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Adaptation of The Epistemological Beliefs in Science Scale for High School Students in Türkiye

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Abstract

In this study, we adapted the Epistemological Beliefs in Science Scale originally developed by Conley et al. (2004) for high school students in Türkiye. Some previous studies done in Türkiye have been conducted to adapt this scale for different target audiences and revealed different factorial structures from the original scale and lost some items. Therefore, we aim to investigate the scale's psychometric properties for high school students. We applied the scale to 1205 9th to 12th-grade students face-to-face in three public high schools in Yalova district in Türkiye. We used confirmatory factor analysis to examine the fit of the observed model to the expected model based on the theoretical framework developed by Conley et al. (2004). We also investigated the convergent and divergent validities of the scale. For scale reliability, Cronbach alpha and omega coefficients were calculated. We comparatively discussed the psychometric properties of the scale with previous studies. We have concluded that the factorial structure in this study was almost the same as in the original scale and can be considered to use in high schools in Türkiye. We also have some improvement suggestions for a better scale.

Keywords: Epistemological beliefs in science, scale adaptation, high school students.

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Introduction

Researchers studied various theoretical and empirical presuppositions about epistemological beliefs and their importance (Ogan-Bekiroglu and Sengul-Turgut, 2011). Epistemological beliefs are a set of multidimensional beliefs that develop over time and in getting along with education and experience, exist at both the domain-general and domain-specific level, and are activated in context (Hofer, 2004). Epistemological beliefs can influence the knowledge acquisition process directly or indirectly, both the kinds of new information picked up from the physical and sociocultural context and how this information is interpreted (Stathopoulou and Vosniadou 2007). Scientific epistemological beliefs shape how they interpret evidence, learn from inquiry, and persist through conceptual change in science (Hofer and Pintrich (1997). Stronger "sophisticated" beliefs are linked to richer science learning, argumentation, and achievement across K–12 samples (Tsai, 1998). Hence, the determination of learners' scientific epistemological beliefs is valuable.

The Epistemological Beliefs in Science Scale developed by Conley et al. (2004) operationalizes epistemological beliefs for school science and is widely used in empirical work. Adapting and validating the EBSS for high school students in Türkiye is important to ensure linguistic/cultural equivalence, accurate factor structure, and valid score interpretations for local curricula and needs underscored by recent syntheses emphasizing cross-cultural comparability of science-specific epistemic beliefs (Schiefer et al., 2022). Moreover, Turkish studies show growing interest in epistemic beliefs at secondary levels, but consistent, context-validated instrumentation remains uneven (Sadi and Dağyar, 2015).

Epistemological Models

There are various models of what individuals think that knowledge is and how one comes to know (Hofer and Pintrich, 1997). Piaget and Duckworth (1970) explained genetic epistemology as mechanism in the growth of the different kinds of knowledge. Then Perry (1970) worked on abstract structural aspects of knowing and valuing. He administered an instrument about educational values to college students and then interviewed with some of them. His scheme was clustered into four positions as dualism, multiplicity, relativism, and commitment with relativism. Since Perry's participants were all males, Belenky et al. (1986) focused on women's ways of knowing and interviewed with women. Their epistemological perspectives included categories of silence, received knowledge, subjective knowledge, procedural knowledge, and constructed knowledge. Baxter Magolda (1988) conducted interviews and used an instrument to measure intellectual development. Her epistemological reflection model contained four different ways of knowing, that is absolute, transitional, independent, and contextual.

