Researcher; Can you give the example that is used? Subject; What is not used in everyday life may be just the abstract form as far as I know Trigonometry Researcher; Trigonometry Subject; Not all, maybe no one wants to use trigonometry in everyday life in the form like putting up a house or our time talking to a friend in trigonometry learning except learning. Trigonometry may be used when we study but when we enter the outside world as if we are talking, trigonometry is never used Researcher; If the engineering person is in the construction do you think trigonometry is not used? Subject; Actually it is used. But in general from people who are not construction, they never use	Relationship of Mathematics with daily life	Mathematics is used to solve problems in everyday life
Researcher; According to DPW does the knowledge of Mathematics develop from time to time? Subject; Still the same because Mathematics itself is an exact science that certainly does not change Researcher; Can it be described why it does not change? Subject; It is an agreement that has existed in previous inventors and it is still used today in learning	View on the development of Mathematics knowledge	Mathematics knowledge is predicted absolute, fixed and unchanged

Table 2: Analysis of DP's beliefs

Reduction and presentation of data	Categories	Conclusion
Researcher; according to your beliefs, if we talk about Mathematics, what is math? Subject; Mathematics is knowledge that the material context relates between the material to be studied and the previous material Researcher; Do you mean the purpose of the material relates to what is learned and the previous material? Subject; Suppose we will learn about SPLDV material. Previously, we must know in advance what the system of linear equations of one variable is Researcher: Is that what you believe relating to Mathematics? Subject; Yes Researcher; In the past, did Mathematics exist by itself or how? Subject: In the past Mathematics existed already and found	View of Mathematics	Mathematics is the body of static knowledge, which involves a series of interrelated rules and procedures, if it is followed, it will produce a correct answer
Researcher; Is mathematics related to daily life? Can you give the reason! Subject; Mathematics relates to daily life for example when we buy something like pencils, rice, and sugar. All apply Mathematics in everyday life Researcher; What is the meaning of the relationship of Mathematics used to solve problems in everyday life or problems in everyday life requiring Mathematics? Subject; Mathematics is used to solve problem in everyday life Researcher; So Mathematics is used to solve problems in everyday life. The illustration is as mentioned earlier, what was it? Subject; SPLDV (in indonesian) Researcher; Can you give another example? Subject; Another example like linear program. When buying meatballs, for example 2 meatballs are later added by buying iced tea like that	Relationship of Mathematics with daily life	Mathematics is used to solve problems in everyday life
Researcher; Then according to your beliefs does the knowledge of Mathematics experience development or not? Can you give the reason! Subject; No, because the Mathematics has already existed from ancient times and today we only use and apply it in everyday life Researcher; Does it not change? Subject; It has been around ancient times and now, we only use and apply it in everyday life	View on the development of Mathematics knowledge	Mathematical knowledge predicted absolute, unchanged, irrespective of human and therefore Mathematics is invented not created

another, Mathematics already existed and was discovered by humans not created. This opinion reflected a view that Mathematics was something static but it was an integrated field of science, a field of structured field and truths that were strongly intertwined with one another by logic and meaning. The subject asserted that what was believed about the definition of Mathematics had never changed. The following excerpt second interview with the subject DP. Related to the relationship of Mathematics to everyday life, subject DP had the same beliefs as subject DPW that Mathematics was used to solve problems in everyday life, for example related to social arithmetic and linear programming. In general, the subject had valid beliefs about the relationship of Mathematics to everyday life namely Mathematics was used and applied to solve problems in everyday life. Subject DP had the beliefs that the knowledge of Mathematics was still the same from time to time because Mathematics itself in ancient times had existed and was discovered. Although, in the written work, subject DP wrote that 'Mathematics knowledge has been progressing since there are also practical formulas as well but this opinion implied that Mathematics knowledge was predicted to be absolute, fixed, unchanged and undeveloped which developed only a way of solving the Mathematics problem itself but numbers, geometric shapes or other objects in Mathematics remained the same. This was like the opinion, that the knowledge of Mathematics developed because it was used in other fields such as engineering, physics and biology something that developed was another knowledge that used Mathematics knowledge.

