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The Development and Construct Validation of Scientific Epistemological Beliefs Inventory

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ABSTRACT

Objective – Based on Schommer theory, the present study was conducted to construct and validate epistemological beliefs inventory for science (EBIS) in Malaysian context.
Type the brief purpose of the paper and illustrate the direction that is taken, whether it is empirical or theoretical testing in analyzing the research subject.

Methodology/Technique – The survey data from 450 matriculation students and 350 degree students were collected in two phases to facilitate both exploratory factor analysis (*EFA*), parallel analysis and the confirmatory factor analysis (*CFA*). Furthermore, the reliability analysis of the scores and convergent, discriminate, and subgroup validity coefficients were examined.

Findings – 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

Novelty –*EBIS* is a valid and reliable instrument which may serve as useful in guiding future research aiming to understanding students' epistemological beliefs about science. EBIS is the first scale in the local level measuring epistemic beliefs about science according to multi-dimensional model..

Type of Paper: Empirical.

Keywords: Innate ability; Certainty of knowledge; Source of knowledge; Speed of knowledge acquisition; Structure of knowledge.

1. Introduction

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). Epistemological beliefs about science have been found to play an important role in determining their learning orientations towards science. Students' understanding the nature, structure of knowledge and how knowledge is developed is important in science education (National Research Council [NRC], 2007). Epistemological beliefs of both students and teachers play a significant role in the successful implementation of standards-based curriculum in higher education and, therefore, meaningful measurement of science related

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epistemological beliefs should provide an effective tool in implementing the vision of science instruction provided in the Standards (Abedalaziz, Hai Leong & AlHarthy, 2013).

If beliefs are formed as a result of the structure of instructional contexts, then it is important for beliefs to be addressed directly in science 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 science 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. As such, we want to develop an Epistemological Beliefs Inventory for science (EBIS) in Malaysian context, as well as in some eastern countries. A combination of EFA and CFA approach to construct validity is called for in future studies (Tang, 2007). Existing scales, 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 multiple regression and MANOVA analysis.

2. Problem Statement

Despite researchers' growing interest in personal epistemology in recent years, its literature base seems to be limited (Laster, 2010). Studies of personal epistemology are comparatively sparse, with conflicting results as to the underlying dimensions of personal epistemology (Epler, 2011; Wheeler, 2007; Laster, 2010; Knight & Mattick, 2006; Buehl & Alexander, 2001; Hofer, 2001). In Malaysia, researchers are newly beginning to turn their attention to the area of epistemological belief about science (e.g. Abedalaziz & Chin, 2012; Lim, 2006; Jaring & Lourdusamy, 2005). This lack of related research on adult students' epistemological beliefs about science in Malaysia is a key reason for conducting the present study. 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 science) 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, Alexander, & Murphy, 2002).

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 science related epistemological beliefs. The EBIS fills a void, in that existing domain specific scales are based solely on general epistemological belief measures and suffer from similar psychometric inconsistencies. The psychometric inadequacies of the general epistemological belief instruments currently used in educational studies may be due to a lack of contextual reference for students to use in responding to statements. Domain specific instruments have simply inserted a word or phrase regarding a particular field of study into the generic instruments rather than to provide a richer discipline specific context (Wheeler, 2007).

To date, only several studies mainly focused on adapting existing scales to Malaysian context have been carried out (e.g. Abedalaziz & chin, 2012; Lim, 2006; Jaring & Lourdusamy, 2005). As a result, there is a need to construct Epistemological Beliefs Inventory for Science in Malaysian context.