Kitchener and King (1981) studied epistemic assumptions underlying reasoning. After years of interviewing, they constructed their reflective judgment model focusing on epistemic cognition. The stages of the model were pre-reflective thinking, quasi reflective thinking, and reflective thinking. Kuhn (1991) aimed to investigate argumentative thinking and to understand how and why individuals reasoned. She defined the following categories of epistemological views via interviews: absolutist, multiplist, and evaluative. Schommer (1990) proposed that epistemological beliefs were unidimensional. She developed a questionnaire consisting of short statements on a Likert scale to measure epistemological beliefs and reached five dimensions that are as follows: "Certainty of knowledge, simplicity of knowledge, source of knowledge, quick learning, and innate ability". Hofer and Pintrich (1997) defined two areas, "beliefs about the nature of knowledge and the nature of process of knowing", representing the core structure of individuals' epistemological theories. She suggested two dimensions, "certainty of knowledge and simplicity of knowledge", under the nature of knowledge. Within the area of nature of knowing, she proposed "source of knowledge and justification for knowing".

Although epistemology has been conceptualized in various ways, the common feature across these frameworks is that individuals hold implicit beliefs about what knowledge is and how it is acquired. Synthesizing these perspectives, epistemological beliefs can be defined as individuals' views about the certainty, simplicity, source, and justification of knowledge. These beliefs represent cognitive and metacognitive assumptions that guide how learners interpret information, evaluate evidence, and construct meaning within learning contexts.

In science education, epistemological beliefs are particularly significant because science itself is characterized by uncertainty, empirical justification, and theory change. Students who view scientific knowledge as tentative, evidence-based, and open to revision are more likely to engage in argumentation, evidence evaluation, and conceptual change (Conley et al., 2004; Kampa et al., 2016; Tsai and Liu, 2005). Conversely, students who perceive science as a collection of certain facts transmitted by authority figures often demonstrate surface learning approaches and limited understanding of the nature of science. Therefore, examining students' epistemological beliefs provides valuable insight into how they learn and reason in science.

Measurement of Epistemological Models

Researchers have utilized various data collection methods, such as interviews, competing cases, production tasks, and written instruments to measure epistemological beliefs. Although interviews provide researchers for accessing deeper information, they are costly, limited to small sample, and time-consuming. On the other hand, Measure of Epistemological Reflection (Baxter Magolda, 1988), Epistemological Belief Questionnaire (Schommer, 1990), Beliefs about Knowledge and Learning (Jehng, Johnson and Anderson 1993), Epistemic Belief Inventory (Schraw, Dunkle and Bendixen, 2002), and Epistemic Understanding by Judgment (Kuhn, Cheney and Weinstock, 2000) are the written instruments widely used by the researchers and educators.

Conley et al. (2004) developed Epistemological Beliefs in Science Scale (EBSS) by following the cognitive domain specific perspective in their study and examined four dimensions of epistemological beliefs: "Source, certainty, development, and justification". Conley et al., (2004) declared that these four dimensions represented two general areas that Hofer and Pintrich (1997) argued: "Beliefs about the nature of knowing, and beliefs about the nature of knowledge". The source and justification dimensions reflect beliefs about the nature of knowing while the certainty and development dimensions represent beliefs about the nature of knowledge. Conley et al., (2004)'s inventory was originally developed for fifth grade students and its various adaptations have been used widely in many countries (Schiefer et al., 2022).

Despite increasing international research on epistemological beliefs, there is still a need for valid and reliable measurement tools adapted to different cultural and linguistic contexts. Özkan (2008) adapted the EBSS for seventh-grade students into Türkiye, for the first time. But this adaptation has a different factor structure from the original one. In the original scale and its theoretical background, source and justification are under the nature of knowing, and the other two factors, certainty and development, are under the nature of knowledge (Conley et al., 2004). But in Özkan (2008)'s study, two factors (sources and certainty) from different areas merged into one factor. Item 2 and the item 7 did not work and were omitted from the scale. A year later, Kurt (2009) adapted the EBSS for sixth, eighth, and tenth-grade students in Türkiye by skipping some grades. In this study, the factorial structure consisted of the theoretical background, but five items were omitted from the scale, and the sample did not cover all high school grades. Bahçıvan (2014) re-examined the validity and the reliability of the EBSS for undergraduate students in Türkiye and found the same construct as Conley et al. did (2004). Since varied results and different factor structures were emerged from the aforementioned studies, a new study examining the adaptation of the EBS for high school students in Türkiye is needed. Therefore, the purpose of this research was to investigate the validity, reliability and psychometric properties of the EBSS for high school students in Türkiye. This adaptation would fill a methodological gap and support robust research and instruction in Türkiye.

