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Exploratory and Confirmatory Factor Analysis of Epistemic Beliefs Questionnaire about Mathematics for Chinese Junior Middle School Students

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Using a combination of exploratory and confirmatory factor analytic approaches, this research developed an epistemic beliefs questionnaire about mathematics. Initially, an exploratory factor analysis (N=591) evaluated a number of solutions, ranging from five to eight factors. The use of multiple evaluation indices and theoretical viewpoints provided clear support for 22 items on five factors. Next, a confirmatory factor analyses, using the second sample (N=613), examined the five–factor model identified by the exploratory factor analysis. A number of indices were used to evaluate model fit, and these indices demonstrated that the model identified in the exploratory analysis had the most adequate fit. The Cronbach alpha coefficients ranged from 0.82 to 0.92. These analyses provide strong support for a five factor structure for the 22–item EBQM, which will serve as a valuable tool for both instructors and researchers to assess junior middle school students' epistemic beliefs about the mathematics in eastern cultural background.

Key words: epistemic beliefs, questionnaire, factor analysis, cultural background.

Introduction

Research on students' epistemic beliefs has its origins in theories of genetic epistemology (Piaget, 1950). Genetic epistemology proposes discovering the roots of the different varieties of knowledge. An Individual's knowledge stems from the interaction between the individual and the environment. Since Perry's (1970) seminal work on the development of students' views of knowledge, the study of epistemic beliefs has become one of the fastest growing areas of research in general and in specific subject–

matter domains over the past 30 years.

In general terms, epistemic beliefs (some researchers call the term epistemic beliefs epistemological beliefs) refer to beliefs about the nature of knowledge (including its structure and certainty) and knowledge acquisition (knowing) (including sources and justification of math knowledge) (Hofer, & Pintrich, 1997; Schommer, 2004). Individuals' epistemic beliefs are complex, multidimensional, interactive, sociocultural, contextual, and developmental (Buhl & Alexander, 2006).Students epistemic beliefs have become one of critical components of understanding students learning. They like an invisible hand, deeply hiding behind an individual's behavioral expression, cognitive processes and emotional experience, but deeply influencing and mediating the learning process and the learning outcome (DE Backer & Crowson, 2006; Hofer,2001; Muis, 2004 & 2007; Schommer et al. 2005; Tang, 2007;).

Throughout theory and research, although multiple theoretical frameworks have been pursued, two overarching frameworks can be identified: those that examine epistemic beliefs from a developmental approach and those that explore epistemic beliefs from a multidimensional approach (Hofer, 2001; Schommer, 2004; Yu, & Tang, 2007). The multidimensional approach considers individuals' epistemic beliefs as a system of a small number of orthogonal (uncoordinated) dimensions that are more or less independent, developing not necessarily in synchrony. This approach focuses on the relationship of the hypothesized dimensions of the construct (separately or in certain combinations) with other cognitive constructs. Individuals' epistemic beliefs comprise initially of a narrow but relatively coherent structure of beliefs regarding the nature of knowledge and the process of knowing (Schommer, 2004).

For one thing, based on a multidimensional approach, many researchers have extensively discussed the nature and structure of epistemic beliefs, which have resulted in a growing common understanding, but there are still some major points of discussion, especially, the lack of consensus on the context–general and/or context–specific nature (such as mathematics) of epistemic beliefs deserves attention (Op't Eynde et al., 2006). For another, the social beliefs accumulated in a certain time and region profoundly influence individuals' epistemic beliefs. Many researches (Buehl & Alexander, 2006; Chan & Elliot, 2004; Schommer, 2004; Young, 2000) have revealed that cultural background is an important variable in the study of epistemic beliefs.

In this present research, we want to develop an Epistemic Beliefs Questionnaire about Mathematics (EBQM) for junior middle school students in China, as well as in some eastern countries. We will start from a review of the components and structure of students' epistemic beliefs about mathematics, and then make use of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to develop the EBQM. Lastly, from these three aspects we will discuss the results of this present research.

