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Jordanian Version of the Epistemological Beliefs Questionnaire about Mathematics: The Validation Study

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Abstract: This article describes a study measuring epistemology about mathematics by means of the Epistemological Belief Survey about Mathematics developed in USA which was then adapted to be used in Jordan. The survey data from 300 tenth grade students and 450 twelve grade students were collected in two phases to facilitate both exploratory factor analysis (EFA) and the confirmatory factor analysis (CFA). Furthermore, the reliability analysis of the scores and convergent, discriminate, and subgroup validity coefficients were examined. Finding suggested that the inventory measures five constructs, namely, the innate ability, the structure of knowledge, the source of knowledge. The certainty of knowledge, and the speed of knowledge acquisition. These results demonstrated that the Jordan version of EBQM is a valid and reliable instrument which may serve as useful in guiding future research aiming to understanding students' epistemological beliefs about mathematics.

Keywords: Innate ability, Certainty of knowledge, Source of knowledge, Speed of knowledge, Structure of knowledge

INTRODUCTION

Beliefs influence a variety of cognitive processes and, ultimately, learning (Muis & Foy, 2010). Parajes (1992) pointed out that "beliefs cannot be directly observed or measured but must be inferred from what people say, intend, and do" (p. 314). Because beliefs reside in an individual's mind, they are often referred to as implicit beliefs (Epler, 2011). Muis and Foy (2010) pointed out that epistemological beliefs often function as an implicit belief. Epistemological beliefs focus on the manner in which individuals come to know, their beliefs about knowing, and how those beliefs are a part of and influence cognitive processes (Hofer & Pintrich, 1997). Because epistemological beliefs about knowledge and knowing influence learning and can even enhance teaching effectiveness, Hofer points out that the study of personal epistemology as a construct with educational implications is at a critical point in time (Hofer, 2001). Moreover, a learner's epistemological beliefs also influence the type of achievement goals a learner sets. Achievement goals "refer to students'self-reported motivations for completing tasks in specific achievement settings" (Ravindran et al., 2005, p. 222).

Individuals' epistemic beliefs are complex, multidimensional, interactive, sociocultural, contextual, and developmental (Buhl & Alexander, 2006). Student's 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).

The various theoretical models used to conceptualize personal epistemology include: developmental models, cognitive models, multi-dimensional models, resource models, domain specific models, and integrated models. The multidimensional approach considers individuals' epistemological beliefs as a system of a small number of orthogonal (uncoordinated) dimensions that are more or less independent, developing

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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 (Tang, 2010).

Schommer's (1990) multi-dimensional theory of epistemological characterized epistemological beliefs as a set of "more or less" independent dimensions. Initially, her theory consisted of five epistemological dimensions: Simple Knowledge-knowledge is simple rather than complex, Omniscient Authority-knowledge is handed down by authority rather than derived from reason, Certain Knowledge-knowledge is certain rather than tentative, Innate Ability-the ability to learn is innate rather than acquired and Quick Learning-learning is quick or not at all rather than gradual.

Many researchers have extensively discussed the structure of epistemological 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 epistemological beliefs deserves attention (Op't Eynde et al., 2006). More recently, researchers have begun to focus on domain or discipline specific epistemological beliefs (Buehl, Alexander, & Murphy, 2002; Hofer, 2000) and the results suggest that students' epistemological beliefs vary by domain. For instance, researchers have documented distinct views of knowledge and learning between domains like mathematics and social studies (Buehl et al., 2002).

In this present research, we want to develop an Epistemological Beliefs Questionnaire about Mathematics (*EBQM*) for secondary school students in Jordan, as well as in some eastern countries. We will start from a review of the components and structure of students' epistemological beliefs about mathematics, and then make use of exploratory factor analysis (*EFA*), confirmatory factor analysis (*CFA*) and further techniques to develop the *EBQM*.

Epistemological beliefs about mathematics

"Students' mathematics-related beliefs are the implicitly or explicitly held subjective conceptions students hold to be true that influence their mathematical learning and problem solving" (Op'T Eynde, DeCorte, & Verschaffel, 2002, p. 24). Mathematics beliefs have been shown to influence student engagement, effective strategy use in problem solving, and academic achievement (e.g., Lerch, 2004; Schommer-Aikins et al., 2005). A number of attempts have been made to quantitatively measure mathematics beliefs (Schoenfeld, 1989; Kloosterman & Stage, 1992; Hofer, 1999; Koller, 2001; Op't Eynde & DeCorte, 2003; Tang, 2010).

Research related to mathematics beliefs has documented that students generally view mathematics knowledge as static, believe the goal of problem solving is to produce the right answer, believe that mathematics knowledge is passively received from a teacher, believe that mathematics skill is either something you have or you don't (Lerch, 2004; Kloosterman, 2002; Mtetwa & Garofalo, 1989; Schoenfeld, 1989), Moreover, the findings were generally consistent and indicated that students at all levels of instruction viewed mathematics as the memorization of a variety of algorithms (De Corte et al. 2002).

