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Research Article

Exploring the factor structure of the Epistemic Beliefs Inventory

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The study explored the factor structure of the Epistemic Beliefs Inventory (EBI). The sample consisted of 200 pre-service science teachers drawn from four colleges of education in Ghana. The EPI, originally developed by Schraw, Dunkle, and Bendixen (1995), was the instrument employed in this study. The EBI consists of 32 items on a 5-point Likert scale and was developed to assess five fundamental epistemological belief constructs: certain knowledge, innate ability, quick learning, simple knowledge, and omniscient authority. The basic structure of the EBI was investigated using exploratory factor analysis and confirmatory factor analysis. The factorability of the sample and its appropriateness for factor analysis were tested using Bartlett's test of sphericity. The results showed support for the five-factor model of the EBI. Initial results revealed eight factors, and parallel analysis revealed five factors. However, based on the indices, the five-factor model with 24 items did not have a strong model fit. The study confirms the volatility of the EBI in its factorial structure and other psychometric indices.

Keywords: Epistemological beliefs, Epistemological beliefs inventory, Confirmatory factor analysis, Exploratory factor analysis

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1. Introduction

Personal epistemology is integral to student learning (Hofer, 2001; Welch & Roy, 2012). Schraw et al. (1995) developed the EBI, based on the work of Schommer (1990), to measure five constructs related to the nature of knowledge and learning (Welch & Roy, 2012). Leal-Soto and Ferrer-Urbina (2017) defined epistemic beliefs as beliefs about knowledge and its acquisition. According to Schommer-Aikins et al. (2000), epistemological beliefs are related to various aspects of learning. According to Perry (1968), undergraduate students enter college believing that knowledge is simple, certain, and handed down from authority, but by the time they reach senior year levels, these views have changed. As they progress in their learning to senior levels, they come to believe that knowledge is complex, tentative, and gained by reason and empirical evidence (Schommer-Aikins et al., 2000).

Schommer (1990) asserts that epistemic beliefs are a collection of more or less independent dimensions that progress from a simplistic dualist perspective to a sophisticated, relativistic one. Personal epistemology is made of multiple beliefs that do not always develop at the same time (Schommer, 1990). Schommer proposed five beliefs about epistemology: the structure of knowledge (from discrete pieces to integrated concepts), the stability of knowledge (from certain to developing), the source of knowledge (from handed down by authority to derived from reason and evidence), the speed of learning (from rapid to gradual), and the ability to learn (from fixed at birth to improvable).

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Thus, the epistemic questionnaire was developed by Schommer (1990) has five dimensions: the structure of knowledge, the stability or certainty of the knowledge, the source of the knowledge, the control over learning, and the speed of learning. Schommer (1990) believe that epistemic views are too complex to be encapsulated in a single dimension. However, the reliability of the epistemological questionnaire has not been good, and its factor structure has been inconsistent (Hofer, 2001). The Epistemological Belief Questionnaire [EBQ] has been widely employed in empirical research; however, its validity has often been questioned (Clarebout et al., 2001). Hofer and Pintrich (1997) noted a lack of consensus among researchers regarding the conceptualization and measurement of epistemological beliefs using the EBQ. Researchers such as Teo and Chai (2011), Welch and Roy (2012), Nussbaum and Bendixen (2003), and Leal-Soto and Ferrer-Urbina (2017) have reported instability in the factor structure of the EPI.

Schraw et al. (1995) developed the EBI to address limitations in the original epistemic belief questionnaire. The EBI comprises five factors aligned with Schommer's model: omniscient authority, quick learning, simple knowledge, certain knowledge, and innate ability. However, the EBI has demonstrated considerable instability in its factorial structure and other psychometric properties across cultural contexts (DeBacker et al., 2008). For instance, Leal-Soto and Ferrer-Urbina (2017) did not support the proposed five-factor structure. Consequently, the EBI has faced criticism regarding its construct validity.

1.1 Statement of the Problem

The EBI is a 32-item self-report instrument using a 5-point Likert scale to assess individuals' epistemological beliefs across five dimensions: innate ability, omniscient authority, quick learning, certain knowledge, and simple knowledge (Cazan, 2013). The lack of reliable self-report tools has been a persistent challenge for researchers investigating epistemic beliefs (Bendixen et al., 1998; Schraw et al., 2002). According to Hofer and Pintrich (1997), the dimension of omniscient authority may not adequately capture the complexity and multidimensional nature of the source of knowledge.

