Analyzing Mathematics Beliefs of Pre-Service Teachers using Confirmatory Factor Analysis

Mazlini Adnan
Marzita Puteh
Universiti Pendidikan Sultan Idris, Tanjong Malim, Malaysia

Effandi Zakaria
Universiti Kebangsaan Malaysia, Bangi, Malaysia

ABSTRACT

Mathematics beliefs play an important role in enhancing the quality and the effectiveness of teaching and learning. This study analyzes the mathematics beliefs of 317 pre-service teachers from six Higher Education Institutions (HEIs) (Government Public Universities) who were randomly selected to participate in this study. Questionnaires consisting of twenty three items were given to the respondents during the data collection process. The validation of the items was done by using confirmatory factor analysis (CFA). In order to obtain a model fit for the measurement model of mathematics beliefs, several fit index tests such as CMINDF, GFI, AGFI, IFI, NFI, CFI, TLI and RMSEA were used. Constructivist beliefs and traditional beliefs were identified as the contributing factors in the model. The analysis also revealed that mathematics beliefs consist of structures of two hidden variables. The correlation between the two variables (constructivist beliefs and traditional beliefs) is at a moderate level. Hence, pre-service teachers should be able to recognize their type of mathematics beliefs in order to become effective mathematics teachers.

Keywords: pre-service teachers, mathematics beliefs, confirmatory factor analysis (CFA), structural equation modeling (SEM)

Mathematics Beliefs

Research on teachers' beliefs and goals as well as research on teachers' practices is common. But in recent years, research on the relationship between teachers' beliefs in practice has been an important issue in mathematics education (Goldin, Rösken. & Törner, 2009; Pehkonen, 2004). Marzita (2003) also states that teachers bring with them a variety of beliefs about mathematics based on their teaching and learning experiences. Hence, knowledge and beliefs held by teachers influence their practices and behavior in the classroom (Barkatsas & Malone, 2005; Beswick, 2007; Fuson, Kalchman & Bransford, 2005). Understanding the beliefs of pre-service teachers is also of paramount importance in mathematics education in order to develop and implement an effective teacher education program (Barlow & Reddish, 2006).

There are many opinions regarding the number of factors pertaining to mathematics beliefs. According to Effandi et al. (2009), Barkatsas and Malone (2005), Howard, Perry and Lindsay (1997), Bernardo (2002), Rosemarievic (2005), Jeongyeon (2009) and Thompson (1992), there are two factors. On the other hand, according to Yu (2008), Ernest (1991), Malmivouri (2001), Dionne (1984), Torner and Grigutsch (1994), Op't Eynde, De Corte and Verschaffel (1999), Op't Eynde De Corte and Verschaffel (2002) and Siti Mistima and Effandi (2010), there are three factors pertaining to mathematics beliefs but Van der Sandt (2007) suggested that there are four factors regarding mathematics beliefs. This study uses only constructivist and traditional beliefs as the two factors pertaining to mathematics beliefs.

The constructivist beliefs factor focuses on student centred approaches in the mathematics teaching and learning processes. It emphasises students' active participation in the process of acquiring knowledge and stresses the importance of understanding mathematics concepts. Traditional beliefs, on the other hand, emphasise that mathematics is a subject that involves mostly factual formulas, rules and procedures. Students are required to memorise the formulas, symbols, rules and their computational steps. Due to its importance, research regarding mathematics beliefs should be included as an important issue in mathematics education.

Research that has been conducted locally or internationally regarding mathematics beliefs shows that many teachers especially mathematics teachers are still using the traditional approaches and techniques that were used by their teachers as a benchmark. This is supported by several researchers who claim that most novice teachers teach the way they were taught. For example, if mathematics learning was through the process of memorization and teaching was based on many rules then this belief will be handed on to their students so that the emphasis is on memorizing rather than understanding actual mathematical concepts. These beliefs if not managed early will be disseminated to their students. This may lead to encouraging teachers to only teach mathematical procedures.