Method

The items we used in this study were already translated into Turkish by Özkan (2008) and used in previous research (Bahçıvan, 2014; Kurt, 2009). After getting official permission and consent, we applied the scale face-to-face by visiting three schools in Türkiye.

Participants

The participants of the study were 1205 9th to 12th-grade students. These students were enrolled in two types of public high schools in the city of Yalova located in the Marmara region, one of the provinces of Türkiye. The types of schools, frequencies, and percentages of the participants were presented in Table 1. Two were Anatolian high school, and one was science high school. Therefore, 81.9% of the students were from Anatolian high school, and 18.1% were from science high school.

Table 1
Frequencies of The Schools

School	Counts	% of Total	Cumulative %
Anatolian High School (1)	393	32.6 %	32.6 %
Anatolian High School (2)	594	49.3 %	81.9 %
Science High School	218	18.1 %	100.0 %

The distribution of the students to the grades is presented in Table 2. Most of the students were in the 9th grade, with 30.6% of the participants. It was followed by 10th grade 27.7%, 12th grade 23.7%, and 11th grade 18.0%.

Table 2
Frequencies of the Grades

Grade	Counts	% of Total	Cumulative %
9th	369	30.6 %	30.6 %
10th	334	27.7 %	58.3 %
11th	217	18.0 %	76.3 %
12th	285	23.7 %	100.0 %

The Epistemological Beliefs in Science Scale

Conley et al. (2004) originally developed The Epistemological Beliefs in Science Scale. The factorial structure of the scale was grounded on a solid theoretical basis by the authors citing the most influential research in the field. The scale has 26 items distributed under four dimensions (factors). The validity of the scale was examined by using confirmatory factor analysis. Items are rated on a 5-point Likert scale (1: strongly disagree; 5: strongly agree). Names of the dimensions, number of items, validity and reliability results of the scale across the studies were presented in Table 7. Because the reliability coefficients were calculated two times by Conley et al. (2004), there are two values for the reliability in Table 7. Factor explanations and one example item for each factor are (Conley et al., 2004, 194):

> Source was concerned with beliefs about knowledge residing in external authorities: "Whatever the teacher says in science class is true",
>
> Certainty referred to a belief in a right answer: "All questions in science have one right answer",
>
> Development measured beliefs about science as an evolving and changing subject: "Sometimes scientists change their minds about what is true in science",

Justification was concerned with the role of experiments and how individuals justify knowledge: "Good answers are based on evidence from many different experiments".

The items in the source and certainty dimensions are reversed; consequently, higher scores reflect more sophisticated beliefs in the scale. The Turkish items of the scale were presented at Appendix 2.

Data Analysis

Firstly, we examined the distribution of the data. According to George and Mallery (2010), skewness and kurtosis values between -1 and +1 can be considered excellent, and values between -2 and +2 are acceptable for most psychometric purposes. The skewness and the kurtosis values were between ±2. Therefore, it can be said that the data could be accepted as normally distributed. Next, we used confirmatory factor analysis to investigate the fit between the expected and observed models. After examining the scale's construct validity, we calculated Cronbach alpha and composite reliability coefficients, the scale reliability (if items delete), average variance extracted, and item-rest correlations.

Findings

We started the analysis to examine the fit of the proposed model depending on the priori. Then, we assigned 26 items to their factors and ran the confirmatory factor analysis. The chi-square result was significant because of the high sample size, with a value of 1397, p>.001, and df:293 (χ2/sd:4.77). The goodness of fit values results were RMSEA: 0.056, SRMR:0.061, GFI: 0.977, CFI:0.910, TLI: 0.900, NNFI: 0.900, and NFI: 0.889. These results showed that the construction of the scale was suitable for the 4-factors structure. However, Item 7 had the lowest factor load with 0.05. Except for that, the other items' loadings varied from .50 to .75. We noticed that several authors excluded item 7 from the scale in Turkish adaptation studies in previous studies (Özkan, 2008; Kurt, 2009). Therefore, we omitted item 7 and reran the analysis.