Similarly, Schommer's constructs of fixed ability and quick learning have been criticized for insufficiently operationalizing critical aspects of the nature or origin of knowledge (Hofer & Pintrich, 1997). Hofer and Pintrich further noted that fixed ability and quick learning may instead reflect beliefs about intelligence and task difficulty, respectively. Despite these critiques, researchers have widely applied the EBI to investigate epistemic beliefs in relation to various educational constructs (Wang et al., 2013). Although the EBI has been validated in Western contexts, this study employed both exploratory factor analysis [EFA] and confirmatory factor analysis [CFA] to examine the instrument's psychometric properties in the Ghanaian context.

Hence, this study investigates the psychometric characteristics of the EPI.

2. Literature Review

2.1. Theoretical Framework

Epistemology, a subfield of philosophy, concerns the nature of knowledge and the justification of belief (Muis, 2004). In the educational context, epistemology is defined as "an individual's cognitions of the nature of knowledge and the nature of knowing" (Pintrich, 2002, p. 390). Research on personal epistemology is grounded in Perry's (1968) model of intellectual development. Perry's model begins with dualism—also referred to as naïve epistemology—which posits that truth is absolute and that every legitimate question has a single correct answer (Gallagher, 2019).

The second stage of Perry's model is *Multiplicity*, characterized by the belief that "truth" is a matter of opinion rather than judgment, where conflicting views are seen as equally valid because everyone is entitled to their own perspective (Gallagher, 2019). The third stage, *Contextual Relativism*, introduces the necessity of sound reasoning, replacing reliance on opinion with evidence-based justification. The fourth stage, *Commitment within Relativism*, reflects an understanding that learning is a lifelong process involving engagement with complex ideas (Gallagher, 2019). According to Moore (2002), individuals at this stage recognize that issues are best addressed through rational argument supported by both personal and professional philosophical frameworks. Epistemological beliefs [EBs] are multifaceted; Schommer (1990) conceptualized them as a multidimensional system of relatively independent beliefs. Muis (2004) similarly argued that personal epistemology is too nuanced to be captured by a single dimension.

Schommer (1990) proposed five dimensions of epistemological beliefs. Three are knowledge-related: certainty of knowledge (ranging from viewing knowledge as fixed to evolving), source of knowledge (from authority-based to reason-based), and structure of knowledge (from fragmented facts to integrated concepts). She also identified two learning-related dimensions: control of knowledge (fixed ability vs. improvable ability) and speed of learning (instant learning vs. gradual acquisition). In contrast, Hofer and

Pintrich (1997) proposed a four-dimensional model comprising source of knowledge, justification for knowing, certainty of knowledge, and simplicity of knowledge.

2.2. Empirical Studies on the Epistemic Beliefs Inventory

Wang et al. (2013) used confirmatory factor analysis to assess the construct validity of the Chinese version of the EPI. Their findings supported the presence of five factors—Simple Knowledge [SK], Certain Knowledge [CK], Innate Ability [IA], Omniscient Authority [OA], and Quick Learning [QL]—but indicated that the overall model fit was unsatisfactory. Similarly, Teo (2013) examined the psychometric properties of the EBI and found support for the five-factor model; however, issues such as poor model fit, cross-loadings, and low factor loadings were evident. Welch and Roy (2012) also evaluated the EBI's psychometric features, identifying five underlying components. Although the factor structure aligned with that proposed by Schraw et al. (2002), the item loadings differed from the original model.

Wheeler (2007) reported a five-factor solution using principal axis factor analysis; however, only three of the five factors—Innate Ability, Simple Knowledge, and Omniscient Authority—were clearly interpretable, while Certain Knowledge and Quick Learning failed to emerge. In another study, confirmatory factor analysis was used to validate a theoretical model of the EBI using empirical data (Alavi et al., 2020). Exploratory factor analysis aims to uncover complex patterns in datasets and generate hypotheses, whereas CFA is employed to test and confirm predefined theoretical models (Child, 2006). According to Bartholomew et al. (2011) and Yong and Pearce (2013), factor analysis is a statistical technique used to reduce a large set of observable variables into a smaller number of latent constructs based on shared variance. EFA is particularly useful in identifying how many underlying factors influence a dataset and determining which variables cluster together to measure the same construct (Yong & Pearce, 2013).