A Review: Research on Measure of Epistemic Beliefs about Mathematics

The measure of epistemic beliefs most commonly encountered in the most important classical literature are Schommer's Epistemological Questionnaire (EQ;Schommer,1990) and Hofer's Domain–specific Epistemological Belief Questionnaire (DEBQ;Hofer,2000). Schommer brought both conceptual and methodological changes to the study of epistemological understanding. First, she conceptualized personal epistemology as a belief system, which included beliefs about the structure of knowledge (simple vs. Complex), the certainty of knowledge (certain vs. tentative), and the source of knowledge (omniscient authorities vs. Personal construction) as well as beliefs about the nature of learning ability (fixed vs. malleable) and speed of learning (e.g., learning happens quickly or not at all) (Schommer, 1990). Schommer (1990) then created the 63–item questionnaire with two or more subsets of items to capture each of the five proposed dimensions of beliefs. Through EFA she introduced the EQ, which is composed of four factors, stated from a naïve perspective, which are: (i) simple knowledge—ranging from the belief that knowledge is isolated facts to the belief that knowledge is best characterized as highly interrelated ones; (ii) certain knowledge—ranging from the belief that knowledge is absolute and unchanging to the belief that knowledge is tentative and evolving; (iii) innate ability—ranging from the belief that ability to learn is given at birth to the view that ability to learn can be increased; and (iv) quick learning—ranging from the belief that learning takes place quickly or not at all to the belief that learning is gradual. Based upon Schommer's work, many researchers attempted to validate her instruments.

Based on a thorough review of the literature, Hofer (2000) argued that personal epistemology should be restricted to dimensions concerning the nature of knowledge and the process of knowing, and that each dimension could be expressed as a continuum. Within this framework, combining observations and interviews in introductory college classes, she developed a DEBQ, which consists of four dimensions: (i) certainty of knowledge—

ranging from the belief that knowledge is absolute and unchanging to the belief that knowledge is tentative and evolving; (ii) simplicity of knowledge—ranging from the belief that knowledge consists of more or less isolated facts to the belief that knowledge consists of highly interrelated concepts; (iii) source of knowledge—ranging from the belief that knowledge is transmitted from external authority to the belief that knowledge is actively constructed by individuals in interaction with the environment; and (iv) justification for knowing—ranging from justification through observation, authority, or what feels right to the use of rules of inquiry and the evaluation and integration of multiple sources.

In summary, empirical evidence is offered that dimensions of epistemic beliefs have been mixed in published factor analyses, but they are still worth examining. For example, in the wake of findings suggesting potential problems with the EQ, researchers have created other measures of epistemic beliefs. Kardash and Howell (2000), using a 42–item version of Schommer’s EFA custiument (1990), identified the factors as Nature of Learning, Speed of Learning, Certain Knowledge, and Avoid Integration. In Nussbaum and Bendixen’s (2003) research, factor analysis produced only three factors: Simple Knowledge, Certain Knowledge, and Innate Ability.

About students’ epistemic beliefs about mathematics, the majority of researchers substitute students’ mathematics beliefs for students’ epistemic beliefs about the mathematics (Tang， 2007). In line with Schoenfeld’s definition (1985), belief systems are one’s mathematical world view, the perspective with which one approaches mathematics and mathematical tasks. On the last decades, there has been increasing interest in the role of mathematics beliefs in mathematics education. In her review of research, with a focus on mathematics learning and problem solving, Muis (2004) pointed out that the components of students’ epistemic beliefs about mathematics may include the nature of mathematics knowledge, justifications of mathematics knowledge, and sources of mathematics knowledge, except for beliefs about mathematics learning. However the majority of research that has examined students' beliefs about mathematics suggests that students at all levels hold non availing beliefs. For example, students believe mathematics knowledge is passively handed to them by some authority figure, typically the teacher or textbook author, and they believe those who are capable of doing mathematics were born with a “mathematics gene” (a belief in innate ability). Students who held sophisticated epistemological beliefs about the nature of mathematics knowledge scored higher on a mathematics performance test than did those who held simpler or more naïve beliefs.

When research on students' beliefs is applied to cross–national comparisons, invariant factor structures and similarity of factor loadings become vitally important. Based on a review of the relevant research literature, Op't Eynde et al. (2006) through a principal components analysis developed a Mathematics–related Beliefs Questionnaire (MRBQ), in line with their literature–derived theoretical perspectives, which identified four major categories of students' beliefs that constitute their mathematics–Related belief system and four factors: (i) beliefs about the social context, (ii) beliefs about the self, (iii) beliefs about mathematics as a social activity, and (iv) beliefs about mathematics as a domain of excellence.

