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The Influences of Mathematical Beliefs on Mathematics Anxiety among Pre-Service Elementary School Teachers in East Borneo, Indonesia

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Abstract. The study investigates the influences of mathematical beliefs on mathematics anxiety among pre-service elementary school teachers in East Borneo, Indonesia. The sample of this study is 374 pre-service elementary school teachers from the elementary school teacher education departments in public universities in East Borneo, Indonesia. The data obtained from the questionnaire used in the study are analyzed via SPSS 21.0. The regression analysis results show that there is a significant relationship between the combination of independent variables in the model and the dependent variable. The study suggests that mathematical beliefs can predict mathematics anxiety to a small extent.

Keywords: mathematical beliefs, mathematics anxiety, pre-service elementary school teachers

INTRODUCTION

Elementary teachers are assigned with an extremely important role and that among them is to engender an excitement for learning in all subject areas, including mathematics (Wood, 1988). Teachers should understand the subject in sufficient depth to be able to represent it appropriately and in multiple ways – with story problems, pictures, situations and concrete material (Ball, 1990). Thus, the elementary teacher education programme has an important role to prepare pre-service elementary school teacher to be good teachers.

However, most of the pre-service teachers believe that mathematics as difficult and boring subject (Jamiah, 2008). If a teacher believes that mathematics is difficult and boring, it is obvious to imagine how they represent mathematics in front of their future students. Timmerman (2004) suggests that pre-service elementary teachers' beliefs directly influence their future teaching practice. Pre-service mathematics teachers should have positive beliefs toward mathematics so they will be able to represent mathematics as an interesting subject, challenging, applicable in many areas and can be learned by everyone, not as difficult subject, abstract and only for high cognitive students (Widjajanti, 2010).

Raymond (1997) notes that past school experiences, early family experiences and the teacher education programme have the greatest effect on developing pre-service teachers' mathematical beliefs. All teachers possess beliefs about their profession, their students, how learning takes place and the subject areas they teach, and their practices should flow from these beliefs (Capraro, 2005). Thus, they transfer their own attitudes and beliefs to their students (Kalder & Lesik, 2011). As a result of their past experiences, pre-service teachers come to their education courses with deeply rooted anxieties and attitudes about mathematics (Nisbet, 1991; Bryant, 2009).

Research related to elementary pre-service teachers' mathematics anxieties has consistently shown that elementary pre-service teachers have higher levels of mathematics anxiety than the general college population, which has prompted concern in the mathematics education community for decades (Brown et. al., 2011). Pre-service teachers' mathematics anxiety is caused by the teachers, their behaviour or teaching approach in their past (Bekdemir, 2010). Most of the teachers teach mathematics using their own experience based on the lesson they attended in elementary school, junior high school or senior high school (Kusumah & Marsigit, 2010).

Some previous studies suggest that mathematical beliefs relate to mathematics anxiety (Walsh, 2008; Cox, 2011; Usop et. al., 2013; Haciomeroglu, 2013). However, these studies did not investigate whether mathematical beliefs have an influence on mathematics anxiety. This study investigates whether mathematical beliefs have an influence on mathematics anxiety among pre-service elementary school teachers.

LITERATURE REVIEW

Mathematical Beliefs

In the past three decades, the subject of beliefs has become the focus of a considerable body of research projects, studies, theories and publications in the field of mathematics education (Kalder & Lesik, 2011; Žalska, 2012). However, the concept of belief has no definition agreed on by the researchers (Furinghetti & Pehkonen, 2002; McLeod & McLeod, 2002), and has generally been mistaken for the concepts of attitude and knowledge (Pajares, 1992; Thompson, 1992). As one of the affective domains in mathematics education, beliefs differ from attitudes and emotions in the degree to which cognition plays a role in the response and in the time they take to develop (McLeod, 1992).

There are different definitions of beliefs in the literature. Scott (2005) argues that beliefs mean an individual's opinion or view on a specific issue or practice. Beliefs are used to mean anything a person regards as true, while any positive or negative evaluation arising from a belief or belief constitutes an attitude (Beswick, 2006). Schoenfeld's (1992) interpreted beliefs as an individual's understandings and feelings that shape the ways that the individual conceptualizes and engages in mathematical behaviour.

There are some researchers who used the term 'mathematical beliefs' in their studies. Mathematical beliefs are considered as personal philosophies or conceptions (Thompson, 1992), personal judgements about mathematics formulated from experience in mathematics, including beliefs about the nature of mathematics, learning mathematics and teaching mathematics (Raymond, 1997). Törner (2002) structures mathematical beliefs in a hierarchical form in which global beliefs (general beliefs of teaching and learning), domain-specific beliefs (beliefs about specific domains such as algebra or geometry), and subject-matter beliefs (beliefs of amount and organization of the subject) interact among each other via top-down or bottom-up influences.