3. Method

3.1. Research Design

The research design utilized in the study was a survey. According to Check and Schutt (2012), a survey is the process of collecting information from a sample of individuals through their responses to questions. Singleton and Straits (2009) explain that surveys are commonly employed in social and psychological research to characterize and investigate human behavior.

3.2. Participants

The sample for this study comprised a total of 200 pre-service science teachers, drawn from four different colleges of education in Ghana. These institutions were purposefully selected to ensure representation from both science-focused and mathematics-focused colleges of education. The purposive selection of these institutions was guided by the aim of capturing a diverse range of experiences and perspectives related to science teacher preparation across different institutional contexts.

Once the colleges were identified, the selection of participants within each institution was conducted using a simple random sampling technique. This approach was employed to minimize sampling bias and to ensure that every pre-service science teacher within the target population had an equal and independent chance of being selected. By combining purposive sampling at the institutional level with random sampling at the participant level, the study aimed to enhance both the relevance and the generalizability of the findings within the context of pre-service science education in Ghana.

The final sample reflected a balanced distribution across the selected colleges, thereby providing a robust basis for examining the views, experiences, and preparedness of future science educators in relation to the study's objectives.

3.3. Data Collection

The EBI (Schraw et al., 1995) was the primary tool used in this study. The EBI consists of 32 items rated on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The inventory was designed to assess five core epistemological belief constructs: Certain Knowledge, Innate Ability, Quick Learning, Simple Knowledge, and Omniscient Authority. Data were collected at the end of the second semester. The questionnaire was administered under the supervision of the researchers, allowing participants ample time to respond.

3.4. Data Analysis

SPSS version 25 and SPSS AMOS version 26 were used to analyze the data. The basic structure of the EBI was examined using exploratory factor analysis and confirmatory factor analysis. The first step was to conduct EFA. Prior to the EFA, the factorability of the sample and its appropriateness for factor analysis were tested using Bartlett's test of sphericity. The Kaiser-Meyer-Olkin [KMO] test was employed to assess the sample's adequacy (Kaiser, 1974).

Subsequently, CFA was performed using a maximum likelihood estimate. Multiple fit indices were used to assess model fit, including Chi-square (χ^2), the ratio of chi-square to degrees of freedom (χ^2/df), goodness-of-fit index [GFI], adjusted goodness-of-fit index [AGFI], comparative fit index [CFI], Tucker-Lewis's index [TLI], standard root-mean-square residuals [SRMR], and root-mean-square error of approximation [RMSEA]. For model fit indices, the following cut-off values were considered: Chi-square with $p \geq .01$, $\chi^2/\text{df} \leq 5$, GFI ≥ .95, AGFI ≥ .90, CFI ≥ .90, TLI ≥ .95, and SRMR and RMSEA ≤ .06 (El-den et al., 2020; Hu & Bentler, 1999; Islam, 2019). These indicators provide basic indications of how well the proposed model fits the data (Hooper et al., 2008).

The Chi-square fit index evaluates the fit between the data from the observed variables and the hypothesized model. It examines the validity of the covariance matrix produced by the model (Alavi et al., 2020). A low Chi-square value relative to the degrees of freedom and a higher p-value indicate better model fit, respectively (Alavi et al., 2020). According to Alnaami et al. (2002), Chi-square goodness-of-fit values under 500 are acceptable. To demonstrate a model's fit, the goodness-of-fit index and adjusted goodness-of-fit index values should be 0.9 or higher. For RMSEA, values must be less than 0.07. According to Alnaami et al. (2002), the comparative fit index and normed fit index [NFI] values should be at least 0.9.

4. Results

4.1. Suitability of the Data for EFA

The original EBI instrument consisted of 32 items across five dimensions: simple knowledge, certain knowledge, omniscient authority, quick learning, and innate ability. Data were examined for factorability (El-den et al., 2020). First, the inter-item correlation matrix revealed a pattern of low-to-moderate correlations. Eight items with very low item-item correlations (r = .3 or lower) were deleted. The deleted items included item 1 ("It annoys me when teachers do not tell pupils the answers to tough problems"), item 6 ("Absolute moral truth does not exist"), item 9 ("If a person tries too hard to comprehend a problem, they will end up confused"), item 10 ("Too many scientific theories just complicate things"), item 14 ("I like teachers who present several competing theories and let their students decide which is best"), item 20 ("Children should be allowed to question their parents' authority"), item 22 ("Science is easy to understand because it contains so many facts"), and item 31 ("There are sometimes no right answers to life's big problems").