From a methodological perspective, the majority of the research in the past has relied solely on self–report measures and EFA. There are several issues that limit contributions of studies with EFA (Henson & Roberts, 2006). A combination of EFA and CFA approach to construct validity is called for in future studies (Tang, 2007). Therefore, combining EFA and CFA, this present research will both explore and confirm an Epistemic Beliefs Questionnaire about Mathematics (EBQM).

Method

Sample

The sample consisted from Chinese public school: Guilin, Nanning, Baise, Liuzhou, Nanjing districts in the southwestern Chinese Mainland. There were 1204 effective surveys from 1246 total students in the 23 participating schools (8 key middle schools and 15 common schools), which represents a return rate of 82.2%.

In order to determine the best factor structure to represent the EBQM, both an EFA and a CFA were performed. The sample of 1204 surveys was randomly split into two parts: sample 1 and sample 2. Sample 1 was used for the EFA while sample 2 was used for the CFA (MacCallum, Roznowski, Mar & Reith, 1994). Sample 1 was a total of 591, which included 199 in Grade 7 (108 male and 91 female), 189 in Grade 8 (100 male and 89 female) and 203 in Grade 9 (107 male and 96 female); urban students (55.2%) and rural students (44.8%). Sample 2 consisted of 613 effective data, which included 211 in Grade 7 (102 male and 109 female), 203 in Grade 8 (107 male and 96 female) and 199 in Grade 9(101 male and 98 female); urban students (52.4%) and rural students (47.6%).

Procedure

Firstly, based on Schommer's EQ and Hofer's DEBQ, integrating from various perspectives in mathematics education, an open–ended questionnaire of epistemic beliefs about the mathematics was developed. The initial information from the EBQM was encapsulated and extracted by from analyzing the questionnaire of thirty junior middle school students (Good, average, and poor students 10 respectively; 15 male and 15 female) selected at random.

Secondly, drawing upon Schommer's EQ and Hofer's DEBQ, as well as initial information from the EBQM, six dimensions with 65 items were proposed as an initial model of EBQM. For the purpose of content validation, a group of 6 experts in mathematics education, educational psychology, and educational measurement were asked to assess the quality of each item, verify the matching of items to the corresponding dimensions, and to provide further suggestions. These individuals recommended keeping the core wording of items to enhance comparability and to reduce error variance.

After deciding on six dimensions, a preliminary model with 30 items of EBQM on a 5–point Likert–type scales (from 1 strongly disagree to 5 strongly agree) was generated. The six dimensions were: (i) Structure of Math Knowledge (STRMK, ranging from isolated pieces to integrated connection), (ii) Stability of Math Knowledge (STAMK, ranging from certain knowledge to changing knowledge), (iii) Justification of Math Knowledge (JMK, ranging from experimental evidence to reasoning), (iv) Speed of Learning Math (SLM, ranging from quick learning to gradual learning), (v) Ability to Learn Math (ALM, ranging from innate to improvable), and (vi) Method of Learning Math (MLM, ranging from rote learning to meaningful learning). Every dimension is captured by three or more items. For analysis, all items were coded so that a higher score represented what the literature has identified as more sophisticated or availing beliefs. For instance, four items were assigned to the STRMK dimension, with high scores on this dimension representing the belief that mathematics knowledge is integrated and theoretical, and low scores representing the belief that mathematics knowledge consists of a loose collection of proven facts. (e.g., "Math knowledge consists of a loose collection of facts, formulas, theorems and problem solving"). Thirdly, the preliminary model of EBQM was administered to students inside the class. Specifically, students were instructed to ‘‘read the following items based on the scale below and fill in the appropriate circle on the scantron sheet.

Respond to each item based on what you believe. There are no right or wrong answers''. An EFA was then used to develop the underlying structure and the preliminary model of EBQM. Finally, a CFA was conducted to cross–validate the EBQM.

Results

Exploratory Factor Analysis

EFA is used to uncover the underlying structure of a relatively large set of variables. EFA with Principal Component Analysis was employed for Sample 1, aiming at empirically revealing and demonstrating the hypothesized, underlying structure of the preliminary model of EBQM. Before conducting an EFA, the results of the KMO measure of sampling adequacy and the Bartlett's test of sphericity were examined to determine the appropriateness of factor analysis. Bartlett's test was significant (BTS value=7446.60, $p<0.001$), showing that the correlation matrix was significantly different from an identity matrix. Similarly, the KMO Measure of Sampling Adequacy of 0.84 was substantial. Both revealed that it was appropriate to perform a factor analysis. A varimax rotation was then undertaken to assist in the interpretation of the factors.