Broadly there are four sets of beliefs about mathematics i.e. beliefs about the nature of mathematics, beliefs about teaching and learning of mathematics, beliefs about the self in the context of mathematics teaching and learning and beliefs about the nature of knowledge and the process of knowing (Kislenko et al., 2005). For the present study, mathematical beliefs refer to beliefs about the nature of mathematics, beliefs about mathematics teaching and beliefs about mathematics learning. The following discusses beliefs about the nature of mathematics, beliefs about mathematics teaching and beliefs about mathematics learning.

Beliefs about the Nature of Mathematics

There is a broad acceptance that teachers' beliefs about the nature of mathematics influence in which they teach the subject (Lerman, 1990; Andrews & Hatch, 2001). Beswick (2011) suggests that more attention needs to be paid to the beliefs about the nature of mathematics that teachers have constructed as a result of the cumulative experience of learning mathematics in primary school, secondary school and university.

A teacher's conception of the nature of mathematics may be viewed as teacher's conscious or subconscious beliefs, concepts, meanings, rules, mental images, and preferences concerning the discipline of mathematics (Thompson, 1992). He notes that the beliefs professed by individual teachers concerning the nature of mathematics have been found to be generally consistent, whereas the diversity of conceptions has been documented across teachers.

Beliefs about Mathematics Teaching

What a teacher considers to be desirable goals of the mathematics, his or her own role in teaching, the students' role, appropriate classroom activities, desirable instructional approaches and emphases, legitimate mathematical procedures, and acceptable outcomes of instruction are all part of the teacher's conception of mathematics teaching (Thompson, 1992). Furthermore, teachers' conceptions of mathematics teaching are also likely to reflect their views of students' mathematical knowledge, of how they learn mathematics, and of the roles and purposes of schools in general.

The model of teaching mathematics is the teacher's conception of the type and range of teaching roles, actions and classroom activities associated with the teaching of mathematics (Ernest, 1989). He further introduces three different models which can be specified through the teacher's role and intended the outcome of instruction i.e. *instructor* who intends the mastery of the skill with correct performance, *explainer* who intends the conceptual understanding with unified knowledge, and *facilitator* who intends the confident problem posing and solving.

To assess pre-service teacher beliefs about mathematics teaching, Van Zoest et al., (1994) provide a framework built upon three views of how mathematics should be taught. The views are the learner-focused with an emphasis on social interaction, the content-focused with an emphasis on conceptual understanding and content-focused with an emphasis on performance. They claimed that three elements of the framework provide a continuum to assess pre-service teacher beliefs about mathematics teaching with a socio-constructivist orientation at one end (the learner-focused) and a performance-driven orientation (content-focused with an emphasis on performance) at the other extreme. The content-focused with an emphasis on the conceptual understanding view of teaching was considered to be an intermediate point between the learner-focused with an emphasis on social interaction and the content-focused with an emphasis on performance views of teaching mathematics.

Beliefs about Mathematics Learning

According to Ernest (1989), teacher's mental model of the learning mathematics consists of the teacher's view of the process of learning mathematics, what behaviours and mental activities are involved on the part of the learner, and what constitute appropriate and prototypical learning activities. In addition, two of the key constructs for these models are learning as active construction, as opposed to the passive reception of knowledge; the development of autonomy and child interests in mathematics, versus a view of the learner as submissive and compliant.

Handal (2003) supports the two key constructs for the model of learning mathematics by Ernest (1989). He reviewed the two views of teaching and learning mathematics as progressive and traditional views. The concept of progress is associated with socio-constructivist (for the sake of brevity will be called just constructivism) that gives recognition and value to new instructional strategies in which students are able to learn mathematics by personally and socially constructing mathematical knowledge. In turn, the traditional concept is associated with a behaviourist perspective on education. Behaviourist practices are said to emphasize the transmission of knowledge and stress the pedagogical value of formulas, procedures and drill, and products rather than processes.

Mathematics Anxiety

Mathematics anxiety is defined as negative affective responses to mathematics (Aarnos & Perkkilla, 2012). Wood (1988) uses the term mathematics anxiety as the general lack of comfort that someone might experience when required to perform mathematically. Gresham (2007a) argues that mathematics anxiety is a feeling of helplessness, tension (Ashcraft, 2002), or panic when asked to perform mathematics operations or problems. Bekdemir (2010) expresses the mathematics anxiety as an illogical feeling of panic, embarrassment, flurry, avoidance, failing and fear, which are physically visible, and which prevent solution, learning and success about mathematics. Kargar et al., (2010) state that mathematics anxiety is synonymous with "number anxiety", which is often assumed to be a high level of anxiety and is the outcome of low esteem and the fear of failure. In this study, mathematics anxiety refers to a feeling of panic, embarrassment, flurry, avoidance, failing and fear, and the general lack of comfort that someone might experience when required to perform mathematically, which are physically visible and which prevent solution, learning and success about mathematics (Bekdemir, 2010; Wood, 1988).