3. Literature Review

Several researchers across different countries investigated students' beliefs about nature of knowledge and knowing in science. For this purpose, different scales have been developed (e.g. Tsai & Liu, 2005; Conley et. al., 2004; Kardash& Howell, 2000; Saunders, 1998; Pomeroy, 1993). For instance, Tsai and Liu (2005) developed the scientific epistemological views scale to measure the high school students' scientific epistemological beliefs. The scientific epistemological views were measured with five dimensions: role of social negotiation, invented and creative nature of science, theory-laden exploration, cultural impacts, and changing and tentative feature of science knowledge. Whereas, Conley et al. (2004) developed a scale of four dimensions to determine beliefs about the nature of knowledge (i.e. certainty of knowledge and simplicity of knowledge) and the nature of knowing (i.e. source of knowledge and justification for knowing). Furthermore, Kardash and Howell (2000) developed Epistemological Beliefs Scale to measure epistemological beliefs with structure of knowledge (structure), knowledge construction and modification (construction), the speed of knowledge acquisition (speed), characteristics of successful students (success), and attainability of truth (truth). Saunders (1998) developed a one-dimensional scale *(Science Knowledge Scale)* to measure students' epistemological beliefs about chemistry. Pomeroy's (1993) developed Scientific Epistemological Belief questionnaire with two dimensions (constructivist-orientated and empiricist-orientated epistemological views of science).

4. Purpose of the Study

Schommer's (1990) multi-dimensional theory characterized epistemological beliefs as a set of "more or less" independent dimensions. Initially, her theory consisted of five epistemological dimensions: Stability (tentative to unchanging), structure (isolated to integrated), source (authority to observation and reason), speed of acquisition (quick or gradual), and control of acquisition (fixed at birth or lifelong improvement) (Abedalaziz, Hai Leong & AlHarthy, 2013).

Based on multi-dimensional theory, the purpose of the current study was to develop and evaluate a new scale, namely the Epistemological Beliefs Inventory for Science, designed to measure epistemological beliefs specific to the context of science learning; and to build upon previous research by empirically examining the relationship between EBIS and theoretically related constructs (i.e. implicit intelligence, epistemological beliefs, achievement goal orientation, Cumulate Grade Point Average (CGPA), and education level).The purpose of the present study was twofold. First, we generate *EBIS* items. Second, we tested the reliability and the validity of Malaysian version. The construction of the instrument would illuminate alternative ways to measure students epistemological beliefs about science and highlight researchers draw upon parallel development processes in different language and different national context for international comparative (Aydin & Upoz, 2010).

5. Method

5.1 Sample(s)

All matriculation (foundation) and degree students from seven public and private universities in Kuala Lumpur/ Malaysia 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, 450 matriculation students (47% males, 53% females) from two public universities and two private universities participated in the study. For the phase 2, the sample involved 350 degree students (44.3% males, 55.7 females) from three universities, two public and one private university different from the previous sample.

5.2 Procedure

Based on previously published research (Wheeler, 2007; Tsai & liu, 2005; Conely et al. 2004; Elder, 1999; Pomeroy, 1993; Schommer, 1990), five distinct dimensions were identified and labelled, source of knowledge, certainty of knowledge, structure of knowledge, speed of knowledge acquisition, and innate ability, Students responded to each item on a 5-point likert scale which range from “1-strongly disagree” to “5-strongly agree”. EBIS was translated to Malay language and re-translated to English by three English language teachers. Malaysian version of EBIS was also checked by two Malay language teachers in order to provide content-related evidence of validity. For the purpose of content validation ten 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. Based on the experts comments, 38 items of 55 items were retained.

A tow-phase study was conducted during 2011-2012 academic year. In phase-one, the exploratory factor analyses were performed to evaluate the factor structure of EBIS with regard to the data obtained from Malaysian students. A principal component factor analyses with oblimin rotation was conducted to determine the factor structure underlying the data. 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 .15 to .57, sufficient to justify using an oblique rotation and analyzing both pattern and structure matrices (Henson & 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 .40 on at least one factor (Hair et al., 2010) and (b) at least three significant loading is required to identify a factory (Zwick & Velicer, 1986).

In Phase-two, the confirmatory factor analysis was performed to provide supportive evidence to the factor structure. 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.

The inventory which was developed with regard to the results of Phase 1 was administered to the new sample. 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 & Bonett 1980), the Comparative Fit Index (*CFI*; Bentler 1990), the Root Mean Square Error Approximation (*RMSEA*; Steiger & 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. *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).