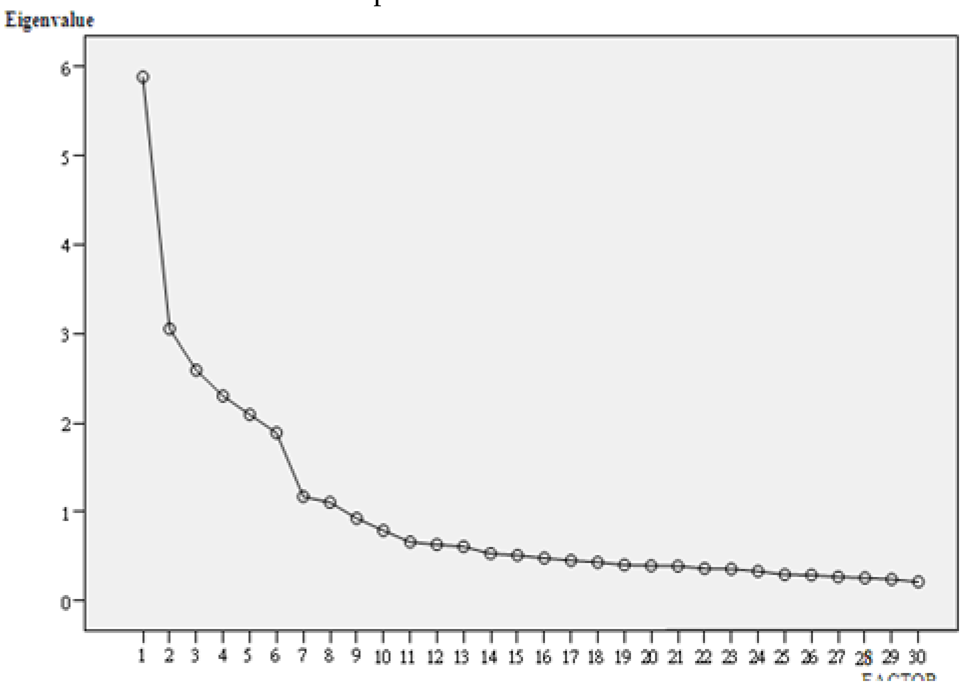

Figure 1. **Screen plot diagram showing the Eigenvalues of the items.**

Table1

Item Communalities and Final Exploratory Factor Analysis Results

Item	Communalities	CES SL(%)	Factor Loading MLM	ALM	STRMK	STAMK	SLM
T24	0.76	19.60	.856				
T28	0.74		.834				
T26	0.72		.833				
T23	0.68		.809				
T25	0.73		.800				
T13	0.77	29.76		.834			
T11	0.63			.778			
T14	0.63			.775			
T15	0.65			.759			
T12	0.61			.749			
T3	0.79	38.40			.869		
T4	0.71				.829		
T1	0.69				.821		
T2	0.69				.794		
T16	0.74	46.08				.814	
T17	0.69					.811	
T20	0.69					.810	
T18	0.68					.794	
T7	0.72	53.06					.830
T10	0.69						.817
T8	0.67						.806
T22	0.68						.788
Eigenvalues			5.879	3.05	2.60	2.30	2.10

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 7 iterations. CESSL Cumulative Extraction Sums of Squared Loadings; MLM method of learning math; ALM ability to learning math; STRMK structure of math Knowledge; STAMK stability of math knowledge; SLM speed of learning math.

From the scree plot (fig.1) and the Kaiser–Guttman rule, factor analysis of results on the 30 items indicated that five and six factors were most interpretable. The rotated principal factor loading matrix for the EBQM items was shown in Table 1. T24, T28, T26, T23, and T25 were assigned to factor 1 which reflected the beliefs about MLM. T13, T11, T14, T15, and T12 were assigned to factor 2 which reflected the beliefs about ALM. T3, T4, T1, and T2 were assigned to factor 3 which reflected the beliefs about STRMK. T16， T17, T20,and T18 were assigned to factor 4 which reflected the beliefs about STAMK. T7, T10, T8, and T22 were assigned to factor 5 which reflected the belief about SLM.