The results of the second analysis yielded better values of GIF indices. The chi-square result was 1215, p>.001, and df:269 (χ2/sd:4.52). The goodness of fit values were RMSEA: 0.054, SRMR:0.050, GFI: 0.979, CFI:0.921, TLI: 0.912, NNFI: 0.912, and NFI: 0.902. According to Fabrigar et al. (1999), RMSEA values less than 0.05 are good, values between 0.05 and 0.08 are acceptable, values between 0.08 and 0.1 are marginal, and values greater than 0.1 are poor. Therefore, the RMSEA value of 0.054 indicates an acceptable fit and is very close to a good fit. There is no golden rule or a thumb rule of cut points for the goodness of fit indices, but according to Hu and Bentler (1999, p. 27), values close to .08 for SRMR, .06 for RMSEA .95 for TLI, CFI seem to result in lower Type II and acceptable cost of Type I error rates. The results of this analysis indicated the fit of the observed model to the expected model. The four-factor model of Conley et al.'s (2004) Epistemological Beliefs in Science Scale worked well with the high school sample in Türkiye by omitting item 7.

Factor names, items (indicators), estimates, standardized values, and error variances are provided in Table 3. According to confirmatory factor analysis results, the standardized factor loadings varied between .50 to .75. The loadings and inter-factor relationships in the model were significant. According to Stevens (2002) factor loadings should be greater than .40 but Hair et al. (2009) discussed they should be .50 at least. The factor loadings in Table 3 are higher than .50 and sufficient. These values are also evidence for convergent validity (Fornel ve Larcker, 1981; Peterson, 2000). Another important indicator for convergent validity is average variance extracted (AVE) value which should be higher than .50 for each factor (Fornel ve Larcker, 1981; Peterson, 2000). The AVE values of the scale were .37 for the certainty factor, .40 for the source factor, .41 for the development factor, and .46 for the justification factor. The AVE values of the factors were lower than they should be for confirming convergent validity as one of them was below .40, and the others were between .40 and .50. The loadings of the items affirmed the convergent validity, but AVE values were not enough to comply with it. On the other side, the construct reliability coefficients of the factors (see Table 5) are higher than the factors' AVE values. This finding is another evidence to support convergent validity. Considering the goodness of fit indices of the DFA results and item loadings, the scale has adequate validity. Regarding the item translations performed almost two decades ago, some improvements like re-examining the translation of the items, their clarity, and understanding may be needed.

Table 3
Confirmatory Factor Analysis Results

Factors	Items	Estimates	Standardized	Errors	t values*
Source	1	.67	.58	.66	20.57
	6	.78	.67	.55	24.54
	10	.79	.65	.57	23.82
	15	.54	.51	.74	17.46
	19	.85	.72	.48	26.99
Certainty	2	.64	.50	.75	17.52
	12	.86	.69	.52	25.82
	16	.65	.55	.70	19.51
	20	.81	.69	.52	25.67
	23	.71	.60	.64	21.53
Development	4	.75	.66	.57	24.60
	8	.77	.68	.54	25.60
	13	.76	.60	.64	21.99
	17	.76	.68	.53	25.77
	21	.65	.58	.66	21.09
	25	.68	.65	.58	24.20
Justification	3	.70	.66	.57	24.77
	5	.78	.68	.53	26.16
	9	.81	.74	.46	29.06
	11	.66	.62	.62	23.03
	14	.85	.75	.43	29.87
	18	.84	.73	.46	28.86
	22	.71	.60	.64	22.22
	24	.72	.67	.55	25.62
	26	.73	.66	.56	25.01

*p< .001

The inter-factor correlations and average variances extracted (AVEs) are shown in Table 4. According to these results, factors have positive and significant relations. Remarkably, Justification and Development dimensions as well as Certainty and Source dimensions have the highest relationships. Additionally, the square roots of AVE values of these factors are higher than .63. These values vary between .63 to .68. All square root values of the AVE are higher than .50. This is a good finding for divergent validity (Fornel ve Larcker, 1981). But these values are not higher than all other correlation coefficients for each factor. Therefore, the discriminant validity cannot fully comply.