In Malaysia, a lot of research regarding mathematics beliefs has been conducted using quantitative mathematics beliefs instruments. (Maizan, 2010; Siti Mistima & Effandi, 2010) or qualitative ones (Roslina, 2007; Marzita, 2005; Cheah, 2001). All this research uses available mathematics beliefs instruments or revised versions. Effandi et al. (2009) have taken an initiative to develop a mathematics beliefs instrument especially for pre-service teachers in Malaysia. However, this analysis of the instrument is limited to testing exploratory factor analysis (EFA). Hence, this study will use a similar instrument developed by Effandi et al. (2009) but its testing and validation will extend to conducting confirmatory factor analysis (CFA) for mathematics beliefs of pre-service teachers.

Methodology

A total of 317 pre-service mathematics teachers from six public universities were chosen as respondents using stratified random sampling. The research involved respondents who are pre-service teachers in their third and fourth year from six HEIs that offer mathematics education programs. The number of respondents and their institution, gender and race is shown in Table 1. There are 24 (7.6 %) from Universiti Malaya (UM), 33 (10.3 %) from Universiti Putra Malaysia (UPM), 26 (8.2 %) from Universiti Sains Malaysia (USM), 20 (6.3 %) from Universiti Teknologi Malaysia (UTM), 29 (9.1 %) from Universiti Kebangsaan Malaysia (UKM) and 185 (58.4 %) from Universiti Pendidikan Sultan Idris (UPSI). Of these, 60 (18.9%) are males, and 257 (81.1%), are females. Of the respondents, 261 (82.3 %) are Malays, 43 (13.6%) Chinese, 6 (1.9%) Indian and 7 (2.2 %) Bumiputra Sabah/Sarawak (please refer to Table 1).

Table 1 Respondents' Profile

Type	N	Factor	Frequency	Percentage (%)
Gender	317	Male	60	18.9
		Female	257	81.1
Race	317	Malay	261	82.3
		Chinese	43	13.6
		Indian	6	1.9
		Bumiputera Sabah/Sarawak	7	2.2
IPTA	317	UM	24	7.6
		UPM	33	10.4
		USM	26	8.2
		UTM	20	6.3
		UKM	29	9.1
		UPSI	185	58.4

These teachers were given a questionnaire, Mathematics Beliefs Questionnaire, (MBQ) which consisted of 22 items on mathematics beliefs. The questions were adapted from Effandi et al. (2009). The number of items for each of the mathematics beliefs components in this study is shown in Table 2. The questions were distributed to 83 pre-service teachers to determine the reliability of the questions. It was found that alpha Cronbach value of the overall questions was 0.793. The reliability values of each construct ranged from 0.58 to 0.832. The value 0.58 was considered low (below 0.60); however, this value increased when the researcher conducted the confirmatory factor analysis.

Table 2 Number of item per component in mathematics beliefs

Component of mathematics beliefs	Number of item
Constructivist beliefs	15
Traditional beliefs	7

Results

The study used confirmatory factor analysis to validate the underlying hypothesized factor structure of MBQ. The items of MBQ were represented by measured or observed variables. The data were analyzed using SPSS 16.0 and AMOS 16.0. A confirmatory factor analysis were used to validate the measurement model of mathematics beliefs with two factors that include constructivist beliefs (fifteen items) (Figure 1) and traditional beliefs (seven items) (Figure 2).

At the beginning of the analysis, seven of the items (a22, a10, a16, a19, a6, a2 and a39) from constructivist beliefs and three of the items (a3, a35 and a13) from traditional beliefs were omitted since their factor loading value was lower than 0.33. Fit index tests like Absolute Fit Measure (GFI, AGFI), Incremental Fit Measure (NFI, TLI, IFI and CFI) and Parsimonious Fit Measure (CMIN/df) (Byrne, 2010; Hair et al., 2006; Hair et al., 2010) were used to test for the model fit which is obtained when all conditions of fit index are fulfilled. Non significant Chi-Square (χ^2) values and higher values (> 0.90) on GFI, CFI, AGFI, IFI, TLI and NFI indicate acceptable fit and Root Mean Square Error of Approximation (RMSEA) value should be less than 0.08 (Byrne, 2010; Hair, Black, Babin, Anderson, & Tatham, 2006; Hair, Anderson, Tatham, & Black, 2010).

It was found that the value of CMIN/df is 1.243 and all the values of GFI, CFI, AGFI, IFI and TLI are greater than 0.90. The value of RMSEA is 0.028 which is smaller than 0.08 as desired. These values indicate that the model has an acceptable fit.