Mathematics anxiety is an important and common phenomenon among students from elementary through university levels (Peker, 2009). It is a phenomenon where students suffer from the irrational fear of mathematics to the extent that they are unable to think about, learn, or be comfortable with mathematics (Gresham, 2007b). Mathematics anxiety has been found to be related to a range of concerns and problems in the learning of mathematics (Ma & Xu, 2004).

Mathematics anxiety has been affected by all aspects of mathematics education directly or indirectly (Catliouglu et al., 2009). Baloglu and Kocak (2006) state that anxiety has been found to be one of the most prevalent emotional problems associated with mathematics. Mathematics anxiety may affect students' success in their higher education studies (Nunez-Pena et al., 2013). They further argue that mathematics anxiety does not only impact on the decisions and career choices of young people today but also affect the achievement of university students when they have to take courses with high mathematical content. Mathematically anxious people steer their lives and careers away from mathematical applications, impacting their career development and future potential (Hadley & Dorward, 2011).

METHOD AND SAMPLING

The study employed questionnaires to obtain the data about mathematical beliefs that consist of three dimensions i.e. beliefs about the nature of mathematics, beliefs about mathematics teaching and beliefs about mathematics learning; mathematics anxiety and demography. The questionnaire used in this study consists of three sections. Section A presents sixteen items with five-point Likert-scale to investigate pre-service elementary school teachers' mathematical beliefs. The items were adopted from Mathematical Beliefs Questionnaire (MBQ) (Zakaria & Musiran, 2010). Section B presents twenty-seven items with five-point Likert-scale to investigate the level of mathematics anxiety among pre-service elementary school teachers. The items were adopted from the Revised-Mathematics Anxiety Survey (R-MANX) Bursal & Paznokas, 2006). The last section of the questionnaire consists of five items to obtain information about gender, age, ethnicity, year of study and secondary school major. The demographic questionnaire was used to know the profile of the respondents.

A total of 374 respondents were chosen using stratified random sampling. The sample of this study was pre-service elementary school teachers who were pursuing a four-year program in Elementary School Teacher Education and had not taught yet in the actual elementary school. All respondents were Indonesian pre-service elementary school teachers and they enrolled in full-time study in public universities in East Borneo, Indonesia.

Most of the respondents were female pre-service elementary school teachers (82.1%). Their ages ranged from 17 up to 26 years old however most of the respondents were 20 up to 23 years old (57.5%). They enrolled in the first (23.3%), second (17.4%), third (29.4%) and fourth years (29.9%). A proportion of 43.6% of the respondents were Javanese followed by Bugis (11.5%), Dayak (8.8%), Kutai (7%) and other ethnicities (17.4%). Although elementary school teacher education is under social science major, there were pre-service elementary school teachers who come from science (39%), language (3.2%) and other majors (19%). The other majors were from vocational schools with different subjects.

The questionnaires were administered by one of the researchers directly with respondents with the facilitation of a lecturer in each university. Before the administration of the main questionnaires, the researcher asked the respondents to complete the consent form. The completed consent forms were collected first, then, the main questionnaires were administered. The researcher waited in the classroom while the respondents were completing the questionnaire. The completed questionnaires were then collected at the site. The data was then analysed using IBM SPSS Statistics version 21.0. The independent sample *t*-test and ANOVA were engaged.

FINDINGS AND DISCUSSION

Assumptions Fulfilment

This study used regression analysis. According to Cohen et al., (2007), it is important to be aware of certain assumptions in the statistical test. The fulfilment of the assumptions is required before running the analysis. In general, regression analysis required a sample that selected randomly for the population. The samples of this study were chosen using stratified random sampling from the population, so this assumption was considered fulfilled. The following sub-sections discuss the other assumptions.

Normality

The analysis used in this study required normality to be fulfilled. The data of variables should be normally distributed. The normality of the data is assessed by checking the measures of skewness and kurtosis. The measure of skewness is a measure of the asymmetry of a distribution. The normal distribution is symmetric and has a skewness value of 0. The measure of kurtosis indicates the extent to which the scores are "bunched" around the mean. The measures of skewness and kurtosis which is close to 0 indicate that the distribution of scores is considered approximately normal (Argyrous, 2011). The measures of skewness and kurtosis are summarized in Table 1.