If beliefs are formed as a result of the structure of instructional contexts, then it is important for beliefs to be addressed directly in mathematics classrooms, teacher education programs, and professional development programs. Teachers and students must be made aware of beliefs that may influence learning outcomes. It follows that in order for mathematics beliefs to be addressed, they must be assessed. One of the most efficient methods of measuring student and/or teacher beliefs is the use of scales that can be quickly scored and analyzed to provide feedback to students and teachers (Wheeler, 2007). Existing instruments have little or no psychometric information with which to judge the reliability and validity, therefore "more comprehensive instruments have to be designed and validated" (DeCorte et al., 2002, p. 315). A need has been expressed (Muis, 2004) for a better understanding of the relationship between student beliefs, learning environments, and the influence of teacher's beliefs on student beliefs. These questions cannot be effectively answered without a reliable and valid measure of mathematics related epistemological beliefs.

Given that the *EBQM* items were intended to measure student's epistemological beliefs about mathematics in the United State, cross-cultural adaptation would highlight the interpretation of results from studies in other countries. Researchers suggest the need for Multilanguage versions of educational and psychological tests (Ercikan, 2002; Hambleton, 2005; Hambleton & DeJong, 2003, Aydin & Upoz, 2010) as interest in cross-cultural psychology and international comparative studies of achievement grows. The social beliefs accumulated in a certain time and region profoundly influence individuals' epistemic beliefs (Tang, 2010). 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. Wheeler (2007) developed mathematical beliefs questionnaire about mathematics with partially focus on conducting *EFA* to provide construct-related evidence of validity. 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*). Wheeler (2007), however, neither attempt to conduct *CFA* in terms of discriminate validity nor to investigate evidence for subgroup and convergent validity. These recognitions have raised the need to provide an in-depth study reporting exploratory and confirmatory factor analysis together with further techniques such as canonical analysis.

The purpose of the present study was twofold. First, we took *EBQM* originally developed by Wheeler (2007) and translated into Arabic. Second, we tested the reliability and the validity of Jordanian version. The adaptation of the instrument would illuminate alternative ways to measure students epistemological beliefs about mathematics and highlight researchers draw upon parallel development processes in different language and different national context for international comparative (Aydin & Upoz, 2010).

METHODS

Participants

All tenth and twelve grade students (science stream) in Irbid/Jordan were identified as the target population of the study. The desired sample size was determined and cluster random sampling was used to obtain the samples. In the first phase, 300 tenth grade students (45% males, 55% females) from two public secondary schools and two private secondary schools in Irbid-Jordan participated in the study. For the phase 2 the sample involved 450 twelve grade students (47.3% males, 52.7 females) from five secondary schools, three public and two private schools in Irbid-Jordan different from the previous sample. The participants of the both phases had an age range of 16 to 19.

PROCEDURE

Participants were informed of their rights, provided an explanation of the purpose of the study, and provided a copy of the approved informed consent. Those who chose to participate were given a packet that included a brief demographic survey, the Epistemological Beliefs Questionnaire for Mathematics (EBQM).

A tow-phase study was conducted during 2011-2012 academic year to adapt the EBQM for Jordanian secondary students. In the first phase, the dimensions of the inventories were determined. The data gathered from the first phase were evaluated by exploratory factor analyses. The second phase included the confirmatory factor analysis to evaluate whether the Jordanian factor model specified in the first phase provides a good fit or not.

Phase 1. The exploratory factor analyses were performed to evaluate the factor structure of EBQM with regard to the data obtained from Jordanian secondary students. A principal component factor analyses with oblimin rotation was conducted to determine the factor structure underlying the data within the framework of *SSPS* 20.0 for Window. The oblique method of rotation was chosen as a correlation between the subscales of *EBQM* was expected (Ford, MacCallum, & Tait, 1986). In addition, the inter item correlation ranged from .11 to .52, sufficient to justify using an oblique rotation and analyzing both pattern and structure matrices (Henson and Roberts, 2006). The Kaiser-Meyer-Olkin (*KOM)* measure of sampling adequacy and Bartlett's Test of Sphericity (*BTS*) were analyzed to ensure that the characteristics of the data were suitable for performing *EFA.* Since the results of *KOM* and *BTS* indicated satisfactory indexes, a further consideration was to determine the number of factors to be extracted in the subsequent analyses. Thompson and Daniel (1996) suggested three methods to selected factors. Accordingly, the present study used: (a) eigenvalue-greater-than-one rule (Ksiser, 1960), (b) scree test (Cattell, 1978), and (c) parallel analysis (Horn,1965). To decide which items to retain in each factor, the following rules were used: (a) item loading have to exceed .30 on at least one factor (Hair et al., 2006) and (b) at least three significant loading is required to identify a factory (Zwick and Velicer, 1986).

Phase 2. The confirmatory factor analysis was performed to provide supportive evidence to the factor structure by using Amos 20.0. Prior to Confirmatory factor analysis, the data were examined for multivariate normality, multicollinearity and outliers. The bivariate correlations, tolerance, and variance inflation values (Tabachnick & Fidell, 2007) indicated that neither bivariate nor multivariate multicollinearity was present. Because maximum likelihood estimation assumes multivariate normality of the observed variables, the data were examined with respect to univariate and multivariate normality. No items showed skew or kurtosis that exceeded the cutoffs of |3| or |8| (Kline, 2005), respectively, indicating no problems with univariate nonnormality. On this basis, the data for this study was considered adequate for confirmatory factor analysis.