However, with respect to the theoretical framework from which the items were created, after a careful investigation of the content of those items, the sixth factor had only three items (T30,T27,T21) with substantial loadings and had split loadings on another factor as well. As far as the theory, T21 should be assigned to justification of math knowledge, while T27 and T30 should be assigned to factor 5. For these reasons, the six–factor solution did not appear to be the best representation of the structure of the EBQM. Examination of the item loadings, of items with substantial loadings on more than one factor, and of the actual wording of items that ended up being grouped together led to the determination that the five–factor solution was the best (see Table I). The overall percentage of variance extracted (53.06%) supported the assertion that the five factors were deemed sufficient and conceptually valid in their correspondence to the existing theory. All items had pattern coefficients higher than 0.30. Further, reliability coefficients for each factor all exceeded the threshold of 0.80 for acceptance (Stevens, 2002). Analysis of data from this pilot study guided the formation of the final form of the EBQM (see Appendix) with 22 items on five factors.

Confirmatory Factor Analysis

CFA seeks to determine if the number of factors and the loadings of measured (indicator) variables on them conform to what is expected on the basis of pre–established theory. A CFA was conducted with AMOS 7.0 (Arbuckle, 2006) to test the fit between the five–factor model and the data. The maximum likelihood estimation method was used. Multiple criteria were used to assess the goodness–of–fit between the model and the data as recommended in the literature. Figure 1 illustrated the model specification and the parameter estimates. As can be observed from the figure, the five–factor model of the EBQM was allowed to correlate to each other.

A multitude of measures exist that assist the researcher in deciding whether to reject or tentatively retain a priori specified over–identified model. In general, multiple goodness–of–fit tests were used to evaluate the fit between the hypothesized model and the data to determine if the model being tested should be accepted or rejected. These are Normed Fit Index (NFI; Bentler and Bonett 1980), the Comparative Fit Index (CFI; Bentler 1990), the Root Mean Square Error Approximation (RMSEA; Steiger and Lind 1980), and the minimum fit function Chi–Square ratio degrees of freedom (CMIN/DF, Marsh & Hocevar, 1985). NFI and CFI greater than 0.90 indicates a good fit to the data, and the RMSEA of about 0.05 indicates a close fit of the model and 0.08 represents a reasonable error of approximation. Despite its common use in the literature, Chi–Square is dependent on sample size and it is not recommended for use in assessing a single model. Rather, Chi–Square is useful for making comparisons between two nested models (Kline, 2005). Therefore, in this study, CMIN/DF indices were considered rather than chi–square indices, for the ratio should be close to one for correct models. CMIN/DF valve in the range of 2 to 1 or 3 to 1 are indicative of an acceptable fit between the hypothetical model and the sample data (Arbuckle, 2006).

errors nor were any additional alterations of the model specified.

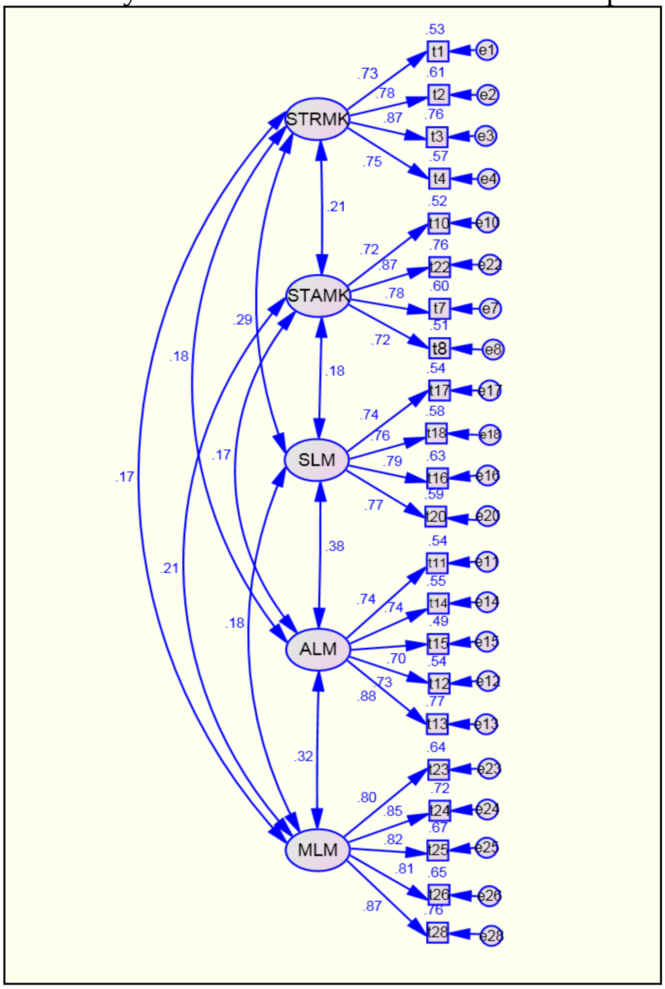

Figure.2 **Standardized coefficients for the five–factor model of EBQM.**

All coefficients are significant at p<0.01.NFI=0.95;

CFI=0.95;RMSEA=0.04;CMIN/DF=1.88.MLM method of learning math; ALM ability to learning math; STRMK structure of math knowledge; STAMK stability of math knowledge; SLM speed of learning math.