FP's beliefs: Subject FP believed that Mathematics was a branch of science that formed a more logical, systematic and dynamic mindset that could change. For example there was a new phenomenon that Mathematical researchers would conduct further research to find a solution of the phenomenon. This means the subject agreed that Mathematics was concerned with thinking and understanding the phenomena that existed in life. This view reflected the Mathematics view that was dynamic, namely the space of creation and human discovery that developed continuously in which patterns were raised and then filtered into knowledge. So, Mathematics is a process of searching, knowing that caused addition of knowledge.

Table 3: Analysis of FP's beliefs

Reduction and presentation of data	Categories	Conclusion
Researcher; According to you what is Math? Subject; In my opinion, Mathematics is a branch of science where the branch of science will form a more logical, systematic and dynamic mindset. The truth of a mathematic is a deductive axiom where the truths have been proved before Researcher; What do you mean by dynamic in the context of what you said before? Subject; Dynamic can be changed. We see the phenomenon that happen like that, if there is a new phenomenon then from the world of education, especially in Mathematics itself there is a further research to find solutions of the phenomenon	View of Mathematics	Mathematics is a dynamic field of human creation, continually evolving according to the pattern of discovery and the results remain open to revision
Researcher; In your opinion, how is the relationship between Mathematics and everyday life? Subject; If I think there is actually a connection between Mathematics and everyday life. For example when doing a transaction buying-selling in fact we can also use two-variable linear equation system. So, providing an example related to the SPLDV for example we can use the context in everyday life So, there is a connection between Mathematics and the application in everyday life Researcher; (for example SPLDV) is Mathematics for solving the problem or what? Subject; Actually Mathematics itself when there is a problem it can be solved with Mathematics but because it has dynamic characteristic, it is able to adapt to the problems arising or phenomena that arise in the end what will be like. Then, Mathematics gives a solution. So, it is suitable with the problems that arise and we use mathematical solutions that are suitable to solve the problem	Relationship of Mathematics with daily life	Mathematics knowledge is created by humans based on their observations of the phenomena in everyday life; Then, the knowledge is used to solve the problem
Researcher; Does Mathematics develop until now? Subject; From some articles I have read, Mathematics was originally from Greece where from the ancient Greeks they only knew the symbols and have not given the name or meaning of the symbols. But gradually mathematical books have changes where researchers find out the meaning of the symbols that have been formed in ancient Greece what it is like Researcher; You said from Greece and now? Subject; There are researches conducted or followed-up from the previous inventors Researcher; Does it have development? Subject; Yes	View on the development of Mathematics knowledge	Mathematics knowledge is always changing and never static

As subject FP's beliefs that Mathematics was dynamic and developing, the subject believed that Mathematics was capable to develop to match with the problems that existed in everyday life, provide Mathematics solutions, then use such solutions to solve problems in everyday life. This opinion showed the subject had the beliefs that Mathematics was created based on the phenomenon that existed in everyday life then the Mathematics itself was used to solve the problems that existed in the everyday life. Subject had beliefs that Mathematical knowledge developed from ancient times until now because of the research conducted by Mathematicians. From the results of written work subject FP illustrated that Mathematics was progressing because of the propositions/rules/new formulas made by Mathematicians. Surely, it was in line with the view of Mathematics as a space of creation and human discovery that developed continuously in which patterns were raised then filtered into knowledge. So, Mathematics was a process of searching and came to know, so that, there was addition of knowledge (Table 3).

It was clearly described that subject DPW's beliefs to the Mathematics nature was in line with instrumentalists beliefs, especially when the subject stated that Mathematics is science whose truth cannot be changed. Certainty is a quality inherent in Mathematics activity. The procedures and methods used in Mathematics guarantee the correct answer. This is in line with Ernest (1989)'s view that Mathematics is a set of tools made up of facts, unrelated but useful rules; a given body of knowledge and standard procedures (Swan, 2007). The 122 students of Mathematics prospective teachers who had instrumentalist beliefs view that Mathematics was an exact science, discussing calculations, numbers and formulas. In line with their choices that emphasized Mathematics was an exact science, the subject asserted that Mathematics knowledge was predictable absolute, fixed, not much changed and could be used to solve problems in everyday life. It is reinforced by Buehl and Fives (2009) that Mathematics is a set of unchanging knowledge, proven true and stands on a proven theory.