CFA is a theory-driven technique (Bollen, 1989) which is strongly recommended as a robust procedure for testing hypotheses about factor structures (Harris and Schaubroeck, 1990). The inventory which was modified with regard to the results of Phase 1 was administered to the new sample. Multiple criteria including the ratio of chi-square to the degrees of freedom (x^2/df). The root mean square residual (*RMR*), goodness-of-fit-index (*GFI)*, adjusted- goodness-of-fit-index (*AGFI*), root mean square error of approximation (*RMSEA*), and comparative fit index (*CFI*) were used to test model-data-fit. It is suggested substantively interpretive models with chi-square ration of three or less, a *RMR* below .05, a *GFI* above .90, an *GFI* above .90, a *RMSEA* from .06 to .08, and a *CFI* above .95 as good fitting (Schreiber et al., 2006).

Multiple regression analyses and *MANOVA* were conducted to collect data about *EBQM* validity. The students allow 65 minutes to respond the inventories. They were also requested demographic data including gender, grade level, and mathematics grade taken in the previous semester.

INSTRUMENT

1. **Epistemological Beliefs Questionnaire for Mathematics**

EBQM developed by Wheeler (2007) was used to assess students epistemological beliefs about mathematics in six major constructs: Innate ability (general and personal) (11 items), Structure of knowledge (4 items), Certainty of knowledge (4 items), Speed of knowledge acquisition (7 items), Source of knowledge (5 items), and Real world applicability (8 items). It was translated to Arabic and re-translated to English by three English language teachers. Jordanian version of *EBQM* was also checked by two Arabic language teachers in order to provide content-related evidence of validity. For the purpose of content validation five experts in educational psychology and educational measurement were requested to assess the appropriateness of each item within idiomatic expressions, verify the matching of items to the corresponding subscales through semantic structure, and provide further suggestions with reference to the heuristic approaches. Thus, the adaptation process was enriched in terms of both contextual and conceptual aspects. There were negative items (24 items); hence, all the negative items were recorded. The possible scores of this inventory ranged from 39 to 236 which were used to identify student's level of epistemological beliefs (e.g., 39= low level of epistemological beliefs; 236=high level of epistemological beliefs). For further analysis, the real world applicability dimension has been excluded. Moreover, innate ability-general and innate ability-personal dimensions have been combined in one dimension (Innate ability).

The original version of *EBQM* included thirty nine items and students responded to each item on a 6-point likert scale which range from "1-strongly disagree" to "6-strongly agree".

2. Mathematics achievement

Mathematics achievement was determined through mathematics grade taken in the previous semester.

RESULTS

Prior to principal components analysis (PCA), the bivariate correlation matrix was visually inspected as a preliminary assessment of inter-item correlation. Most values were in the low to moderate range (.04-.39). The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was then calculated, which is a ratio of the sum of the squared correlations to the sum of the squared correlations plus squared partial correlations. As the partial correlations decrease in size, which indicates distinct factors may emerge from the factor analysis, the *KMO* value will approach 1.0. Thus, the *KMO* is useful to predict if data are likely to factor well. The *KMO* value for the *EBQM* was acceptable at .882, indicating factor analysis was appropriate for the scale. Additionally, Bartlett's Test of Sphericity was significant [$\chi 2$ = 23830.375; (p=.000], which rejected the null hypothesis that the correlation matrix was an identity matrix. By rejecting the null hypothesis the correlation matrix was deemed acceptable for factor analytic techniques. Initial results revealed high communalities ranging from .53 to .72, and eleven factors with eigenvalues greater than 1.00, accounting for 62.57% of variance. All items had factor loading of at least .30. The screeplot was investigated to select the correct number of factors to be extracted. This inspection revealed a clear break between the fifth and sixth factors, and that first five factors explain the much more of the variance than the remaining factors. Hence, using Catell's (1966) scree test it was decided to retain five factors for subsequent analyses. The scree plot is presented in Figure 1. This was further supported by the results of parallel analysis (figure 2, and table 1).

