CAUSAL EFFECT OF EPISTEMOLOGICAL BELIEFS AND METACOGNITION ON CRITICAL THINKING DISPOSITION[1]

ELEŞTİREL DÜŞÜNME EĞİLİMİNE EPİSTEMOLOJİK İNANÇLARIN VE ÜSTBİLİŞİN NEDENSEL ETKİSİ

Tuncer AKBAY[2] Lokman AKBAY[3] Vesile Gül BAŞER GÜLSOY[4]

Başvuru Tarihi: 06.11.2017 Yayına Kabul Tarihi: 12.01.2018 DOI: 10.21764/maeuefd.349581

Abstract: Many studies in the literature indicate relationships between epistemological beliefs, metacognition, and critical thinking. All these constructs either directly or indirectly affect learning and cognition. In this research, we aim to disclose the magnitude of the direct effect the epistemological beliefs has on metacognition and critical thinking as well as determining the size of direct effect of metacognition and indirect effect of epistemological beliefs on critical thinking. To determine magnitude of the postulated direct and indirect causal effects between the three constructs, we collected and analyzed a set of data reflecting 234 college students' level of epistemological beliefs, metacognition, and critical thinking. After careful examination, 18 cases were outliers and were removed prior to the analyses. Therefore, the analysis proceeded with a sample size of 215 participants Then a specific structural equation model (SEM), namely structural regression (SR) model, employed for data analysis. The results of this study suggested that fostering epistemological beliefs of learners on naive-sophisticated axis might develop their metacognitive and critical thinking skills.

Keywords: *SEM, epistemological beliefs, metacognition, critical thinking, SR*

Öz: Birçok çalışma epistemolojik inanç, üstbiliş ve eleştirel düşünme arasında ilişki olduğunu göstermektedir. Bu üç yapının da doğrudan ve/veya öğrenmeye ve bilişe etki ettiği vurgulanmaktadır. Bu çalışmada ise, amaç epistemolojik inanç ve üstbilişin eleştirel düşünmeye doğrudan etkileri ile epistemolojik inancın üstbiliş üzerinden yine eleştirel düşünmeye olan etkisinin büyüklük derecesini kestirmektir. Bu üç yapının varolduğu kabul edilen etkilerinin büyüklük derecesini belirlemek için 234 lisans öğrencisinden epistemolojik inanç, üstbiliş, ve eleştirel düşünme verileri toplanmıştır. Özenle yapılan veri incelemesinde 18 katılımcının verileri uçdeğer olarak değerlendirildiğinden çalışmadan çıkarıldı. Böylece analize 215 katılımcıdan elde verilerle devam edildi. Verileri analiz etmek için yapısal regresyon adında özgül bir yapısal eşitlik modeli kullanılmıştır. Bulgular bireylerin epistemolojik inançlarının naif-karmaşık ekseninde gelişmesinin üstbiliş ve eleştirel düşünme yetilerini geliştirebileceğini göstermektedir.

Anahtar Kelimeler: *YEM, epistemolojik inanç, üstbiliş, eleştirel düşünme, yapısal regresyon*

[1] Earlier version of this study has been presented at *II^nd International Eurasian Educational Research Congress* in 2015 under the title of *Two Predominant Causal Latent Variables Effecting Critical Thinking Disposition: An SEM Model*

[2] Sorumlu Yazar, Arş. Gör, Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi, Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü, tuncerakbay@mehmetakif.edu.tr, ORCID No: 0000-0003-3938-1026

[3] Yrd. Doç. Dr., Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi, Ölçme ve Değerlendirme Anabilim Dalı, lakbay@mehmetakif.edu.tr, ORCID No: 0000-0003-4026-5241

[4] Yrd. Doç. Dr., Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi, Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü, vbaser@mehmetakif.edu.tr, ORCID No: 0000-0002-0752-9498

Introduction

There are many studies in the literature indicating that epistemological beliefs, metacognition, and critical thinking have interrelationships and they all either directly or indirectly affect learning and cognition. Cano and Cardelle-Elewar (2004) and Paulsen and Wells (1998) are among the examples of research explaining the relationship between epistemological beliefs and learning strategies. Bromme, Pieschl, and Stahl (2010) argued that one's epistemological beliefs progress from naïve to sophisticate via schooling. This article vastly discusses metacognition, epistemological beliefs, and critical thinking as well as their interplay.

Akar, Tekkaya, and Çakıroğlu (2011), Hofer (2004), and Kuhn and Dean (2004) are among the studies that account for interaction between epistemological beliefs and metacognition. Further, Kitchener (1983) referred to the interaction between the two constructs as epistemic cognition (as cited in Bromme et al. 2010). Further, due to the close relationships between epistemological beliefs and metacognition, Spray, Scevak, and Cantwell (2013) suggested conceptualizing them together. In many studies, correlation and regression analyses employed to unveil the relationships between these two constructs; which suggested similar results yielding positive relationship between epistemological beliefs and metagoctition (see Akar et al., 2011; Bedel, 2012; Bromme et al., 2010; Pulmmones, 2010).