Internal Consistency

Internal consistency of the five–factor model of EBQM was checked by calculating alpha reliability coefficients using SPSS 15.0. Results are shown in Table 2. The overall alpha coefficient of 0.86 was good. There were no items whose elimination would have improved the coefficient substantially. The individual alpha coefficients for different scales ranged from 0.85–0.92, indicating satisfactory reliability. Furthermore, examining item–total correlations indicated that all items in each dimension contributed to the consistency of scores with item–total correlations higher than 0.64.

Table 2

Internal Consistency Reliability Results for the Five–Factor, 22–Item EBQM

Factor	**Item**	**Alpha coefficient**
Method of Learning Math(MLM)	T24, T28, T26, T23, and T25	0.92
Ability to Learning Math (ALM)	T13, T11, T14, T15, and T12	0.87
STRucture of Math Knowledge(STRMK)	T3, T4, T1, and T2	0.86
STAbility of Math Knowledge(STAMK)	T16，T17 ,T20,and T18	0.85
Speed of Learning Math (SLM)	T7,T10,T8,and T22	0.85
five–factor model of EBQM	all the items above	0.86

Conclusions and Discussion

The five–factor model of EBQM was developed as a result of an extensive review of literature, dialogue with mathematics educators for content validation, an EFA with a sample of 591 junior middle school students in order to test the factorial structure of the scale, and a CFA with a sample of 631 junior middle school students to confirm the five–factor model and to provide further reliability evidence.

Factor analytic evidence indicated that all pattern coefficients were high, indicating a significant contribution of each item to the corresponding factor. In addition, the results of the CFA also indicated that the five–factor model showed a good fit with high fit indices. These findings provide a single piece of evidence for the construct validity of the EBQM scores with this sample of junior middle school students. All five factors also showed high internal consistency estimates higher than 0.85. Overall, it can be concluded that the EBQM was a multidimensional construct consisting of five dimensions or factors: Factor 1 refers to the beliefs about Method of Learning Math (MLM), ranging from rote learning to meaningful learning, (e.g. T26: Memorizing Mechanically the process and method of math problem solving is not more important than seeking thorough understanding them). Factor 2 refers to the beliefs about Ability to Learning Math (ALM), ranging from innate to improvable (e.g.T11: Math success depends largely on natural talent or ability, but not much on effort). Factor 3 refers to the beliefs about STRucture of Math Knowledge (STRMK), ranging from isolated pieces to integrated connection (e.g. T4: Math learned at school relates to our everyday life). Factor 4 refers to the beliefs about STAbility of Math Knowledge (STAMK), ranging from certain knowledge to changing knowledge (e.g.T8: Math knowledge is not a fixed, but continuously evolving, culture). Factor 5 refers to the belief about Speed of Learning Math, ranging from quick learning to gradual learning (e.g. T18: Learning math is by steps and not by leaps, even for people who are good at it.).

The findings of this research shed light on the meaning of the construct EBQM, extend previous research and provide a new perspective on the underlying structure of this questionnaire. The latent structure of EBQM seems better represented by five factors with 22 items. These factors and items are essential to being successful in mathematics education and are commonly suggested in the previous questionnaires, such as EQ (Schommer, 1990) and DEBQ (Hofer, 2000).

However, in comparison to previous research, we found some similarities as well as differences. In terms of factors, except the factor of MLM, the connotation of other four factors is consistent with the previous questionnaires. The factor of MLM seems to combine Hofer’s justification and source of knowledge (Hofer, 2000) with Schommer’s (2004) embedded systemic model of epistemic beliefs, in which asymmetrical interpersonal relations generalize to beliefs in certain knowledge domains and ultimately how students approach learning. In terms of 22 items on the five factors, there are detectable differences between EBQM and the previous questionnaires.