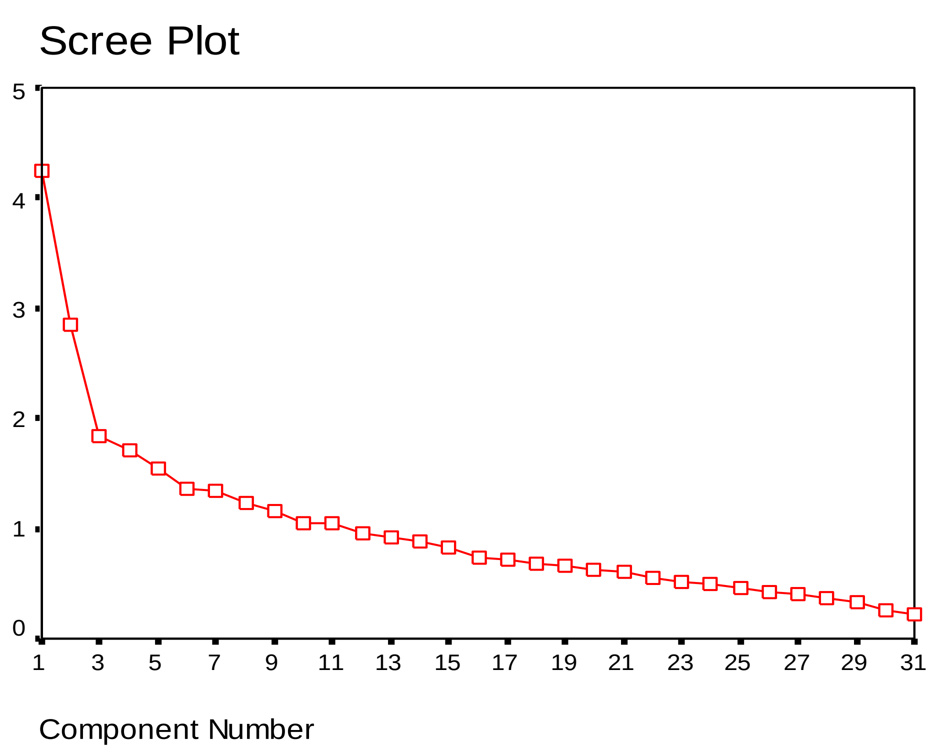

Figure 1: The Scree Plot

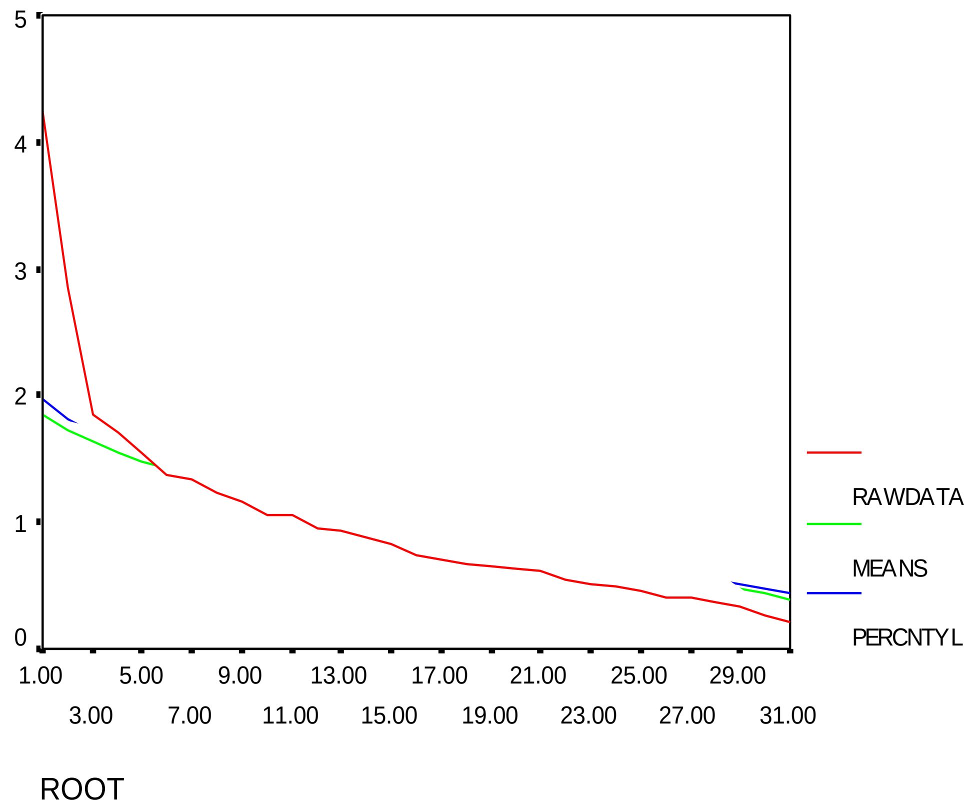

Figure 2: Parallel Analysis

Table 1: Comparison of Results From Principal Components Analysis (PCA) and Parallel Analysis of Results From Principal Components Analysis (PCA) and Parallel Analysis

Component Number	Eigenvalue generated from PCA	Criterion Value from Parallel Analysis	Decision
1	4.24	1.98	Accepted
2	2.85	1.81	Accepted
3	1.84	1.70	Accepted
4	1.71	1.62	Accepted
5	1.54	1.54	Accepted
6	1.36	1.48	Rejected

The second *EFA* was conducted by 31 items using an extraction to five factors. The five factor structure explained 39.32% of the total variance, with factor 1 contributed 13.89%, factor 2 contributed 9.19%, factor 3 contributed 5.95%, factor 4 contributed 5.52, and factor 5 contributed 4.97%. Regarding the Oblimin rotation, the five factors were interpreted in terms of the pattern and structure matrices. The careful examination of the factor loadings showed that items 10, 11, 14, 19 and 20 were problematic as their loading was less than .30, and needs to be deleted. Moreover, their communality was less than .30. It was suggested that communality values less than .30 indicate that the item does not fit well with the other items in its factor (Hair et al, 2010). Thus, within these considerations these items were dropped. Eigenvalues, percentages of variances explained by factors, and pattern and structure matrices along with communalities of the items for the second factor analysis with oblimin rotation of five-factor solution were presented in Table 2.

Table 2: Eigenvalues, Percentage of Variance Explained by Factors, and Pattern and Structure Matrix along with Communality Values of the Itemsfor the Second Exploratory Factor Analysis.