Cronbach's alpha reliability coefficient for the remaining 24 items was satisfactory (α = .740) (see Table 1). The item-total correlations of the EBI were modest, ranging from 0.122 to 0.432 (see Table 2).

Table 1
Reliability of the EBI

Cronbach's Alpha	*Cronbach's Alpha Based on Standardised Items*	*N*
.743	.740	24

4.2. Sampling Adequacy

The Kaiser-Meyer-Olkin test was used to determine sampling adequacy. According to Hair et al. (1995) and Tabachnick and Fidell (2001), KMO values greater than 0.50 are considered adequate for factor analysis. The KMO measure of sampling adequacy was .551, which exceeded the acceptable cut-off of .50, suggesting that the sample was sufficient for factor analysis. Bartlett's test of sphericity was significant [$\chi^2(276) = 590.810$, $p < .05$], indicating that correlations between items were large enough for factor analysis. Table 3 presents the results of the KMO value and Bartlett's test of sphericity.

Table 2
Scale mean, variance, corrected item-total correlations and Cronbach alpha if the item deleted of the EBI

Item	*Scale Mean if Item Deleted*	*Scale Variance if Item Deleted*	*Corrected Item-Total Correlation*	*Squared Multiple Correlation*	*Cronbach's Alpha if Item Deleted*
Item2P	72.6116	95.840	.211	.262	.741
Item3	73.5289	98.368	.155	.334	.743
Item4	71.5455	96.983	.288	.388	.734
Item5	72.4793	95.168	.255	.378	.737
Item7	71.7603	96.000	.337	.285	.732
Item8	73.6281	96.419	.265	.268	.736
Item11	72.3058	98.197	.188	.238	.741
Item12	72.6446	96.664	.266	.380	.736
Item13	72.0413	95.440	.308	.272	.733
Item15	72.9174	91.843	.408	.415	.725
Item16	73.7934	96.565	.310	.374	.733
Item17	72.1570	99.317	.158	.308	.742
Item18	72.4380	99.732	.139	.173	.743
Item19	71.9835	92.550	.398	.463	.726
Item21	73.8926	95.163	.286	.352	.734
Item23	73.4215	94.146	.326	.286	.731
Item24P	71.9752	94.441	.378	.463	.728
Item25	72.6860	93.984	.263	.250	.737
Item26	72.8099	93.405	.381	.468	.727
Item27	72.2397	95.217	.330	.393	.731
Item28	73.5455	96.900	.247	.250	.737
Item29	73.4793	91.035	.432	.487	.723
Item30	72.0165	95.333	.274	.396	.735
Item32	71.1570	101.500	.122	.378	.742

Table 3
KMO value and Bartlett's test of sphericity

Kaiser-Meyer-Olkin		.551
Bartlett's Test of Sphericity	χ^2	590.810
	df	276
	Sig.	<.001

4.3. Factor Rotation

The factors were rotated for improved interpretation, as the unrotated factors were unclear (Yong & Pearce, 2013). Therefore, the remaining 24 items were subjected to exploratory factor analysis (EFA) using Varimax rotation, an orthogonal rotation method. Since the latent variables were considered independent and less likely to correlate (Schommer, 1990), orthogonal (Varimax) rotation was adopted (Costello & Osborne, 2005) to produce uncorrelated factors that are easily interpretable (Schmitt & Sass, 2011).

4.4. Number of Factors Retained

The number of factors to retain is one of the most critical and challenging tasks in factor analysis, and it is closely related to the fit of either a CFA or EFA model (Schmitt et al., 2018). According to researchers such as Gorsuch (2003) and Schmitt et al. (2018), there is no single ideal statistical criterion for determining the number of factors to retain. Researchers must present robust evidence and rationale, supported by both data and theory, in deciding the number of factors to keep (Schmitt et al., 2018).