Table 1 Skewness and Kurtosis of Variables

Variable	Skewness	Kurtosis
Belief about the nature of mathematics	0.129	−0.220
Belief about mathematics teaching	−0.007	−0.112
Belief about mathematics learning	−0.200	0.017
Mathematics anxiety	0.193	−0.021

According to Table 1, the measures of skewness and kurtosis of the variables were close to 0. It means that the distribution of the scores of beliefs about the nature of mathematics, beliefs about mathematics teaching, beliefs about mathematics learning and mathematics anxiety were considered normally distributed.

Beside the data of the dependent variable is normally distributed, normality of the residuals for the dependent variable (the differences between calculated and observed scores) must be met in regression analysis. In this case, residuals for mathematics anxiety scores should be approximately normally distributed. To determine the normality of residual mathematics anxiety scores, the Kolmogorov-Smirnov test was used. The result can be seen in Table 2.

Table 2 One-Sample Kolmogorov-Smirnov Test

		Standardized Residual
Normal Parameters[a, b]		374
	Mean	.0000000
	Std. Deviation	.99597043
Most Extreme Differences	Absolute	.033
	Positive	.033
	Negative	−.014
Kolmogorov-Smirnov Z		.629
Asymp. Sig. (2-tailed)		.824

According to Table 2, the output shows that Sig. (2-tailed) value is 0.824, more than 0.05. It means that the residual for mathematics anxiety scores were normally distributed. Therefore, the normality of the residual for the dependent variable was fulfilled.

Multicollinearity

The next assumption that must be met in regression analysis is multicollinearity. To conduct a regression analysis, the multicollinearity between independent variables must not exist (each independent variable is independent of the others). In this study, the multicollinearity between the dimensions of mathematical beliefs should not exist. To determine the multicollinearity, Tolerance and Variance Inflation Factor (VIF) value in SPSS output can be used (Hair et al., 2010). If Tolerance value is not less than 0.1 or VIF value is less than 10 then there is no multicollinearity between independent variables. The Tolerance and VIF value of mathematical beliefs are shown in Table 3.

Table 3 Tolerance and VIF Values of Mathematical Beliefs

Variable	Tolerance	VIF
Belief about the nature of mathematics	0.999	1.001
Belief about teaching mathematics	0.990	1.010
Belief about learning mathematics	0.989	1.011

According to Table 3, Tolerance values of belief about the nature of mathematics, belief about teaching mathematics and belief about learning mathematics were not less than 0.1. In addition, the VIF values were less than 10. It means that there was no multicollinearity between them. In other words, the assumption of multicollinearity was fulfilled.

Linearity

Beside normality and multicollinearity, the assumption that must be met is linearity. If the plot between the standardized residual value and standardized prediction value does not make a clear or systematic pattern then the model is considered linear (Pallant, 2011). Figure 1 showed the scatterplot between the standardized residual value and standardized prediction value of mathematics anxiety. The scatterplot did not make a pattern, so the model was considered linear.

Outliers

To conduct a regression analysis, outliers should be removed. The presence of outliers can be detected from scatterplot (Pallant, 2011). Outliers are cases that have a standardized residual of more than 3.3 or less than −3.3 (Tabachnik & Fidell, 2007). As displayed in Figure 1, there were no standardized residuals that more than 3.3 or less than −3.3. Therefore, there were no outliers in the data so the assumption for outliers was fulfilled.