Factor	1	2	3	4	5
Eigenvalues	4.24	2.85	1.84	1.71	1.54
% of variance	13.89	9.19	5.95	5.52	4.97

Item	**Pattern Matrix**					**Structure Matrix**					
Factors	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**Communalities**
Item1	.77					.78					.62
Item4	.71					.69					.45
Item2	.64					.66					.54
Item19	.22					.18					.23
item3	.54					.53					.35
Item25	.51					.51					.32
Item6	.46					.50					.35
Item18	.45					.48					.31
Item17	.43					.47					.46
Item26		.72					.68				.53
Item10		.23					.24				.18
Item14		.29					.19				.08
Item9		.66					.65				.45
Item30		.61					.58				.58
Item8		.57					.51				.41
Item24			.67					.66			.45
Item22			.52					.56			.44
Item12			-.52					-.48	.44		.54
Item21			.51				.46	.58			.60
Item 20			.26					.21			.13
Item 7			.44					.42			.33
Item23			.43					.44			.32
Item13				.67					.65		.43
Item29				.63					.62		.40
Item15				.47					.51		.32
Item16				.43					.47		.33
Item27					.58					.60	.48
Item31					.53					.54	.33
Item14					.11					.24	.11
Item 5					-.52					-.51	.33
Item28					.44					.45	.30

Table 3: Eigenvalues, Percentage of Variance Explained by Factors, and Pattern and Structure Matrix along with Communality Values of the Items for the Third Exploratory Factor Analysis.

Factor	1	2	3	4	5
Eigenvalues	4.09	2.54	1.81	1.52	1.44
% of variance	15.73	8.77	6.95	5.85	5.53

Item	**Pattern Matrix**					**Structure Matrix**					
Factors	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**Communalities**
Item 1	.80					.80					.64
Item 2	.72					.70					.50
Item 4	.71					.70					.55
Item 3	.62					.58					.51
Item 25	.59					.51					.39
Item17	.58					.56					.34
Item18	.53					.51					.34
Item 6	.38					.42					.32
Item26		.72					.71				.49
Item 9		.68					.68				.55

Item30		.58					.59				.36
Item 8		.51					.56				.33
Item24			.69					.69			.40
Item22			.57				.	.61			.48
Item12			.56					.59			.35
Item21			-.54					.54			.61
Item 7			.51					.52			.47
Item23			.43					.41			.40
Item13				.78					.69		.48
Item29				.59					.54		.44
Item15				.48					.53		.54
Item16				.32		.			.39		.57
Item27					-.68					-.69	.41
Item31					-.66					-.65	.57
Item5					.57					.53	.48
Item28					-.31					-.33	.64

Consequently, the third *EFA* was conducted to determine the common factor structure of the remaining 26 items with oblimin rotation of five factor extraction. The *KMO* and *BTS* which yielded an index of .74 and 1070.43, respectively, ensured that the characteristics of the data set were suitable for *EFA*. The interpretation of the five factors with regard to the obblimin rotation in terms of the pattern and structure matrices demonstrated that all factor loading and communality values were above .30, concurrent with the suggestion of Hair et al (2006). This analysis revealed that eight items (items 1, 2, 4, 3, 25, 17, 18, and 6) constituted the first factor, four items (items 26, 9, 30, and 8) constituted the second factor, six items (items 24, 21, 22, 12, 23, and 7) constituted the third factor, four items (items 29, 13, 16, and 15) constituted the fourth factor, and four items (items 27, 31, 5, 28) constituted the fifth factor. Items in factor 1 revolved around innate ability, items in factor 2 revolved around structure of knowledge, items in factor 3 revolved around speed of knowledge, items in factor 4 revolved around source of knowledge, items in factor 5 revolved around certainty of knowledge. Minimum eigenvalues of these factors were 1.44 and together they explained 43.83% of the common variance in item responses. In terms of variance explained by each factor, innate ability accounted for 15.73%, structure of knowledge accounted for 8.77%, speed of knowledge accounted for 6.95%, source of knowledge accounted for 5.85%, and certainty of knowledge accounted for 5.53%. Along with the suggestion of Pett, Lackey, and Sullivan (2003) both the pattern and structure matrices were the focus of evaluation. As we can see in table 3, all items loading substantially on only one factor. Table 3 demonstrates the eigenvalues, percentages of variances explained by factors, pattern and structure matrices along with the communalities of the items for the third factor analysis with oblimin rotation of five-factors.

Analysis of data from this *EFA* guided to form the final version of the *EBQM* with twenty six items on five subscales. These subscales along with the definitions are:

1. **Innate ability (8 items):** The ability to learn is innate rather than acquired. A person with a fixed or naïve view of innate ability generally takes a deterministic view of intelligence and would endorse the idea that you have only what you are born with and no more. The person with a more sophisticated or incremental view of innate ability believes that intelligence functions more like a skill that can be improved with effort (Wheeler, 2007). Sample items from this subscale included: "I'm just not a math person" and "I'm confident I could learn difficult material like geometry if I put in enough effort".
2. **Structure of knowledge (4 items):** This belief reflects a continuum ranging from understanding knowledge as isolated bits to an understanding of knowledge as interrelated concepts. Sample items from this subscale included: "I like to find different ways to work problems" and "It is a waste of time to work on problems that have no solution".
3. **Speed of knowledge (6 items):** This belief ranges from the naïve view that learning happens quickly or not at all to the more sophisticated view that learning is a gradual process that requires continued effort and persistence. Sample items from this subscale included: "It takes a lot of time to learn math" and "When it comes to math, most students either *get it* quickly or not at all".