Table 4
Correlations and Root Square Values of AVE of the Factors

	Source	Certainty	Development	Justification
Source	*.63**			
Certainty	.74	*.63**		
Development	.35	.41	*.64**	
Justification	.35	.44	.81	*.68**

*The italic numbers show the Root Square Value of AVE. All values p < .001

We calculated Cronbach's α and McDonald's ω to examine the scale's reliability (see Table 5). Cronbach's α is the most commonly used reliability coefficient in studies. However, it depends on the assumption that the factor loadings are equal across indicators and are not equal in most cases. That is why some researchers suggest preferring to construct reliability (Fornell and Larcker, 1981), also known as McDonald's omega (ω) (McDonald, 1999), and composite reliability (CR) (Ravkov, 1997). CR does not require equivalent factor loadings. Both Cronbach's α and McDonald's ω values of the factors were presented in Table 5. All values were higher than .74 and varied from .74 to .89 for α and .75 to

.89 for ω. There are different views for interpreting the reliability coefficients. According to Nunnally and Bernstein (1994), any value higher than .70 is accepted as adequate reliability regarding Cronbach's α. Some studies say the .70 indicates only modest reliability and recommend .80 and higher values (Lance et al. 2006; Nunnally and Bernstein, 1994; Carmines and Zeller, 1979). In this study Cronbach's α values show modest reliability for Source and Certainty factors, and good reliability for Development and Justification factors. The α values were almost the same as ω values. According to Hair et al. (2009), ω values of .7 and higher show good reliability. Considering the literature and the values in Table 5, we can say the factors of the Epistemological Beliefs Scale have acceptable reliability.

Table 5

Factors' Descriptives, Reliability Coefficients and AVEs

Factors	Number of Items	Mean	SD	Cronbach's α	McDonald's ω	AVE
Source	5	3.78	.83	.77	.77	.40
Certainty	5	3.76	.85	.74	.75	.37
Development	6	3.83	.81	.81	.81	.41
Justification	9	3.97	.80	.89	.89	.46

AVE: Average Variance Extracted

Scale constructions, descriptive statistics, reliability coefficient if the item was deleted, and item rest correlation were presented in Table 6.

Table 6

Items' Descriptives, Reliability Coefficients if Item Drops and Item-Rest Correlations

Factors	Items	Mean	SD	Alpha if item deleted	Omega if item deleted	Item-Rest Correlation
Source	1	3.98	1.15	.73	.73	.53
	6	3.89	1.17	.69	.70	.63
	10	3.81	1.21	.72	.73	.55
	15	3.32	1.06	.76	.76	.44
	19	3.89	1.18	.73	.73	.54
Certainty	2	3.64	1.27	.73	.73	.44
	12	4.08	1.25	.69	.69	.53
	16	3.42	1.18	.71	.72	.47
	20	3.89	1.18	.67	.67	.58
	23	3.79	1.18	.69	.70	.53
Development	4	3.84	1.13	.78	.78	.56
	8	3.79	1.13	.46	.77	.62
	13	4.00	1.26	.79	.79	.52
	17	3.96	1.12	.77	.77	.59
	21	3.63	1.12	.78	.79	.53
	25	3.75	1.04	.77	.78	.58
Justification	3	3.97	1.06	.87	.88	.61
	5	4.08	1.15	.87	.87	.65
	9	3.99	1.10	.87	.87	.68
	11	3.70	1.06	.88	.88	.58
	14	3.99	1.13	.87	.87	.70
	18	4.12	1.14	.87	.87	.69
	22	3.97	1.18	.88	.88	.55
	24	3.89	1.07	.87	.87	.63
	26	4.04	1.11	.87	.88	.62

According to Table 6, each item well contributed to the scale's reliability, and therefore, they were needed.