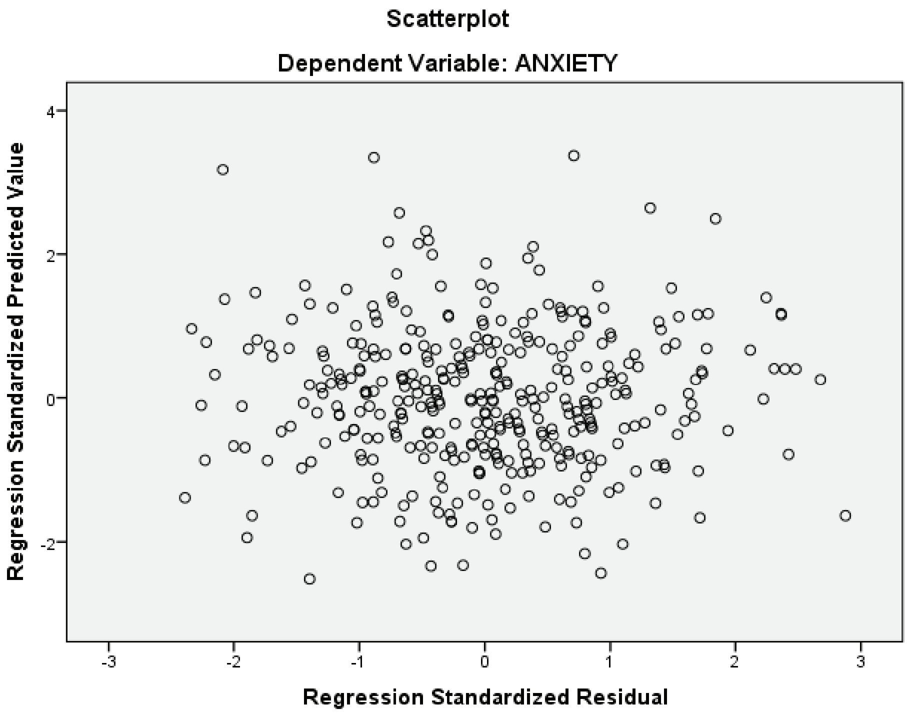

Figure 1 Scatterplot between Standardized Residual Value and Standardized Prediction Value of Mathematics Anxiety

The influences of mathematical beliefs dimensions on mathematics anxiety

In this study, regression analysis was used to determine, if any, the influence of the dimensions of mathematical beliefs on mathematics anxiety. The dimensions of mathematical beliefs are beliefs about the nature of mathematics, beliefs about teaching mathematics and beliefs about learning mathematics. Multiple regression analysis was used to determine the influence of beliefs dimensions on mathematics anxiety. The result of regression analysis is summarized in Table 5.

Table 5 Result of Regression Analysis

Model	*R*	*R* Square	Adjusted *R* Square	Sig. *F* Change
1	0.151	0.023	0.015	0.036

According to Table 5, the correlation coefficient (*R*) value is 0.151. The correlation coefficient indicates the strength of the relationship between the combination of independent variables in the model and the dependent variable. Sig. *F* Change value is less than 0.05 (p=0.036). It means that there is a significant relationship between the combination of independent variables in the model and the dependent variable. The value for *R* Square of 0.023 indicates that mathematical beliefs only can predict 2.3% of mathematics anxiety. However, not all of three dimensions of mathematical beliefs have a significant effect on mathematics anxiety. The standardized coefficients beta values of mathematical beliefs dimensions are shown in Table 6.

Table 6 Standardized Coefficients Beta of Mathematical Beliefs Dimensions

Variable	Beta	Sig.
Belief about the nature of mathematics	−0.057	0.270
Belief about mathematics teaching	−0.077	0.131
Belief about mathematics learning	−0.107	0.038

Based on Table 6, beliefs about the nature of mathematics and beliefs about mathematics teaching have negative effects on mathematics anxiety (Beta = −0.057 and Beta = −0.077) but these are not statistically significant ($p > 0.05$). It means that there is no significant influence of beliefs about the nature of mathematics and beliefs about mathematics teaching on mathematics anxiety. However, beliefs about mathematics learning have a small negative effect on mathematics anxiety (Beta = −0.107) and this is statistically significant ($p = 0.038$, $p < 0.05$). It means that the only mathematical beliefs dimension that has a statistically significant effect on mathematics anxiety is beliefs about mathematics learning.

DISCUSSION

Based on the findings, the only dimension of mathematical beliefs that have a small significant influence on mathematics anxiety is beliefs about mathematics learning. According to Vermeulen (2007), the teacher's beliefs about what mathematics is and how it should be taught and learnt are one of the causes of mathematics anxiety. This finding supports Jackson (2008) study. Jackson conducted the study with a sample of primary teaching students. His study reveals that mathematics anxiety exists for students with their fears influenced by their beliefs and past experience. Furthermore, mathematics anxiety appears to be a real fear influencing the way they think about mathematics and subsequently affecting their learning.

The finding also showed that there is a significant relationship between mathematical beliefs and mathematics anxiety however mathematical beliefs could predict mathematics anxiety in a small percentage. This finding confirms the findings of Walsh (2008), Cox (2011), Usop et al., (2013) and Haciomeroglu (2013). Their studies show that mathematical beliefs correlate with mathematics anxiety.

CONCLUSION

The study shows that only beliefs about mathematics learning have a statistically significant effect on mathematics anxiety. In addition, mathematical beliefs only could predict mathematics anxiety in a small percentage although they are correlated. Since the prediction is only to a small extent, it can be assumed that mathematical beliefs as a whole do not really influence mathematics anxiety. Future research in this area may be undertaken to study other factors that influence mathematics anxiety better.

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