Figure 3 shows the measurement model of mathematics beliefs with two structures. Each observed variable is represented by a box that has an acceptable significant factor loading. Based on confirmation factor analysis (CFA), the CMIN/df = 1.430, the RMSEA is 0.037, which is lower than 0.08 for the fit model. Fit indices GFI, AGFI, IFI, TLI and CFI greater than 0.9 but the value for the NFI index is lower than 0.9. Hence the correspondence is a weak model (Figure 3). However, there is a correlation between hidden variables and observed variables. Hence, it is clear that we have to modify the model (Byrne, 2001; Byrne, 2010).

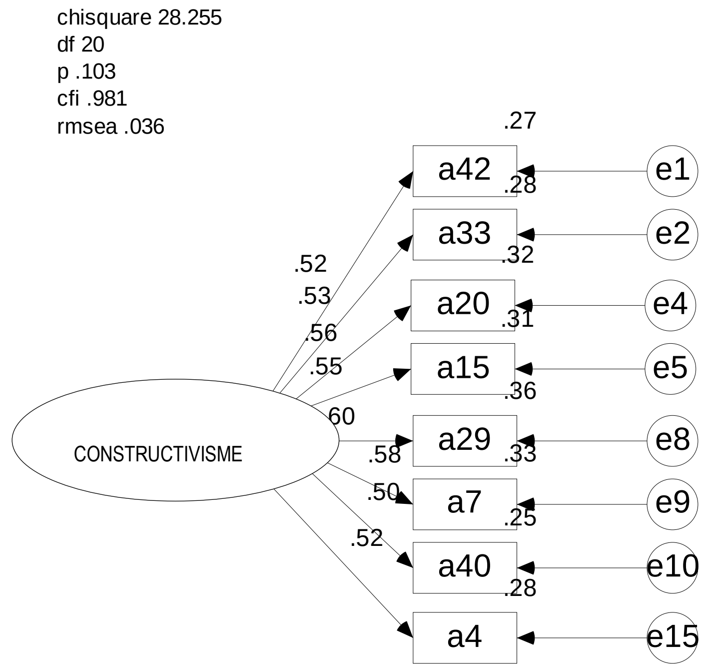

Figure 1 The finalized measurement model of constructivist beliefs of pre-service teachers

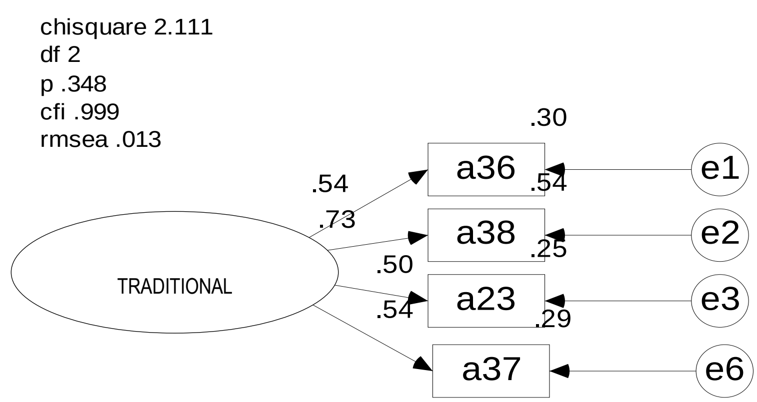

Figure 2 The final measurement model of traditional beliefs of pre-service teachers