Discussion, Conclusion, and Suggestions

This study aimed to validate the Epistemological Beliefs in Science Scale (EBSS) using a sample of ninth, tenth, eleventh, and twelfth graders enrolled public high schools in Türkiye. Similar to previous studies (Bahçıvan, 2014; Kurt, 2009), we also used Özkan (2008)'s Turkish translation for the linguistic adaptation phase. This study demonstrates that the Turkish version of the EBSS is valid for high schools in Türkiye. According to our knowledge, this is the first evaluation of the cross-cultural adaptation, statistical reliability, and validity of the EBSS for all high school grades in Türkiye.

Comparison of the psychometric findings of the Epistemological Beliefs in Science Scale from different studies were demonstrated in Table 7. The first column represents results of the original study done by Conley et al. (2004). The second, third and fourth columns show findings of the previous Turkish adaptation studies from Özkan (2008), Kurt (2009) and Bahçıvan (2014). And the final column presents results of this study. With regards to Table 7, almost all CFA indices of the current study are better and the reliability coefficients are higher than the ones in previous Turkish adaptation studies. When the factor structures are taken into account, this study reveals a very similar factor structure to the one in the original scale except for one omitted item. Item 7 was omitted in this study based on the previous studies' suggestion. Özkan (2008) found three factors by omitting two items and Kurt (2009) reached four factors but had to delete five items. The number of factors and item distribution under the factors of Bahçıvan (2014)'s study is the same with the findings of study; however, his samples are from university students.

Table 7.
Comparison of the Results of Different Studies of The Epistemological Believes in Science Scale

	Conley et al, 2004	Özkan, 2008	Kurt, 2009	Bahçıvan, 2014	This Study
Target Audience	5th grade students	7th grade students	6th, 8th, and 10th grade students	Junior, and Senior Unv. students	9th, 10th, 11th, and 12th grade students
Sample size	187	1240	1557	310	1205
Scale Language	English	Turkish	Turkish	Turkish	Turkish
$\chi2/sd$	396.39/293 ($\chi2/sd$: 1.35)		1089.89/183 ($\chi2/sd$: 5.96)	($\chi2/sd$: 1.44)	1215/269 ($\chi2/sd$: 4.52)
RMSEA	0.038	0.06	0.056	0.04	0.054
RMR	0.062				0.067
SRMR		0.06	0.060		0.050
GFI		0.92	0.937		0.979
AGFI		0.91	0.921		0.910
CFI	0.90			0.95	0.921
NNFI	0.89				0.912
NFI					0.902
Factors and Number of Items	S: 5 C: 6 D: 6 J: 9	S-C: 9 D: 6 J: 9	S: 4 C: 3 D: 5 J: 9	S: 5 C: 5 D: 6 J: 9	S: 5 C: 5 D: 6 J: 9
Omitted items	-	2, 7	2, 7, 13, 16, 19	7	7
Cronbach's α	S: .81; .82 C: .78; .79 D: .57;.66 J: .65; .76	S-C: .70 D: .59 J: .77	S: .59 C: .59 D: .61 J: .83	S: .68 C: .66 D: .71 J: .82	S: .77 C: .74 D: .81 J: .89

S: Source, C: Certainty, D: Development, J: Justification

The item loadings confirmed convergent validity, but the AVEs fell short of requirements. Taking into account the CFA results' goodness-of-fit indices and item weights, it is possible to conclude that the EBSS has adequate validity. In addition, α values were nearly identical to ω values. Considering the literature review, we can conclude that the factors of the EBSS has also adequate reliability. The results of the current study indicate that the Epistemological Beliefs in Science Scale having four factors with 25 items is valid, reliable, and capable of measuring high school students' science epistemological beliefs in Türkiye. This adaptation would contribute to both the national and international literature by enabling more accurate assessment of students' epistemological beliefs in science and supporting further research on their relationship with inquiry-based learning, argumentation, and achievement.