In this study, Kaiser's criterion, the Scree test, and parallel analysis were used to determine the number of factors. Only factors with eigenvalues greater than one were retained (Kaiser, 1974). Kaiser's criterion often suggests retaining an excessive number of components (Izquierdo et al., 2014; Taherdoost et al., 2014). Cattell (1978) defined the Scree test as a plot of eigenvalues against factors, with the number of components to keep being the number of data points above the break or point of inflection (Yong & Pearce, 2013). Initial results indicated eight components (factors) with eigenvalues greater than one (Kaiser, 1974), explaining 59.21% of the variation. However, because the Scree plot was unclear, additional analysis was required to determine the final number of components.

Parallel analysis was also used to determine the number of underlying components for the 24 items on the EPI. Parallel analysis is an empirical technique used to identify the number of underlying constructs that account for the variance in a set of items, thus indicating the number of factors or components that should be retained (Welch & Roy, 2012). This method involves generating a series of random data sets that "parallel" the original data set in terms of sample size and variable count (Horn, 1965). The rationale behind this approach is that if true non-random factors exist, the eigenvalues derived from real data will be greater than those generated randomly (Schmitt, 2011). In this study, parallel analysis was conducted by comparing the measured eigenvalues to the eigenvalues expected from random data (see Table 4).

Table 4
Raw Eigenvalues and Parallel analysis of the EBI

Factor	*Raw Eigenvalues*	*Parallel analysis*	*Decision*
1	3.638	2.066	Retain
2	2.057	1.869	Retain
3	1.765	1.712	Retain
4	1.658	1.615	Retain
5	1.556	1.525	Retain
6	1.357	1.429	Reject
7	1.156	1.348	Reject
8	1.023	1.294	Reject

Parallel analysis revealed five underlying factors. The data were reanalysed using varimax rotation to rotate the five factors. These five factors explained 44.474% of the total variance. A plot of the raw eigenvalues and the eigenvalues from parallel analysis is shown in Figure 2.

Figure 1
Scree plot of EPI

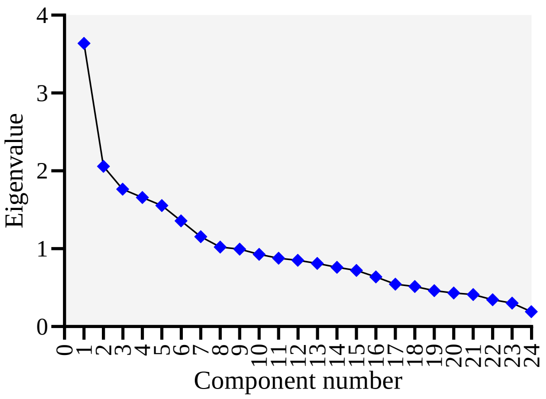


Figure 2
Plot of raw Eigenvalues and Parallel analysis

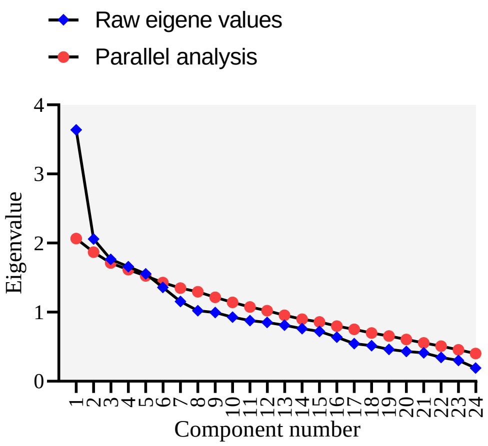


Table 5 shows the eigenvalues, total and percentage of variance explained by components.

Table 5
Eigenvalues and percentage of variance explained by the items

Component	*Initial Eigenvalues*		
	Total	*% of Variance*	*Cumulative %*
1	3.638	15.16	15.16
2	2.057	8.569	23.729
3	1.765	7.353	31.083
4	1.658	6.908	37.991
5	1.556	6.483	44.474
6	1.357	5.656	50.13
7	1.156	4.817	54.946
8	1.023	4.264	59.21

Table 6 presents the identified factors along with their corresponding eigenvalues, the percentage of variance each factor explains, the items loading on each factor, and the internal consistency values (Cronbach's alpha) for each factor.