For instance, the one of four items in the factor of STAMK (i. e. T22: Mathematics knowledge which teachers offer is very reliable) has never appeared in previous questionnaires.

Some possible explanations for these findings could be attributed to the following. Firstly, not only are epistemic beliefs multidimensional, but they are also domain specific (Buehl & Alexander, 2001; Hofer, 2000, 2006; Muis, Bendixen, & Haerle, 2006). The profile of epistemic beliefs may vary by knowledge domain–beliefs about the mathematics versus history–or involve some combination of domain–specific and generalized epistemic beliefs (Hofer, 2000). Hofer (2006) has argued that domain specific measures should be used in discovering how epistemic beliefs may be related to other aspects of cognition and learning. Students' beliefs about mathematics may be interconnected very strongly with their mathematics course. In spite of their respective relations to students' belief systems as a whole, it is clear that each of these independent variables is more closely linked to some categories of beliefs than to others. The features of mathematics subject in nature reflect oneness of the material world, mainly represented as the unification of structure and method, and determine that mathematics learning is to be meaningful learning. Consequently, the items and five factors of EBQM have lots of the taste of Mathematics. Some items on the factor of MLM and ALM fall within epistemic dimensions of students' mathematics–related belief systems (Schoenfeld , 1985; Op't Eynde et al. , 2006) .

Secondly, a possible explanation is most closely linked to educational and cultural backgrounds. For instance, T22 and T24 are most closely linked to cultural characteristics. T22 concerning belief about authority reflects the source of knowledge (Hofer, 2000). This suggests that because of the more authoritarian structure of their society, Chinese students more than U.S. students, in general were willing to accept statements by authorities about mathematics knowledge, and believed that knowledge was both simple and certain. This is consistent with the previous research in cultural settings (Chan & Elliot, 2004; Young, 2000). T24 concerning belief about learning mathematics embodies a key belief in China: practice makes perfect. Mathematics educators in the West usually put an emphasis on understanding in mathematics teaching and learning, while in China, as well as in some Eastern countries, routine or manipulative practice is an important mathematics of learning approach (Li, 2002, Cai & Cifiralli, 2004). For instance, with respect to learning mathematics, U.S. students believe understanding mathematics is more important than doing more exercises, whereas Chinese students would rather believe it is more useful to do more mathematics problems than understand mathematics. In terms of solving mathematical problems, Chinese students are less willing to take risks in problem solving, and can generate more solutions if they are asked for them (Cai,2004). In short, this interpretation supports the connection between general culture–based interpersonal relations and learning depicted by Schommer's (2004) embedded systemic model of epistemic beliefs.

Another possible explanation for these findings could be the questionable methodology adopted in the psychometric development of this instrument. Research based on slightly different theoretical frameworks and methodology may result in slightly different dimensions. A combination of EFA and CFA, this present research explored and confirmed the EBQM. The goal of EFA is to reduce the numerous measured variables to a few more reliable latent constructs. This is not generally being driven by a priori theory. The goal of CFA is to test a theory when the analyst has an adequate rationale regarding the structure of the data. The appropriate use of both methods involves a series of fundamental decisions that directly affect results and interpretations (Henson & Roberts, 2006). Such reliance solely on EFA or CFA would have failed to detect important effects in this present research. With respect to the usage of CFA, it should be acknowledged that these findings are tentative since further research is needed to confirm them by using comparison of models and multi-group CFA to increase external validity.

Nevertheless, CFA should be further studied. It seems clear that these findings shed light on the components and structure of students' epistemic beliefs, extend the previous research ,and provide a new perspective on the underlying structure of this questionnaire. The EBQM scale will serve as a promising tool for both instruction and research in mathematics education and educational psychology fields to assess junior middle school students' epistemic beliefs about mathematics in China, as well as in some Eastern countries.

References

Arbuckle, J.L. (2006) *Amos 7.0 User's Guide*. Chicago,IL: SPSS.

Bentler, P. M. (1990). Comparative fit indices in structural models. *Psychological Bulletin*, 107, 238–246.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, 88, 588–606.

Buhl, M.M., & Alexander, P.A. (2001). Beliefs about the academic knowledge. *Educational Psychology Review*, 13, 385–418.

Buehl, M. M., & Alexander, P. A. (2006). Examining the dual nature of epistemological beliefs. *International Journal of Educational Research*, 45, 28–42.