The EBI, TIS, and AGI were adapted to the Malaysian context. Moreover, Further evidence for the construct validity of the EBIS was explored through the analysis of EBIS relationships with educational level, and through the analysis of relationships with other constructs including scores on the EBI, TIS., AGI, and CGPA.

5.3 Instruments

The Epistemic Beliefs Inventory (EBI) developed by Schraw et al. (2002) consists of 28 items was validated and adapted to measure the same five dimensions first hypothesized by Schommer including, Certain Knowledge, Simple Knowledge, Quick Learning, Omniscient Authority, and Innate Ability. A principal components analysis (PCA) and parallel analysis were conducted to explore the underlying structure of the EBI. The results revealed that four factors were extracted. These factors (scales) were named, Innate Ability (6 items), Source of knowledge (4 items), Certainty of Knowledge (3 items), and Quick Learning (4 items). The overall alpha coefficient of the entire scale was .91. The individual alpha coefficients for different scales ranged from 0.71–0.91, indicating satisfactory reliability. Furthermore, examining item–total correlations indicated that all items contributed to the consistency of scores with item–total correlations higher than 0.51. Initial results indicate that EBI is a reliable and valid measure of epistemic beliefs.

The Implicit Theories of Intelligence Scale developed by Dweck (2000) is an eight items; Likert-type scale designed to measure one's implicit theory of intelligence was validated and adapted to achieve the objectives of the present study. A principal components analysis (PCA) and parallel analysis were conducted to explore the underlying structure of the EBI. The results revealed that two interpretable factor was extracted. These factors (scales) were named, Entity Ability (3 items), and incremental ability (4 items).The overall alpha coefficient of the entire scale was .86. The individual alpha coefficients for different scales ranged from 0.75–0.87, indicating satisfactory reliability. Furthermore, examining item–total correlations indicated that all items contributed to the consistency of scores with item–total correlations higher than 0.59. Initial results indicate that TIS is a reliable and valid measure of implicit intelligence.

Achievement Goal orientation developed by Midgley et al. (1998) is an eighteen items; anchored type five point scales designed to measure one's achievement goal was validated and adopted to achieve the objectives of the present study. Exploratory factor analysis and Oblimin Rotation (with Eigen value greater than 1, and scree plot test) was applied to the AGI item responses. Only items with factor loading equal to or greater than 0.4 were retained in the extracted factors. Tow factors were extracted representing the subscales or dimensions of achievement goal orientation identified within the sample of Malaysian students. According to the nature of the items loaded on the factors, the achievement goal orientation dimensions were labeled Mastery goal (5 items), and Performance-approach goal (5 items). The overall alpha coefficient of the entire scale was .88. The individual alpha coefficients for different scales were .87 for Mastery goal, and .73 for Performance- approach goal. Dweck (1986) distinguished between two types of goal orientations: a mastery goal orientation in which students focus on task mastery and improvement of their own competence, and a performance goal orientation in which students focus on demonstrating competence relative to others.

6. 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 (.003-.480). 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 *EBQS* was acceptable at .90, indicating factor analysis was appropriate for the scale. Additionally, Bartlett's Test of Sphericity was significant [$\chi2(703) = 29156.421$; $p< .001$], 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 .43 to .78, and sex factors with eigenvalues greater than 1.00, accounting for 73.01% of variance. All items had factor loading of at least .40. The scree plot 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. This was further supported by the results of parallel analysis.

The second *EFA* was conducted by 38 items using an extraction to five factors. The five factor structure explained 69.32% of the total variance, with factor 1 contributed 29.20%, factor 2 contributed 21.01%, factor 3 contributed 10.05%, factor 4 contributed 6.04%, and factor 5 contributed 3.02%. 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 8, 9, 11, 18, 19, 20, 25, and 27 were problematic as their loading was less than .40, 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.