Table 5
Factors, eigenvalues, percentage of variance explained, items and alpha values

Factor	*Eigen value*	*% of variance*	*Number of items*	*Items in the scale*	*Alpha (α)*
Quick Learning (QL)	3.638	15.16	6	2,7,16,21,23,29	.027
Omniscient Authority (OA)	2.057	8.569	6	4,24,25,26,27,28	.422
Certain Knowledge (CK)	1.765	7.353	4	13,17,19,32	.438
Simple Knowledge (SK)	1.658	6.908	4	3,11,15,18	.207
Innate Ability (IA)	1.556	6.483	4	5,8,12,30	.627

4.5. Inter-factor Correlations

Table 7 shows the inter-factor correlations, as well as the means and standard deviations for the factors. The inter-factor correlations revealed weak correlations between Quick Learning and Certain Knowledge (r = .178), QL and Simple Knowledge (r = .167), Omniscient Authority and CK (r = .146), QL and Innate Ability (r = .285), OA and IA (r = .217), and SK and IA (r = .254). There were moderate correlations between QL and OA (r = .31), OA and SK (r = .475), CK and SK (r = .502), and CK and IA (r = .366).

Table 7
Inter-Factor Correlations Matrix

Factor	*QL*	*OA*	*CK*	*SK*	*IA*
QL	1				
OA	.31	1			
CK	.178	.146	1		
SK	.167	.475	.502	1	
IA	.285	.217	.366*	.254	1
M	2.94	3.10	3.67	3.33	3.13
SD	0.39	0.552	0.71	0.60	0.88

Note. *significant at the .05 level.

4.6. Factor Loadings

Table 8 shows the factors and the loadings of the 24 items. The results provided support for the five-factor model underlying the EPI. These findings confirmed the five factors proposed by Schraw et al. (2002).

Table 8
Factor loadings of the 24 items of Epistemic Beliefs Inventory (Varimax rotation)

Items	*QL*	*OA*	*CK*	*SK*	*IA*
Item 29	.689				
item 16	.669				
item 21	.592				
item 23	.573				
item 2	.438				
item 7	.330				
item 26		.675			
item 27		.665			
item 24		.582			
item 25		.518			
item 28		.434			
item 4		.352			
item 19			.654		
item 17			.634		
item 32			.608		
item 13			.360		

Table 8 continued

Items	*QL*	*OA*	*CK*	*SK*	*IA*
item 3				.719	
item 11				.538	
item 15				.529	
item 18				.394	
item12					.680
item 5					.600
item 30					.493
item 8					.476

4.7. Mis-specifications and Cross-loadings

There was misrepresentation of items on the factors and cross-loadings, which rendered the factor solution difficult to interpret. Therefore, there was a need to redefine and adjust some items. Three of the factors were closely similar to those identified by Schraw et al. (2002). Factor 1 accounted for 15.16% of the total variance explained and contained six items, three of which were related to quick learning identified by Schraw et al. (2002). The items are: "Working on a problem with no quick solution is a waste of time" (item 29, QL), "If you don't learn something quickly, you won't ever learn it" (item 16, QL), "If you haven't understood a chapter the first time through, going back over it won't help" (item 21, QL), "The moral rules I live by apply to everyone" (item 23, CK), "Truth means different things to different people" (item 2, CK), and "Parents should teach their children all there is to know about life" (item 7, OA).

Factor 2 accounted for 8.569% of the total variance explained and included six items (items 24, 25, 26, 27, 28, 4), three of which were related to omniscient authority identified by Schraw et al. (2002). The items are: "The more you know about a topic, the more there is to know" (item 24, SK), "What is true today will be true tomorrow" (item 25, CK), "Smart people are born that way" (item 26, IA), "When someone in authority tells me what to do, I usually do it" (item 27, OA), "People who question authority are troublemakers" (item 28, OA), and "People should always obey the law" (item 4, OA).