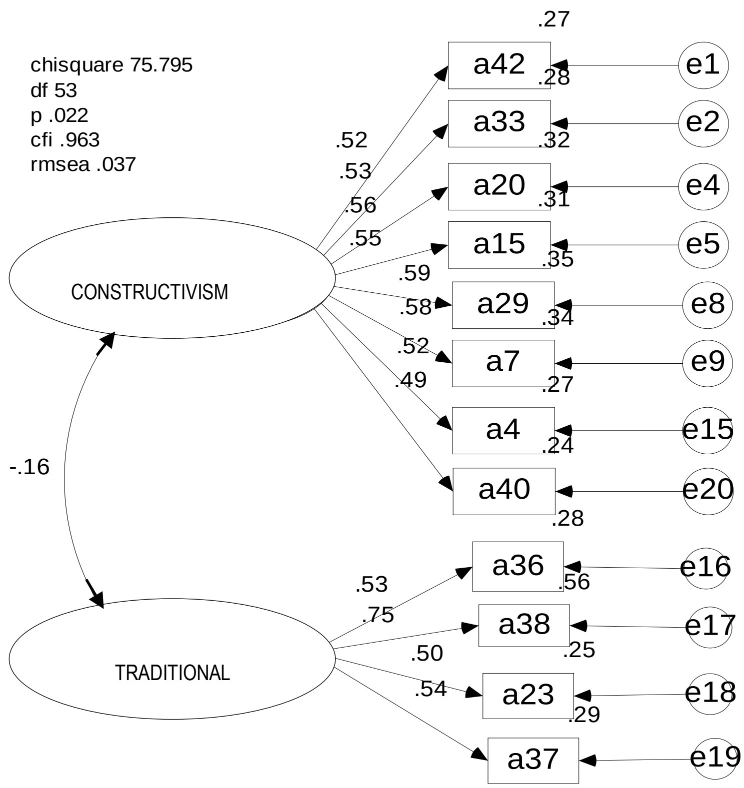

Figure 3 The first measurement model of mathematics beliefs of pre-service teachers

To modify the first measurement model of mathematics beliefs, the variables that had a very weak correlation value were removed from the model. The regression coefficient gives a low value. Although there is no correlation, the model does not fit despite the CMIN / DF and the fit indices GFI, CFI, AGFI, TLI and IFI being greater than 0.9, and the NFI is still less than 0.90, and the value of RMSEA is 0.037, which is lower than the 0.08 for the fit model. To modify the second measurement model of mathematics beliefs, researchers refer to the value of modification indexes (MI) which is given by AMOS. The MI has to do with adding arrows in the model: high MI's flag missing arrows which might be added to a model. In this study, the arrow is connecting e1 to e15 in the constructivist beliefs. Analysis of these modifications give the CMIN/DF = 1.243; fit indices GFI, AGFI, CFI and TLI greater than 0.90, and the value of RMSEA is 0.028 (Figure 4).

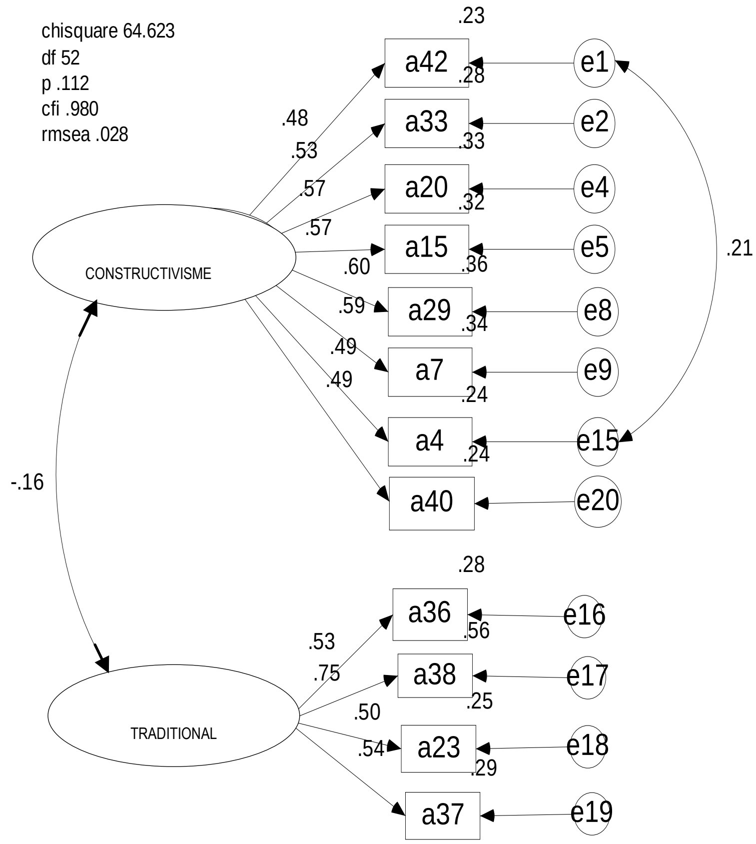

Figure 4 The final measurement model of the mathematics beliefs of pre-service teachers

Discussion

The measurement model of mathematics beliefs in this study is limited to constructivist beliefs and traditional beliefs. Based on the fit index test values of CMINDF, GFI, CFI, AGFI, IFI, TLI and NFI, and RMSEA, the confirmatory factor analysis shows that model is an acceptable fit. Hence, the measurement model of mathematics beliefs in this study consists of two hidden variables: constructivist beliefs and traditional beliefs.