Consequently, the third *EFA* was conducted to determine the common factor structure of the remaining 30 items with oblimin rotation of five factor extraction. The *KMO* and *BTS* which yielded an index of .87 and 44329.29, 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 .40, concurrent with the suggestion of Hair et al (2006). Thus, within these considerations all items were retained. This analysis revealed that eight items (items 12, 25, 38, 21, 32, 34, 14, and 36) constituted the first factor, six items (items 3, 29, 4, 35, 2, and 13) constituted the second factor, four items (items 33, 31, 23, and 37) constituted the third factor, five items (items 5, 22, 6, 10, and 17) constituted the fourth factor, and seven items (items 16, 7, 28, 30, 15, 26, and 1) 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 certainty of knowledge, items in factor 4 revolved around source of knowledge, and items in factor 5 revolved around speed of knowledge. In terms of variance explained by each factor, innate ability accounted for 31.36%, structure of knowledge accounted for 20.12%, certainty of knowledge accounted for 12.83%, source of knowledge accounted for 8.78%, and speed of knowledge accounted for 4.48%,. Along with the suggestion of Pett, Lackey, and Sullivan (2003) both the pattern and structure matrices were the focus of evaluation. Table 1 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. As we can see in table 1, all items loading substantially on only one factor.

Table 1. Eigenvalues, Percentage of Variance Explained by Factors, and Pattern and Structure Matrix along with Communality (h^2) Values of the Items for the Second EFA

Factor	1	2	3	4	5
Eigenvalues	9.41	6.04	3.84	2.64	1.34
% of variance	31.36	20.12	12.82	8.78	4.48

Item	Structure matrix					Pattern Matrix					
Factors	1	2	3	4	5	1	2	3	4	5	h^2
Item12	.81					.82					.73
Item25	.79					.82					.67
Item38	.76					.76					.64
Item21	.72					.66					.64
Item32	.71					.63					.61
Item34	.67					.61					.55
Item14	.62					.60	-.42				.51
Item36	.55					.58					.69
Item3		.87					.83				.79
Item29		.84					.64				.75
Item4		.75		.47			.64				.78
Item35		.74					.61				.66
Item2		.70					.59				.77
Item13		.69					.54				.70
Item33			.57					.60			.71
Item31			.65					.58			.65
Item23			.65					-.55			.62
Item37			.55					.52			.75
Item5				.79					.76		.65
Item22				.75					.73		.59
Item6				.72	.43				.66		.71
Item10				.62					.59		.63
Item17				.54					.53		.68
Item16					.82					.75	.70
Item7					.80					.75	.66
Item28					.73					.69	.75
Item30		.			.71					.66	.67
Item15	.46				.68					.65	.68
Item26					.67					.60	.69
Item1					.64		.44			.56	.78

The data were reanalysed by applying PCA to each scale individually. An iterative process was used to refine each theoretical set of items to a uni–dimensional scale. Results revealed that each subscale of EBQS is uni-dimensional (see. table 2).

Table 2. EBIS Factor Loadings, Communalities (h^2), Eigenvalue (λ), the Percentage of Variance explained by the factor, and Reliability (alpha)

Factor	Item	Factor loading	h^2	λ	% of varience	Alpha
Innate Ability	Item 12	.79	.62	4.37	54.63	.91
	Item 25	.75	.56			
	Item 38	.76	.58			
	Item 21	.75	.57			
	Item 32	.76	.57			
	Item 34	.73	.53			
	Item 14	.68	.47			
	Item 36	.67	.45			
Structure of knowledge	Item 3	.85	.72	4.00	67.67	.85
	Item 29	.83	.70			
	Item 4	.82	.67			
	Item 35	.81	.66			
	Item 2	.80	.64			
	Item 13	.68	.47			
Certainty of knowledge	Item 33	.80	.64	2.49	62.15	.84
	Item 31	.83	.68			
	Item 23	.79	.62			
	Item 37	.74	.54			
Source of knowledge	Item 5	.81	.65	2.90	57.94	.85
	Item 22	.74	.54			
	Item 6	.83	.69			
	Item 10	.68	.46			
	Item 17	.74	.55			
Speed of learning	Item 16	.80	.64	4.13	59.00	.86
	Item 7	.83	.69			
	Item 28	.80	.64			
	Item 30	.75	.57			
	Item 15	.77	.60			
	Item 26	.64	.41			
	Item 1	.58	.34			