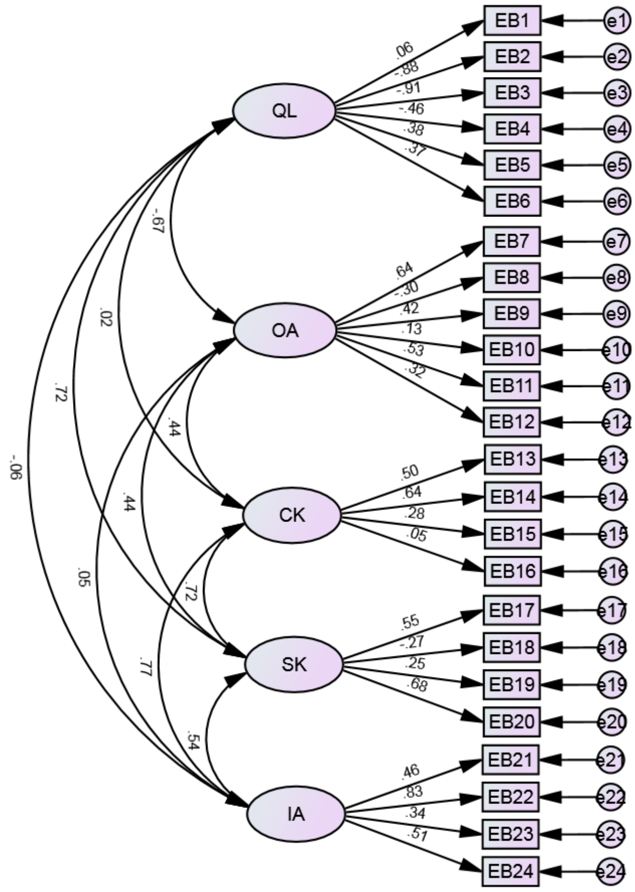
Factor 3 accounted for 7.353% of the total variance explained and contained four items, of which only one item (item 19) was identified by Schraw et al. (2002) as Certain Knowledge. The items in Factor 3 are: "Some people just have a knack for learning and others don't" (item 17, IA), "If two people are arguing about something, at least one of them must be wrong" (item 19, CK), "Some people are born with special gifts and talents" (item 32, IA), and "Instructors should focus on facts instead of theories" (item 13, SK).

Factor 4 accounted for 6.908% of the total variance explained and contained four items, two of which were identified by Schraw et al. (2002) as Simple Knowledge. The items in Factor 4 are: "Students who learn things quickly are the most successful" (item 3, QL), "The best ideas are often the simplest" (item 11, SK), "How well you do in school depends on how smart you are" (item 15, IA), and "Things are simpler than most professors would have you believe" (item 18, SK). Factor 5 accounted for 6.483% of the total variance explained and contained four items (items 12, 5, 8, 30), three of which were related to Innate Ability identified by Schraw et al. (2002). The items are: "People can't do too much about how smart they are" (item 12, IA), "Some people will never be smart no matter how hard they learn or work" (item 5, IA), "Really smart students don't have to work as hard to do well in school" (item 8, IA), and "You can study something for years and still not really understand it" (item 30, SK).

4.8. Confirmatory Factor Analysis

Multiple fit indices were used to assess the adequacy of the model fit. These included Chi-square (χ^2) the ratio of Chi-square and degrees of freedom (χ^2/df), goodness-of-fit index, adjusted goodness-of-fit index, comparative fit index, Tucker-Lewis's index, standard root-mean-square residuals (SRMR), and root-mean-square error of approximation (RMSEA). The following cut-off values were considered for the model fit indices: $\chi^2$with $p \geq .01$, $\chi^2/\text{df} \leq 5$, GFI ≥ .95, AGFI ≥ .90, CFI ≥ .90, TLI ≥ .95, and SRMR and RMSEA ≤ .06 (El-den et al., 2020; Hu & Bentler, 1999; Islam, 2019). Figure 3 depicts the five-factor structure model. However, based on the indices, the five-factor model with 24 items did not show a strong model fit (χ^2 = 459.114, χ^2/df = 1.759, RMSEA = 0.140, SRMR = 0.1823, GFI = 0.565, AGFI = 0.499, CFI = 0.328, NFI = 0.196, TLI = 0.289).

Figure 3
CFA five-factor model of the EBI



Note. Final version of the EBI is presented in Appendix 1.

5. Discussion

The study confirms the five-factor structure model of the EPI; however, based on the indices, the five-factor model did not exhibit a strong model fit. Similarly, Teo (2013) found no credible factor structure for the EBI in his study on the psychometric properties of the instrument. Teo (2013) reported low model fit using confirmatory factor analysis, indicating model mis-specification. Welch and Roy (2012) reported that the EBI comprises five constructs representing distinct degrees of epistemic beliefs; however, only three of the five factors were interpretable and consistent with the existing theory. These factors are Innate Ability, Simple Knowledge, and Omniscient Authority.