According to Chan and Elliott (2004) and Qian and Alvermann (1995), the structure of a scale can be affected by cultural differences. We used Özkan (2008)'s Turkish translation. Scale adaptation can yield varying results because of translation process, cultural and linguistic differences, and individual experiences. Further adaptation studies of the EBSS can be conducted semantically and contextually by retranslating the seventh item.

Disclosure Statements

Contribution rate statement of the researchers: All authors contributed equally to this study.

Conflict of interest statement:

The authors declare that there is no conflict of interest.

CRediT Authorship Contribution Statement

Özcan Erkan Akgün, Feral Ogan-Bekiroglu, Erol Süzük, Cansu Şıvgın: Conceptualization, methodology, data collection, data analysis, writing – review & editing.

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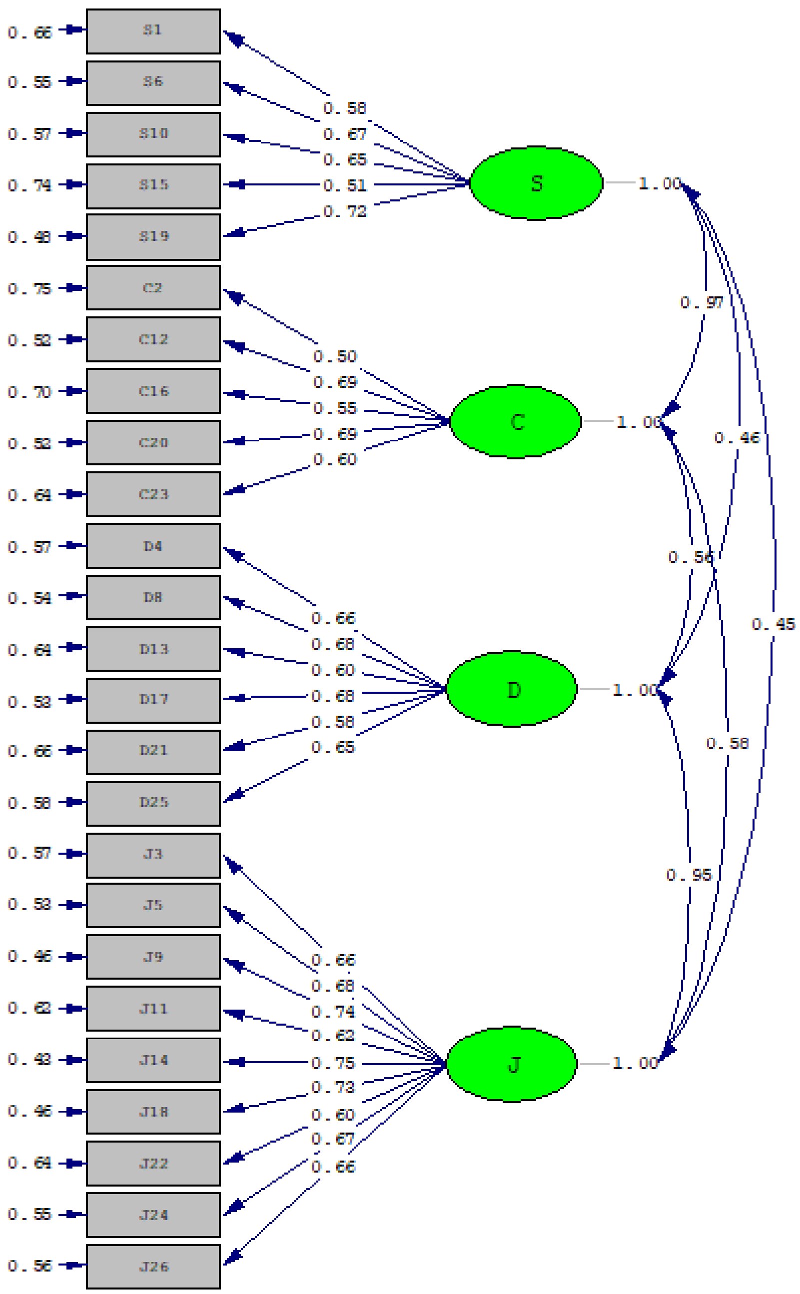
Appendix 1. Path Diagram of the CFA with Standardized Values