4. **Source of knowledge (4 items):** This belief reflects a range of views regarding the role of an authority figure. The naïve view is the belief that knowledge is external to the learner and thus knowledge must be obtained from an authority. The more sophisticated view reflects a constructivist understanding of the learning process as an interactive event with the learner functioning as an active participant rather than a passive recipient. Sample items from this subscale included: "To solve math problems you have to be taught the right procedure" and "Math is something I could never learn on my own".
5. **Certainty of knowledge (4 items):** This belief describes a continuum that ranges from a naïve view of knowledge as absolute truth to a more sophisticated view that knowledge is tentative and evolving. The foundation for this element of personal epistemology was the observation of developmental theorists that students tended to move from an absolutist to a relativistic understanding of knowledge as they progressed through higher education. Sample items from this subscale included: "In math, answers are always either right or wrong" and "Truth is unchanging in mathematics".

Confirmatory Factor Analysis (*CFA*)

The confirmatory factor analysis supported the five factor solution that emerged from *EFA* in the first phase. The maximum likelihood estimations appeared between .40 and .69 and all t-values were significant at $p<.05$. The factor loadings of each item on the related dimension were at a reasonable size to define the five-factor model. Results of the five-factor model χ^2 /df= 2.93, *RMR*= .05, *GFI*= .92, *AGFI*= .91, *RMSEA*= .06, *CFI*= .94. Results from the *CFI* suggested that the five- factor structure fit well to the sample data with all fit indices (*RMR, GFI, CFI, AGFI*, and *RMSEA*) indicating a good fit except for (χ^2 /df) which exhibited a reasonable fit. Furthermore, all parameters were found to be significant which indicated that each item contributes significantly to the corresponding subscale. Table 4 shows the regression estimates and the *t* values of the items and their respective scales.

Table 4: Regression estimate of the first order CFA of the *EBQM*

Factor	Item	Estimate	Standard error	*t* value	*p-value*
Innate ability	Item 1	1.00	-	-	-
	Item 2	1.03	.07	12.03	<.01
	Item 4	1.07	.08	13.52	<.01
	Item 3	.99	.08	11.70	<.01
	Item 25	.89	.08	12.42	<.01
	Item17	.99	.08	12.35	<.01
	Item18	1.08	.24	4.55	<.01
	Item 6	.36	.19	1.99	<.05
Structure of knowledge	Item26	1.00	-	-	-
	Item 9	1.45	.31	4.64	<.01
	Item30	1.06	.26	4.17	<.01
	Item 8	1.32	.32	4.07	<.01
Speed of knowledge	Item24	1.00	-	-	-
	Item22	.90	.22	4.17	<.01
	Item12	1.86	.41	4.58	<.01
	Item21	1.31	.31	4.27	<.01
	Item 7	.86	.26	3.33	<.01
	Item23	.88	.28	3.37	<.01
Source of knowledge	Item13	1.00	-	-	-
	Item29	.63	.26	2.46	<.01
	Item15	1.32	.43	3.07	<.01
	Item16	1.25	.37	3.35	<.01
Certainty of knowledge	Item27	1.00	-	-	-
	Item31	1.31	.41	4.58	<.01
	Item5	1.22	.31	4.06	<.01
	Item28	1.07	.08	13.52	<.01

Reliability Analysis

Reliability analysis with regard to the internal consistency yielded Cronbach alpha coefficients of .81 for the innate ability, .79 for speed of knowledge, .77 for source of knowledge, .76 for structure of knowledge, and .75 for certainty of knowledge, indicating satisfactory reliability. The further examination of item-total correlations revealed that all items in each subscale contributed to the consistency of scores with item-total correlation higher than .40.

Validity Analysis

To demonstrate construct validity for the scores on the five subscales of EBQM, Discriminant, subgroup, and convergent evidence were provided.

Convergent validity

Fornell and Larcker (1981) proposed three approaches to confirm the convergent validity of a set of inventory items in relation to their corresponding constructs. These are (1) item reliability, (2) composite reliability of each construct (*CR*), and (3) the average variance extracted (*AVE*). The item reliability of an item was assessed by its factor loading onto the underlying construct. Hair et al. (2006) suggested that an item is significant if its factor loading is greater than 0.50. As shown in Table 3, the factor loadings of all the items in the *EBQM* were higher than .50, not considering items 6, item 23, and item 26 with loadings lower than .50. The composite reliability of each construct was assessed using Cronbach.s alphas. Finally, average variance extracted (*AVE*), a more conservative test of convergent validity that measures the amount of variance captured by the construct in relation to the amount of variance attributable to measurement error (Teo & Lee, 2012). All *AVE*s are greater than .50. An average variance extracted (*AVE*) of .50 or higher, or a composite reliability (*CR*) of .70 or above, can be a good rule of thumb suggesting adequate convergence at the construct validity (Hair et al., 2006). As presented in Table 5, the five constructs expressed satisfactory convergent reliability.