The analysis showed that the hidden variable mathematics beliefs of these two structures support the mathematical model presented by Barkatsas and Malone (2005), Bernardo (2002), Effandi et al. (2009), Jeongyeon (2009), Howard et al. (1997) and Thompson (1992). However, this finding is not consistent with beliefs in the mathematical model presented by Ernest (1991), Dionne (1984), Malmivouri (2001), Op't Eynde et al. (1999), Op't Eynde et al. (2002), Siti Mistima and Effandi (2010), Torner and Grigutsch (1994) and Yu (2008) which produced three main factors for mathematics beliefs. Van der Sandt (2007) also presents the mathematics beliefs of four major factors that measure the beliefs about the nature of mathematics, learning mathematics, teaching mathematics and beliefs about the students of mathematics.

Conclusion

Without proper mathematics beliefs, teachers may face difficulty in teaching successfully (Marzita, 2005). This study aimed to investigate the mathematics beliefs of mathematics pre-service teachers in Malaysia. Mathematics beliefs held by pre-service teachers are an important aspect that needs to be studied. Therefore, further detailed research looking into mathematics pre-service teachers beliefs need to be conducted in order to understand the short and long term effects on their classroom practices. Some considerations in validating the measurement as well as testing the question in a different context of study are proposed for future study. This may lead to upgrading the quality of mathematics teaching.

References

Barkatsas, T. & Malone, J. (2005). A typology of mathematics teachers' beliefs about teaching and learning mathematics and instructional practices. *Mathematics Education Research Journal, 17(2),* 69-90.

Barlow, A. T. & Reddish, J. M. (2006). Mathematics myths: Teacher candidates' beliefs and the implications for teacher educators. *The Teacher Educator, 41,* 145-157.

Bernardo, A.B.I. (2002). Filipino college math teachers' beliefs about learning and teaching: Reckoning with the school math and the inquiry math traditions. *DLSU-CSB: Learning Edge, 3,* 44-71.

Byrne, B.M. (2001). *Structural equation modeling with AMOS: Basic concepts, applications and programming*. Mahwah, New Jersey: Lawrence Earbaum .

Byrne, B.M. (2010). *Structural equation modeling with AMOS: Basic concepts, applications and programming.* 2nd Ed. New York: Taylor & Francis .

Cheah Ui Hock. (2001). The construction of mathematics beliefs by trainee teachers in a teachers college: A multicase study. Unpublished doctoral dissertation. Universiti Sains Malaysia.

Dionne, J. J. (1984). The perception of mathematics among elementary school teachers. In. J.M Moser (Eds.). *Proceeding of the 6th Annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pg. 223-228). Madison (WI): University of Winconsin: PME-NA.

Effandi Zakaria, Lilia Halim, Khalid Abdullah, Norazah Mohd Nordin, Nor Sakinah Mohamad & Md Yusoff Daud. (2009). Pembangunan instrumen kepercayaan guru-guru pra-perkhidmatan terhadap matematik, pengajaran matematik dan pembelajaran matematik. Unpublished Research Report. Faculty of Education, Universiti Kebangsaan Malaysia.

Ernest, P. (1991). *The philosophy of mathematics education*. Hampshire, UK: The Palmer Press.

Fuson, K. C., Kalchman, M. & Bransford, J. D. (2005). Mathematics understanding: An introduction. In M.S. Donovan & J. D. Bransford (Eds.), *How students learn: History, mathematics, and science in the classroom* (217-256). Washington, DC: National Academic Press.

Goldin, G., Rösken, B. & Törner, G. (2009). Beliefs-no longer a hidden variable in mathematics teaching and learning process. In J. Maaβ & W. Schlöglmann (Eds.), *Beliefs and attitudes in mathematics education: New research result (pp 1-18).* Rotterdam: Sense Publishers.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. & Tatham, R. L. (2006). *Multivariate Data Analysis* (6th Ed.). New Jersey: Prentice Hall.