The DP subject's beliefs in Mathematics nature was largely in line with platonist beliefs, especially when the subject expressed Mathematics as an integrated knowledge having interrelated matter contexts such as statistics, algebra, probability and geometry as well as the interrelationship among them. Ernest (1989) explains that Mathematics is a collection of static rules, concepts and theorems as an integrated, consistent and interrelated structure; Mathematics is seen as static knowledge which involves a series of rules and procedures (Buehl and

Table 4: Definition beliefs about nature of Mathematics

Categories of beliefs	Description
Instrumentalist	Mathematics is an exact science consisting of a set of rules that are unchanged, proved true, not interrelated but useful in life
	Mathematics is used to solve problems in everyday life
	Mathematics knowledge is predicted absolute, fixed and unchanged
Platonist	Mathematics is the body of static knowledge which involves a series of interrelated rules and procedures, if it is followed, it will produce a correct answer
	Mathematics is used to solve problems in everyday life
	Mathematical knowledge predicted absolute, unchanged, irrespective of human and therefore, Mathematics is invented not created
Constructivist	Mathematics is a dynamic field of human creation, continually evolving according to the pattern of discovery and the results remain open to revision
	Mathematics knowledge is created by humans based on their observations of the phenomena in everyday life; Then the knowledge is used to solve the problem
	Mathematics knowledge is always changing and never static

Fives, 2009). The subject described Mathematical knowledge as something that did not change although DP admitted that the process used with Mathematical concepts might change, he believed that the concept itself was stable. In line with the choice of 34 Mathematics prospective teachers who had platonist beliefs, the subject asserted that in the structure of Mathematics knowledge, the subject described it as interconnected and hierarchical. Mathematics knowledge was predicted absolute, fixed, not changed much and could be used to solve problems in everyday life. The subject believed that Mathematics knowledge existed, regardless of human beings and therefore, Mathematics was invented not created. Subject FP's belief in the nature of Mathematics was largely in line with the constructivist beliefs. He believed that a change in Mathematics knowledge as human understanding developed. In line with FP's view, experts reveal that Mathematics knowledge continues to evolve according to the pattern of discovery and the results remain open to revision (Ernest, 1989) an interconnected body of ideas which the teacher and the student create together through discussion (Swan, 2007) and Mathematics is created by human beings based on experience and observation of the regularity of phenomena, Mathematics always changes, never static (Buehl and Fives, 2009). In line with the choices of 16 Mathematics prospective teachers who had constructivist beliefs, the subject believed that Mathematics knowledge was hierarchical in which a new knowledge was built with existing knowledge, It showed that the subject believed that Mathematics was not only created by humans but could also be changed by humans. Grigutsch *et al.* (1998) describes the problem is found together in Mathematical topics then is used to solve problems on the Mathematical topic itself as well as other everyday life issues. Furthermore, he notes that Mathematicians work on challenging patterns, try to solve them then generate new theories, then filtered into knowledge this may happen every day without we know it.

In this study, we used open questionnaires and semi structured interview, so that, what the prospective teachers believed in Mathematics could be clearly revealed. This method can clearly illustrate student's beliefs about the nature of Mathematics, the relationship of Mathematics to everyday life and views on the development of Mathematical knowledge as outlined in Table 4. Finally, hopefully the results of this study can provide a comprehensive picture of belief in Mathematics and serve as a basis for developing further research relating to beliefs in Mathematics as well as their relationship and impact on the learning practices of prospective teachers.

CONCLUSION

The prospective teacher's beliefs in the nature of Mathematics should be directed to constructivist which is in accordance with the curriculum applicable in Indonesia. Very few research subjects believe that Mathematics is dynamic, creative and always develops, perhaps this also reflects the fact that most university professors also have the same beliefs with their students. It is necessary to understand that student's actions and answers should be seen as a reflection of his current beliefs. Lecturers should apply classroom activities that place students who will help them to create new possible Mathematical concepts as well as to encourage reasoning, creativity and information gathering. Furthermore, the lecturer will understand that learning opportunities occur when there is social interaction involving collaborative dialogue with other students as well as lecturers. Finally, we believe that this study may extend theories about the beliefs of prospective teachers towards Mathematics.

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