The confirmatory factor analysis supported the five factor solution that emerged from *EFA* in the first phase. The maximum likelihood estimations appeared between .42 and .67 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 *NFI*=0.952; *CFI*=0.953; *RMSEA*=0.044; *CMIN/DF*=1.793. Results from the *CFI* suggested that the five- factor structure fit well to the sample data with all fit indices (*NFI*, *CMIN/DF* and *RMSEA*) indicating a good fit. Furthermore, all parameters were found to be significant which indicated that each item contributes significantly to the corresponding subscale. Table 3 shows the regression estimates and the *t* values of the items and their respective scales.

Table 3. Regression estimate of the first order CFA of the *EBQS*

Factor	Item	Estimate	Standard error	*t* value	*p-value*
Innate ability	Item 8	1.00	-	-	-
	Item 12	.90	.22	4.17	<.01
	Item 25	.36	.19	1.99	<.05
	Item 38	.99	.08	11.78	<.01
	Item 21	.89	.08	12.42	<.01
	Item 32	.99	.08	11.78	<.01
	Item 34	1.08	.24	4.55	<.01
	Item 14	1.45	.30	4.65	<.01
	Item 36	.36	.19	1.99	<.05
Structure of knowledge	Item 3	1.00	-	-	-
	Item 29	1.45	.31	4.64	<.01
	Item 4	1.06	.26	4.17	<.01
	Item 35	1.32	.32	4.07	<.01
	Item 2	.89	.27	3.33	<.01
	Item 13	.86	.27	3.36	<.01
Speed of knowledge	Item 3	1.00	-	-	-
	Item 29	.90	.22	4.17	<.01
	Item 4	1.87	.41	4.58	<.01
	Item 35	1.31	.31	4.27	<.01
	Item 2	.86	.26	3.33	<.01
	Item 13	.88	.28	3.37	<.01
	Item 3	1.47	.33	4.67	<.01
	Item 29	1.05	.25	4.14	<.01
Source of knowledge	Item 5	1.00	-	-	-
	Item 22	.62	.26	2.46	<.01
	Item 6	1.32	.43	3.07	<.01
	Item 10	1.26	.37	3.35	<.01
	Item 17	1.32	.32	4.28	<.01
Certainty of knowledge	Item 33	1.00	-	-	-
	Item 31	1.31	.41	4.59	<.01
	Item 23	1.22	.31	4.06	<.01
	Item 37	1.07	.08	13.52	<.01

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 2, the factor loadings of all the items in the *EBIS* were higher 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 4, the five constructs expressed satisfactory convergent reliability.

Table 4. Measures of average variance extracted (AVE) and construct reliability (CR)

Factor	AVE	CR
Certainty of Knowledge	.75	.84
Innate ability	.69	.91
Speed of knowledge Acquisition	.58	.86
Source of knowledge	.54	.85
Structure of knowledge	.52	.85

For further evidence of convergent validity, the correlational analysis was employed between five subscales of the *EBIS* and the CGPA taken in the previous semester. Schommer-Aikins, Duell, & Hutter (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 CGPA developed more sophisticated epistemological beliefs about science. Consistent with this prediction, results of multiple regressions indicatedthat structure of knowledge (t = 2.59, *Beta* =.21; p<.05); innate Ability (t = 4.125, *Beta* = .145; $p < .001$); and speed of knowledge (t =-8.089, *Beta* = - .338; $p < .001$) were significantly predictor of CGPA. As such, these results support the convergent validity of EBIS.