Again, Teo and Chai (2011) could not find an interpretable factor solution for the EBI. In a cross-validation study of the EBI factor structure using principal component analysis, Leal-Soto and Ferrer-Urbina (2017) did not confirm the hypothesized five-factor structure of the EBI. They initially identified seven factors and five factors by parallel analysis. However, two of the five factors had very low loadings, forcing a three-factor solution (Leal-Soto & Ferrer-Urbina, 2017). According to Leal-Soto and Ferrer-Urbina (2017), three-factor models provided good indicators of absolute fit, but the fit of the five-factor models was inadequate.

Ordoñez et al. (2009) found that exploratory factor analysis retained four of the five original dimensions of the EPI. Cam et al. (2012) found that the results of exploratory factor analyses of the EBI gave three epistemological belief dimensions: Quick Learning, Innate Ability, and Certain Knowledge. The results of the study further support the multidimensional theories of epistemological beliefs among pre-service teachers. Cam et al. (2012) reported that the five-factor model was not a sufficiently good fit to explain the epistemological beliefs factor structure, as most item loadings on the factors could not be interpreted correctly. The results suggested a three-factor model to explain the factor structure of the EBI; however, Simple Knowledge and Omniscient Authority did not emerge as distinct factors (Cam et al., 2012). DeBacker et al. (2008) revealed that a confirmatory factor analysis with the five-factor model in the EBI instrument did not fit the data in their study. DeBacker et al. (2008) found that both EFA and CFA did not support the hypothesized factor structures of the EBI. Additionally, Nussbaum and Bendixen (2003) could not reproduce the five-factor structure of the EBI and reported three factors: Simple Knowledge, Certain Knowledge, and Innate Ability.

The study found weak and non-significant correlations between Quick Learning and Certain Knowledge, QL and Simple Knowledge, Omniscient Authority and CK, QL and Innate Ability (IA), OA and IA, and SK and IA. However, there were moderate and non-significant correlations between QL and OA, OA and SK, and CK and SK, except between CK and IA, which was significant. In a similar study, Wang et al. (2013) found no significant relationships between CK and IA or SK and QL. Nussbaum and Bendixen (2003) found higher correlations among constructs capturing beliefs about knowledge (e.g., Simple Knowledge, Certain Knowledge, and Omniscient Authority) and among constructs capturing beliefs about learning (Quick Learning, Innate Ability).

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Data Availability: The corresponding author has access to the data supporting the findings of this study upon request.

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Appendix 1. Final version of the EBI

No	*Statement*	*Factors*				
1	Working on a problem with no quick solution is not a waste of time (+).	QL				
2	If you don't learn something quickly, you won't ever learn it (–).	QL				
3	If you haven't understood a chapter the first time, going over it will not help (–).	QL				
4	Successful students understand things quickly (–).	QL				
5	Learning is a slow process of building knowledge (+).	QL				
6	If a person cannot understand something in a short time, he or she should keep trying (+).	QL				
7	For success in school, it is best not to ask too many questions (–).		OA			
8	Sometimes advice from experts should be questioned (+).		OA			
9	How much a person gets out of school mostly depends on the quality of the teacher (–).		OA			
10	When someone in authority tells me what to do, I usually do it (–).		OA			
11	People who question authority are trouble makers (–).		OA			
12	People should always obey the law (–).		OA			
13	What is true today will be true tomorrow (–).			CK		
14	If two people are arguing about something, at least one of them must be wrong (–).			CK		
15	Even when some knowledge is considered absolutely true, I have to rethink it when I see it in a different context or situation (+).			CK		
16	Knowledge is changeable and can be improved (+)			CK		
17	I know I understand a topic once I have memorised the individual facts (–).				SK	
18	The best ideas are often the most simple (-).				SK	
19	I cannot fully understand a topic without relating it to other topics and classes (+).				SK	
20	Things are simpler than most professors would have you believe (–).				SK	
21	People can't do too much about how smart they are (–).					IA
22	Some people will never be smart no matter how hard they learn or work (-).					IA
23	Smart students don't have to work as hard to do well in school (–).					IA
24	Some people are born with intelligence whiles others are not (–).					IA

Note. (–) negative statements should be reverse coded; Factors: quick learning (QL), omniscient authority (OA), certain knowledge (CK), simple knowledge (SK) and innate ability (IA).