Hair, J. F., Anderson, R. E., Tatham, R .L. & Black, W .C. (2010). *Multivariate Data Analysis.* 7th ed. New Jersey: Prentice-Hall.

Howard, P., Perry, B. & Lindsay, M. (1997). Secondary mathematics teachers' beliefs about learning and teaching of mathematics. In. F. Biddulph & K. Carr (Eds.) *People in mathematics education. Proceeding of the 20th Annual conference of* *the mathematics education research group of Australasia*, pg: 50-57. Rotorua, NZ: MERGA.

Jeongyeon Kye Kim. (2009). Investigation of Korean pre-service teachers' beliefs about mathematics: Challenges and implications for effective teacher education. Unpublished Doctoral Dissertation. University of Missouri Kansas City.

Maizan Mahmud. (2010). Kepercayaan dan Pengetahuan Pensyarah Matematik dan Pencapaian Pelajar Politeknik Malaysia: Pendekatan Model Persamaan Berstruktur. Unpublished doctoral dissertation. Universiti Kebangsaan Malaysia.

Malmivouri, M. (2001). The dynamics of affect, cognition and social environment in the regulation of personal learning process: the case of mathematics. *Research report 172*. Department of Education, University of Helsinki. Retrieved 30 March 2009, from http://ethesis.helsinki.fi/julkaisut/kas/kasva/vk/malmivouri/

Marzita Puteh. (2003). Factors Associated with Mathematics Anxiety Among Teacher Trainers. *Mathematics Education Society Journal* at: www.congres-consult.com/mes3/Projects/Puteh.com

Marzita Puteh. (2005). The Affective Domain of Learning Mathematics, in *Improving Teaching and Learning of Mathematics: From Theory to Practice.* Shah Alam: UPENA, Universiti Teknologi MARA.

Op't Eynde, P., De Corte, E. & Verschaffel, L. (1999). *Balancing between cognition and affect: students' mathematic-related beliefs and their emotions during problem solving,* pg: 97-105. Conference Abstract. Mathematics beliefs and their impact on teaching and learning of mathematics. Duisburg University, 21-27 November.

Op't Eynde, P, De Corte, E. & Verschaffel, L. (2002). Framing students' mathematics-related beliefs. In. G.C. Leder, E. Pehkonen & G. Torner (Eds.). *Beliefs: A Hidden Variable in Mathematics Education*, pg: 13-37. Dordrecht: Kluwer.

Pehkonen, E. (2004). State-of-the-art in Problem Solving: Focus on Open Problem. In *ProMath Jena 2003. Problem Solving in Mathematics Education* (Eds. H. Rehlich Zimmermann), 93-111. Hildesheim: Verlag Franzbecker.

Rosemarievic Villena-Diaz. (2005). Exploratory Investigation of the Beliefs and Practices of Elementary Mathematics Teachers of High and Low Performing Schools in Metro Manila. Philippine Normal University – Manila, Philippines.

Roslina Radzali. (2007). Kepercayaan matematik, metakognisi, perwakilan masalah dan penyelesaian masalah matematik dalam kalangan pelajar. Unpublished doctoral dissertation. Universiti Kebangsaan Malaysia.

Siti Mistima Maat & Effandi Zakaria. (2010). Hubungan antara kepercayaan matematik, amalan pengajaran dan pengetahuan pedagogi kandungan guru-guru matematik sekolah menengah. Prosiding Seminar Penyelidikan Siswazah UKM Jilid 5, 2010.

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In. A.D. Grouws (Eds.), *Handbook of research on mathematics teaching and learning,* pg: 127-146. New York: Macmillan.

Torner, G. & Grigutsch, S. (1994). Mathematische weltbilder bei studienanfangern-eine erhebung. *Journal for Mathematik Didaktik* 15(3/4), 211-252.

Van der Sandt, S. (2007). Research framework on mathematics teacher behaviour: Koehler and Grouws' framework revisited. *Eurasia Journal of Mathematics, Science and Technology Education, 3(4),* 343-350.

Yu, Huiying. (2008). A comparison of mathematics teachers' beliefs between England and China. In. Joubert, M. (Eds.*), Proceedings of the British Society for Research into Learning Mathematics,* 121-124.

Email address: mazlini@fsmt.upsi.edu.my