For further evidence of convergent validity, Buehl et al. (2002) pointed out that students can hold both domain specific and domain general beliefs simultaneously. As such, we hypothized that EBI and EBIS scales wuold be significantly related. To assess the relations between EBI and EBIS scales, bivariate correlations were computed between corresponding EBI and EBIS scales. The results revealed significant relationsbetween the corresponding EBI and EBIS scales (r = .66 (p < .01) for innat ability scales,r = .56 (p < .01) for source of knowledge scales, r = .61 (p < .01), and r = .59 (p < .01) for speed of learning scales). These results indicate that there is considerable overlap between general epistemological beliefs and science specific beliefs. It appears that general and domain specific epistemological beliefs are related but not redundant constructs. The present study supports a previous finding that students can hold both domain specific and domain general beliefs simultaneously (Wheeler, 2007). Accordingly, these results provide another evidence for the convergent validity of EBIS.

The foundation of the general epistemological factor, Innate Ability, which is included in general epistemological beliefs measures and included as part of the hypothesized structure of the EBIS, is found in research regarding entity and incremental beliefs about intelligence

(Dweck & Leggett, 1988). It seems intuitive to assume that these constructs would be related. Significant correlations existed between implicit theories of intelligence and innate ability (Epler, 2011; Wheeler, 2007; Braten & Stromo, 2005). To assess the nature of the relationships between innate ability scale and TIS scales, the bivariate correlations between the TIS scales and innate ability scale were computed. The results of the current study produced asignificant relations between the Innate Ability factor of a measure of epistemological beliefs about science and implicit theories of intelligence scales (r = .46 (p<0.01) for entity view of intellegence and r = -.54 (p<0.01) for incremental view of intelligence). As such, a person with a fixed or naïve view of innate ability generally takes adeterministic 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.

The researcher attributes the relationship between the Theories of Intelligence scale and the Innate Ability to the similar nature of the Theories of Intelligence and the Innate Ability. The TIS scale assesses beliefs about the malleability of intelligence (can intelligence be changed or unchangeable). With that in mind, the EBIS‘s Innate Ability construct examines beliefs relating to the ability to learn, which ranges from fixed at birth to improvable over time (Duell & Schommer-Aikins, 2001; Wheeler, 2007). These results seem to be consistent with the past studies regarding the relation between TIS and the innate ability (e.g. Epler, 2011; Wheeler, 2007).These results provide further evidence for EBIS validity.

On the basis of theoretical assumptions and previous findings concerning the relation between epistemological beliefs and achievement goal orientation (Garrett-Ingram, 1997; Hofer &Pintrich, 1997; Neber & Schommer-Aikins, 2002; Schutz, Pintrich, & Young, 1993), the present study expected that naive innate ability and quik learning would be negatively related to mastery goal but positively related to performance-approach goal. To test this hypothesis, the Pearson product-moment correlation coefficient was used to determine if there is a statistically significant relationship between students' epistemological beliefs and achievement goal orientation.

The correlation coefficient shows a moderate, negative, but statistically significant relationship between the Mastery goal scale and the Innate ability scale ($r = -.46$, $p < .01$). In addition, there was a weak, negative but significant relationship between the Mastery goal scale and the Quick learning scale ($r = -.27$, $p < .01$). Further, the correlation coefficient shows a strong, positive significant relationship between the Performance-approach goal scale and the Innate ability scale ($r =.70$, $p < .01$). In addition, there was a moderate, positive and significant relationship between the Performance-approach goal scale and the Quick learning scale ($r = .43$, $p < .01$). Furthermore, these results provide further evidence for EBQS 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 5 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 5, 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. Inter-factor zero-order correlations (2-tailed)

Factor	1	2	3	4	5
Certainty of Knowledge	(.87)				
Innate ability	.175*	(.83)			
Speed of knowledge Acquisition	.181*	.282**	(.76)		
Source of knowledge	.148*	.381**	.363**	(.70)	
Structure of knowledge	178*	.289**	.301**	.289**	(.72)