For further evidence of convergent validity, the correlational analysis was employed between five subscales of the *EBQM* and mathematics grades taken in the previous semester. Schommer-Aikins et. al., (2005) found that epistemological beliefs about mathematics affect students’ mathematical performance and overall academic achievement. Furthermore, Schommer (1993) conducted analyses in which students’ grand point averages (*GPAs*) were regressed on the four epistemological factor scores. Results of analyses revealed that the less students believed (naïve beliefs) in quick learning, simple knowledge, certain knowledge, and fixed ability, the better were their *GPAs*. Accordingly, we predicted that students with higher mathematics achievement developed more sophisticated epistemological beliefs about mathematics. Consistent with this prediction, results of multiple regressions indicated that structure of knowledge (t = 2.69, *Beta* =.21; p <.05); speed of knowledge (t = 2.15, *Beta* =.15; p <.05); certainty of knowledge (t = 2.44, *Beta* =.19; p <.05); and innate ability (t = 3.23, *Beta* =.24; p <.05) were significantly predictor of mathematics achievement. As expected, significant and positive correlations (positive effect) provided further evidence for convergent validity.

Discriminate validity

Discriminate validity is considered adequate when the variance shared between a construct and any other construct in the model is less than the variance that the construct shares with its measures (Teo & Lee, 2012). The variance shared by any two constructs is obtained by squaring the correlation coefficient between the two constructs. The variance shared between a construct and its measures corresponds to average variance extracted (*AVE*). Discriminate validity was assessed by comparing the square root of the average variance extracted for a given construct with the correlations between that construct and all other constructs. At the construct level, it is considered adequate when the square root of the average variance extracted (*AVE*) for a specific construct is greater than the correlation estimates between that construct and all other constructs (Chai, 2010; Fornell & Larcker, 1981). Table 6 shows the correlation matrix for the five constructs (i.e. the off-diagonal elements), and the square roots of *AVE* (i.e. the diagonal elements). As we seen in table 6, the square roots of *AVE* were greater than the correlation coefficients in the corresponding rows and columns. This implies that each construct shared more variance with its items than it does with other constructs. That is, discriminate validity seems acceptable at the construct level. At the item level, Hair et al. (2006) suggested that discriminate validity is evident when an item correlates more highly with items in the same construct than items from other constructs. Considering no cross-loadings among the items were observed, a satisfactory level of discriminate validity at the item level was established.

Table 5: Measures of average variance extracted (AVE) and construct reliability (CR)

Factor	**AVE**	**CR**
Certainty of Knowledge	.65	.75
Innate ability	.60	.81
Speed of knowledge Acquisition	.51	.79
Source of knowledge	.57	.77
Structure of knowledge	.53	.76

Table 6: Inter-factor zero-order correlations (2-tai/ed)

Factor	**1**	**2**	**3**	**4**	**5**
Certainty of Knowledge	**(.81)**				
Innate ability	.19*	**(.77)**			
Speed of knowledge Acquisition	.18*	.28**	**(.71)**		
Source of knowledge	.11	.25**	.31**	**(.75)**	
Structure of knowledge	.21*	.27**	.23**	.27**	**(.73)**

*** Correlation is significant at the 0.05 level (2-tailed).**
****Correlation is significant at the 0.01 level (2-tailed)**

Subgroup validity

For further evidence of discriminate validity, Hinkin (1995) suggested demonstrating subgroup validity when groups whose scores are expected to differ on a measure do so in the hypothesized direction. In the current study, grade level was expected to differentiate students on the five subscales of *EBQM*. Thus, we generated multivariate analysis of variance (*MANOVA*) to check this issue. Preliminary assumption on multivariate normality and homogeneity of variance-covariance matrices was conducted and no violations were detected.

The relationship between grade level and epistemological beliefs about mathematics has been researched with high school (Schommer et al., 1997), collegiate, (Jehng et al., 1993; Schommer, 1998), and adult (Schommer, 1998) samples. Across all samples studied, the increased level of education was associated with more sophisticated epistemological beliefs. Specifically, it was predicted that twelve grade students would have more sophisticated beliefs about mathematics. Consistent with this prediction, results of *MANOVA* indicated a significant main effect for grade level (*Wilks Lambda* = .41, F (5, 746)= 58.34, *partial eta*=.58, p <.05), suggesting that students at different grades differed on a linear combination of the five subscales of *EBQM*. The partial eta squared of .58 would be interpreted as a high effect size (Cohen, 1988). The follow-up univariate analysis indicated that twelve grade students scored higher (more sophisticated belief) than tenth grade students in: Speed of knowledge (F (1, 748) = 41.48, p < .05); Innate ability (F (1, 748) =11.18, p <.05); Certain of knowledge (F (1, 748) = 11.13, p < .05; Source of knowledge (F (1, 748) = 31.56, p <.05); and Structure of knowledge (F (1, 748) = 169.49, p < .05).

DISCUSSION

The central ideas that framed our research are the translation of *EBQM* into Arabic language and the evaluation of its reliability and validity. The results of this two-phase study support the reliability and the validity of scores on the five-factor model of *EBQM*. A measure of epistemological beliefs about mathematics in Jordan is noticeably absent. Results from empirical research combined with the importance of students epistemological beliefs on their achievement served as the basis for the translation and adaptation of the *EBQM* into Jordanian context.

The factor structure that emerged in the *EFA* phase indicated the exclusion of some items from the original scale. Low correlations might be expected due to this process; however, the construct validity of the *EBQM* was supported by the correlations among the five subscales. Content validation of the items of the items developed to capture the five subscales of mathematics beliefs confirmed the reliability of the scores on the five subscales of mathematics epistemology. The corroboration of the factor structure in the *CFA* phase of the study yielded a five- factor model of *EBQM* and thus provided support for the factorial validity of *EBQM* with a different sample.