Cai J. (2004). Why do U.S. and Chinese students think differently in mathematical problem solving? Exploring the impact of early algebra learning and teachers' beliefs. *Journal of Mathematical Behavior*, 23, 135–167.

Cai, J., & Cifarelli, V. (2004). Thinking mathematically by Chinese learners: a cross–national comparative perspective. In: L. Fan, N.–Y. Wong, J. Cai, & S. Li (Eds.), *How Chinese learn mathematics: perspectives from insiders*. Singapore: World Scientific.

Chan, K., & Elliot, R. G. (2004). Epistemological beliefs across cultures: Critique and analysis of beliefs structure studies. *Educational Psychology*, 24(2), 123–142.

DeBacker, T. K., & Crowson, H. M. (2006). Influences on cognitive engagement: Epistemological beliefs and need for closure. *British Journal of Educational Psychology*, 76, 535–551.

Henson, R.K., & Roberts. J.K. (2006). Use of exploratory factor analysis in published research. Common errors and some comment on improved practice. *Educational and Psychological Measurement*, 66, 393–416.

Hofer, B. (2000) Dimensionality and differences in personal epistemology, Contemporary. *Educational Psychology*, 25, 378–405.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Educational Psychology Review*, 13, 353–382.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: beliefs about the knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.

Kardash,C.M.,&Howell,K.L.(2000).Effects of epistemological beliefs and topic–specific beliefs on undergraduates'cognitive and strategic processing of dual–positional text. *Journal of Educational Psychology*,92,524–535.

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd Ed). New York: Guilford Press.

Li Sh. (2002) Practice Makes Perfect: a key belief in China. In *Pre–conference Proceedings of the ICMI Comparative Study Conference, 20th–25th October, 2002*. Hong Kong: The University of Hong Kong, Faculty of Education.

MacCallum, R. C., Roznowski, M., Mar, C., & Reith, J. V. (1994). Alternative strategies for cross–validation of covariance structure models. *Multivariate Behavioral Research*,29, 1–32.

Marsh, H.W. & Hocevar, D. (1985). Application of confirmatory factor analysis to the study of self–concept: First– and higher–order factor models and their invariance across groups. *Psychological Bulletin*, 97, 562–582.

Muis, K. R. (2004). Personal epistemology and mathematics: A critical review and synthesis of research. *Review of Educational Research,* 74(3), 317–377.

Muis, K. R. (2004). Personal epistemology and mathematics: a critical review and synthesis of research. *Review of Educational Research*, 74, 317–377.

Muis, K. R. (2007). The role of epistemic beliefs in self–regulated learning. Educational Psychologist, 42, 173–190.

Nussbaum, E. M., & Bendixen, L. D. (2003). Approaching and avoiding arguments: The role of epistemological beliefs, need for cognition, and extraverted personality traits. *Contemporary Educational Psychology*, 28, 573–595.

Op't Eynde, P., De Corte, E. & Verschaffel, L. (2006). Epistemic dimensions of students' mathematics–related belief systems. *International Journal of Educational Research*, 45(1), 57–70.

Perry, W. G. Jr, (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt, Rinehart and Winston.

Piaget, J. (1950). *The psychology of intelligence*. London. Routledge & Kegan Paul.

Schoenfeld, A. H. (1985). *Mathematical problem solving*. Orlando, FL: Academic Press.

Schommer, M. (1990). Effects of beliefs about the the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M.(2004).Explaining the epistemological belief system: introducing the embedded systemic model and coordinated research approach. *Educational Psychologist*, 39(1), 19–29.

Schommer, M., Duell, O. K., & Hutter, R.(2005).Epistemological beliefs, mathematical problem–solving beliefs, and academic performance of middle school students. *The Elementary School Journal*, 105(3), 289–304.

Steiger, J. H., & Lind, J. C. (1980). Statistically based tests for the number of common factors. *Paper presented at the Psychometric Society Annual Meeting*, Iowa City, IA.

Stevens, J.(2002). *Applied multivariate statistics for the social sciences*. Mahwah, NJ: Erlbaum.

Tang, J.(2007). Review of researches on students' epistemological beliefs. *Journal of Mathematics Education* (Chinese Version), 1, 29–33.

Youn, I.(2000). The culture specificity of epistemological beliefs about the learning. *Asian Journal of Social Psychology*, 3, 87–105.

Yu, P. & Tang J.(2007).The Development and Prospect of Personal Epistemology Researches. *Advances in Psychological Science* (Chinese Version), 3,443–450.

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