S: Source, C: Certainty, D: Development, J: Justification

Appendix 2. Turkish Items of the Epistemological Beliefs in Science Scale

1. Tüm insanlar, bilim insanlarının söylediklerine inanmak zorundadır. **Reverse**

2. Bilimde, bütün soruların tek bir doğru yanıtı vardır. **Reverse**

3. Bilimsel deneylerdeki fikirler, olayların nasıl meydana geldiğini merak edip düşündükçe ortaya çıkar.

4. Günümüzde bazı bilimsel düşünceler, bilim insanlarının daha önce düşündüklerinden farklıdır.

5. Bir deneye başlamadan önce, deneyle ilgili bir fikrinizin olmasında yarar vardır.

6. Bilimsel kitaplarda yazılana inanmak zorundasınız. **Reverse**

~~7. Bilimsel çalışma yapmanın en önemli kısmı, doğru yanıtı ulaştırmaktır.~~ **REMOVED**

8. Bilimsel kitaplardaki bilgiler bazen değişir.

9. Bilimsel çalışmalarda düşüncelerin test edilebilmesi için birden fazla yol olabilir.

10. Fen Bilgisi dersinde, öğretmenin söylediği herşey doğrudur. **Reverse**

11. Bilimsel düşünceler, konu ile ilgili kendi kendinize sorduğunuz sorulardan ve deneysel çalışmalarınızdan ortaya çıkabilir.

12. Bilim insanları bilim hakkında hemen hemen her şeyi bilir, yani bilecek daha fazla bir şey kalmamıştır. **Reverse**

13. Bilim insanlarının bile yanıtlayamayacağı bazı sorular vardır.

14. Olayların nasıl meydana geldiği hakkındaki yeni fikirler bulmak için deneyler yapmak, bilimsel çalışmanın önemli bir parçasıdır.

15. Bilimsel kitaplardan okuduklarınızın doğru olduğunu daima emin olabilirsiniz. **Reverse**

16. Bilimsel bilgi her zaman doğrudur. **Reverse**

17. Bilimsel düşünceler bazen değişir.

18. Sonuçlardan emin olmak için, deneylerin birden fazla tekrarlanmasında fayda vardır.

19. Sadece bilim insanları, bilimde neyin doğru olduğunu kesin olarak bilirler. **Reverse**

20. Bilim insanının bir deneyde aldığı sonuç, o deneyin tek yanıtıdır. **Reverse**

21. Yeni buluşlar, bilim insanlarının doğru olarak bildiklerini değiştirir.

22. Bilimdeki parlak fikirler sadece bilim insanlarından değil, herhangi birinden de gelebilir.

23. Bilim insanlarının neyin doğru olup olmadığı konusunda her zaman hemfikir olmaları gerekir. **Reverse**

24. İyi çıkarımlar, birçok farklı deney sonucunda elde edilen kanıtlara dayanır.

25. Bilimin nasıl çalıştığı ve neyin doğru olduğu ile ilgili düşünceleriniz bazen değişebilir.

26. Bir şeyin doğru olup olmadığını anlamak için deney yapmak iyi bir yoldur.

Kesinlikle Katılmıyorum: 1, Katılmıyorum: 2, Kararsızım: 3, Katılıyorum: 4, Kesinlikle Katılıyorum: 5