The five–factor model of EBQM was developed as a result of an exploratory factor analysis (*EFA*) with parallel analysis (*PA*) in order to test the factorial structure of the scale, and a Confirmatory factor analysis (*CFA*) to confirm the five–factor model and to provide further evidence of *EBQM* validity. 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*. Overall, it can be concluded that the *EBQM* was a multidimensional construct consisting of five factors: Factor one refers to the innate ability, ranging from fixed at birth to life-long improvement; Factor two refers to the source of knowledge, ranging from handed down by authority to glean from observation and reason; Factor three refers to the beliefs about certainty of knowledge, ranging from tentative to unchanging; Factor four refers to the speed of knowledge acquisition, ranging from quick-all-or-none learning to gradual learning; and Factor five refers to the structure of knowledge, ranging from isolated bits to integrated concepts.

For further evidence of the construct validity of *EBQM*, multiple regression analysis revealed that Innate Ability, structure of knowledge, certainty of knowledge, and Speed of knowledge were significant predictors of mathematics achievement. These findings supported the idea that students with higher mathematics achievement developed more sophisticated epistemological beliefs. These results seem to be consistence with the earlier findings (e.g., Schommer, 1990, 1993; Schommer-Aikins, Duell, & Hutter, 2005; Hofer 2000; Paulsen & Wells, 1998; Ryan, 1984). For instance, Schommer (1990, 1993) examined the influence of epistemological beliefs on overall academic performance. She conducted analyses in which students' grade point averages (*GPAs*) were regressed on the four epistemological factor scores. Results of analyses revealed that the less students believed in quick learning, and fixed ability, the better were their *GPA*s. Similarly, students who got higher grade point averages developed more sophisticated epistemological beliefs in quick learning and innate ability. Schommer-Aikins, Duell, & Hutter (2005) found that the belief in Quick/Fixed Learning significantly predicted mathematical problem solving task. Ryan (1984) found speed of knowledge was a significant predictor of GPA. Hofer (2000) found that students' scores on the Certainty/Simplicity of knowledge were significantly correlated with course grades in psychology and science as well as overall *GPA*. In another study, Paulsen & Wells (1998) found simple knowledge was a predictor of *GP*A. The results revealed that students with higher *GPA* had more sophisticated beliefs in simple knowledge than students with lower *GPA*.

To test the assumption that mathematics beliefs, as measured by the *EBQS*, varied by educational level, *MANOVA* results indicated that twelve students are more likely to endorse availing beliefs while tenth grade students are more likely to endorse naïve beliefs. These results seem to be consistent with the related literature (e.g., Wheeler, 2007; Schommer, 1998; Schommer et al., 1997; Jehng et al., 1993). For instance, Schommer (1998) indicated that regression analysis on a large sample of working adults led to the conclusion that more educated participants were less likely to view knowledge as simple or certain. This result seemed not to be surprising because students are expected to be more aware of their own beliefs and cognitive capabilities than younger students (Aydin & Uboz, 2010).

CONCLUSIONS

The findings of this research shed light on the meaning of the construct of EBQM, extend previous research and provide a new perspective on the underlying structure of mathematics beliefs. The latent structure of *EBQM* seems better represented by five factors with 26 items. These factors and items are essential to being successful in mathematics education and are commonly suggested in the previous questionnaires, such as Epistemological beliefs Questionnaire (Schommer, 1990). Moreover, these results are in align with multidimensional theory. In general, the acquired structure with multi-factor supports the presumption that epistemological beliefs have not one-dimensional structure but multi-dimensional structure and consequently, it must be regarded as a belief system.

The results of both alpha reliability estimates and factor analysis indicated that our subscales are reasonably reliable (alpha above .70) and unidimensional (no subscale has more than one factor). Consequently; *EBQM* can be evaluated as an assessment instrument which has acceptable validity indicators and sufficient reliability coefficient. This scale is thought to be a useful scale which can be used in studies carried out with the students who maintain their education with science program based on constructivist education. It is thought that testing the scale in terms of different variables (for example; gender, social-economical level, settlement, approaches to learning, perceptions of learning environment) will enable to achieve stronger data. Thus, we believe that the students 'epistemological beliefs need to be developed in different dimensions for having better mathematics achievement. Teachers, principals, and policy makers should give enough importance to developing students' epistemological beliefs throughout their formal education.

Construct validation of the scores on the five subscales was further assessed with convergent, discriminate, and subgroup validity evidence. *MANOVA* and regression results were acceptable and the validity results were generally consistent with a priori predictions providing initial support for the five subscales of epistemological beliefs about mathematics. With respect to convergent validity, some support was found for our predictions regarding the relationships among the five dimensions of epistemology, and mathematics achievement. Evidence for discriminability of the five subscales was established by *CFA* analysis (*CR* and *AVE*) and subgroup difference. Results indicated that the *EBQM* differentiated between grade levels.

Conducting this study with two independent samples permitted the validation of the questionnaire. EBQM would be useful as a tool in educational research on epistemology that enables the cross-cultural adaptation studies of self-report measures to be conducted with regard to the steadily growing interest in cross-cultural comparisons studies such as Third Mathematics and Science Study (TIMSS). Through this lines, it might mark the beginning of research that provides support to highlight the relation between epistemological beliefs and academic achievement in different cultural settings (Aydin & Uboz, 2010). 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 (Tang, 2010).

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