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

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

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, educational level was expected to differentiate students on the five subscales of *EBIM.* Thus, we generated multivariate analysis of variance (*MANOVA*) and follow up analysis 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 educational level and epistemological beliefs 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 degree students would have more sophisticated beliefs about science. Consistent with this prediction, results of *MANOVA* indicated a significant main effect for grade level (*Wilks Lambda* = .41, F (5, 794)= 59.34, *partial eta*=.58, p <.05), suggesting that students at different education level differed on a linear combination of the five subscales of *EBQS*. The partial eta squared of .51 would be interpreted as a high effect size (Cohen, 1988). The follow-up univariate analysis indicated that degree students scored higher (more sophisticated belief) than matriculation students in: Speed of knowledge (F (1, 798) = 107.101, p < .001); Innate ability (F (1, 798) =272.540, p <.001); Certain of knowledge (F (1, 798) = 29.407, p < .001; Source of knowledge (F (1, 798) = 329.619, p < .001; and Structure of knowledge (F (1, 798) = 13.342, p < .001).

MANOVA results seem to indicate that degree students are more likely to endorse availing beliefs while matriculation students are more likely to endorse naïve beliefs. These results seem to be consistent with the related literature. Accordingly, these results provide further evidence for EBQS validity.

7. Discussion and Conclusions

The central ideas that framed our research are the generation of *EBIS* items 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 *EBIS*. A measure of epistemological beliefs about science in Malaysia is noticeably absent.

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 *EBIM* was supported by the correlations among the five subscales. Content validation of the items developed to capture the five subscales of science beliefs confirmed the reliability of the scores on the five subscales of science epistemology. The corroboration of the factor structure in the *CFA* phase of the study yielded a five- factor model of *EBIS* and thus provided support for the factorial validity of *EBIM* with a different sample.

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 *EBIS*. Overall, it can be concluded that the *EBIS* 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.

However, in comparison to previous research, the present study found some similarities as well as differences. In terms of factors, except the factors of speed knowledge acquisitions and innate ability, the connotation of other three factors is consistent with the previous questionnaires (e.g. Conley et al, 2004; Hofer, 2000). For instance, Hofer and Pintrich (1997) suggested that epistemological theories composed of four dimensions: Certainty of Knowledge, Simplicity of Knowledge, Source of Knowledge and Justification for Knowing. According to Hofer and Pintrich (1997), innate ability (fixed) and quick learning was not epistemological dimensions and these dimensions do not focus on the nature of knowledge and knowing. They stated that quick learning gives information about whether learning is quick or not, and this cannot be considered as an epistemological belief about the nature of knowledge and that fixed ability beliefs concern the nature of implicit intelligence, not nature of knowledge. Conley et. al. (2004) suggested that epistemological theories composed of four dimensions: Source, Certainty, Development, and Justification. In terms of 28 items on the five factors, there are detectable differences between EBIS and the previous questionnaires.

The findings of this research shed light on the meaning of the construct of EBIS, extend previous research and provide a new perspective on the underlying structure of science beliefs. The latent structure of *EBQS* seems better represented by five factors with 30 items. These factors and items are essential to being successful in science 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(Abedalaziz, Hai Leong & AlHarthy, 2013)..

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; *EBIM* 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 science achievement. Teachers, principals, and policy makers should give enough importance to developing students' epistemological beliefs throughout their formal education(Abedalaziz, Hai Leong & AlHarthy, 2013)..

Construct validation of the scores on the five subscales was further assessed with convergent, discriminate, and subgroup validity evidence. *MANOVA* and multiple 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 questionnaire for science. With respect to convergent validity, some support was found for our predictions regarding the relationships among the five dimensions of EBIS and other consructs (i.e. general epistemology, implicie intellegence, achievement goals, and CGPA). Evidence for discriminability of the five subscales was established by *CFA* analysis (*CR* and *AVE*) and educational level difference. Results indicated that the *EBIS* differentiated between educational levels.

Conducting this study with two independent samples permitted the validation of the inventory. EBIS 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)(Abedalaziz, Hai Leong & AlHarthy, 2013). . 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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