Studies argue that epistemological beliefs also have a close relationship with critical thinking, that is, researchers believe that epistemological beliefs and critical thinking have an ordered relationship (Chan, Ho, & Ku, 2011; Gallagher, 1998, and Jones, Merritt, & Palmer, 1999). Chan et al. (2011) rationalize the relationship between the two by the statement that "sophisticated beliefs underlie flexible thinking, which is essential in the process of thinking critically" (p.68). Some of the exemplar research yielding significant correlational association between epistemological beliefs and critical thinking includes Brabeck (1983), and Chan et al. (2011).

Magno (2010) clarified that Schoen (1983) referred to critical thinking and metacognition by enhancement of thinking and process of knowledge organization, respectively. Although the relationship between these two constructs is well-stated, there are limited number of studies investigating the association between metacognition and critical thinking. In their studies, Ku and Ho (2010) concluded that metacognitive strategies improve critical thinking. Sadeghi, Hassani, and Rahmatkhah (2014) and Choy and Cheah (2009) also claimed a close relationship between metacognition and critical thinking. It should also be noted here that, there are some controversial findings in the literature. For example, Başbay (2013) inferred that critical thinking affects epistemological beliefs whereas Magno (2010) argued that the direction of the effect was reverse. In consideration of the studies mentioned above, we are convinced that epistemological beliefs affect metacognition and critical thinking. Further, metacognition directly affects critical thinking such that it plays a mediating variable role between epistemological beliefs and critical thinking.

The aim of this study is to disclose the magnitude of the direct effects the epistemological beliefs have on metacognition and critical thinking. Furthermore, we also aim to determine the size of direct effect of metacognition and indirect effect of epistemological beliefs (through metacognition) on critical thinking. To determine magnitude of the postulated direct and indirect causal effects between the three constructs, we collected and analyzed a set of data reflecting 234 college students' level of epistemological beliefs, metacognition, and critical thinking. Then a specific structural equation model (SEM), namely structural regression (SR) model, employed for data analysis. We hope that the directionality and the magnitude of the direct and indirect effects help practitioners and curriculum developers to direct classroom learning accordingly.

The significance of the current study relies on its analysis technique. Many studies mentioned above did not consider all three latent variables simultaneously that may have direct and/or indirect effect on one another. For instance, associations found between epistemological beliefs and critical thinking in those studies may emerge due to a confounding effect of metacognition. Therefore, looking at the association without considering a possible confounding variable may lead a spurious association rather than a true one. In such circumstances, using structural equation modeling (SEM) can reduce the possibility of specifying a spurious association and avoid incorrect inferences. Additionally, SEM model helps readers to gain insight into causation between the variables (i.e., from *causal variable* to *effect variable*) on top of the magnitude of effect.

Construct Descriptions

Beliefs about the nature of knowledge and knowing are referred to as *epistemological beliefs* (Bromme et al., 2010). They affect individuals' reasoning, learning, and decision-making (Schommer, 1994). There are studies to disclose the theoretical structure and dimensionality of epistemological beliefs. Although Schommer (1994) proposed five dimensions for epistemological beliefs (i.e., omniscient authority, certain knowledge, simple knowledge, fixed ability, and quick learning), many researchers failed to confirm these dimensions. In the sequel, Bromme et al. (2010) argued that commonly recognized and used framework for epistemological beliefs consists of four dimensions (i.e., certainity of knowledge, structure of knowledge, justification of knowledge, and source of knowledge).

As it cited in Bedel (2012), the term *metacognition* used by Flavell (1976) to define cognitive processes' regulation and the knowledge about cognition. Knowledge about using specific strategies for learning and problem solving is one of the multiple forms of metacognition (Metcalfe & Shimamura, 1994). As mentioned in Bromme, Pieschl, and Stahl (2010), Nelson (1999) claims that metacognition— "cognitions about one's own cognitions"— differs from other cognitions as it takes individual's own cognition as the object. Moreover, the literature partitions metacognition into two main components: (1) knowledge about cognition and (2) regulation of cognition (Jacobs and Paris, 1987; Schraw, 1998; Garner, 1990; Schraw and Dennison, 1994).

There are multiple definitions of critical thinking. For instance, Mayer and Goodchild (1990) defined it as "active and systematic attempt to understand and evaluate arguments" (as cited in Magno, 2010). Another definition for it is "reasonable reflective thinking that is focused on deciding what to believe and do" (Ennis, 1987, p.6). Although critical thinking has been conceptualized different ways depending on the study field, common sense for all definitions is that "it entails awareness of one's own thinking and reflection on the thinking of self and others as an object of cognition" (Kuhn & Dean, 2004, p.270).

Methodology and Preliminary Data Analysis

Model Specification

As explained in the introduction, there are studies claiming relationships between the constructs of interest (i.e., metacognition, epistemological beliefs, and critical thinking disposition). In this study, we specified a *structural regression (SR)* model, which presumes *direct effects* of epistemological beliefs on both metacognitive awareness and critical thinking disposition. It also assumes that metacognition has a direct effect on critical thinking disposition, which further implies that metacognitive awareness is a mediating variable between causal factor epistemological beliefs and effect variable critical thinking disposition. *Figure 1* demonstrates this SR model. The *Indicator (i.e., observed)* variables associated with the latent factors are based on three measurement inventories used to measure these factors.

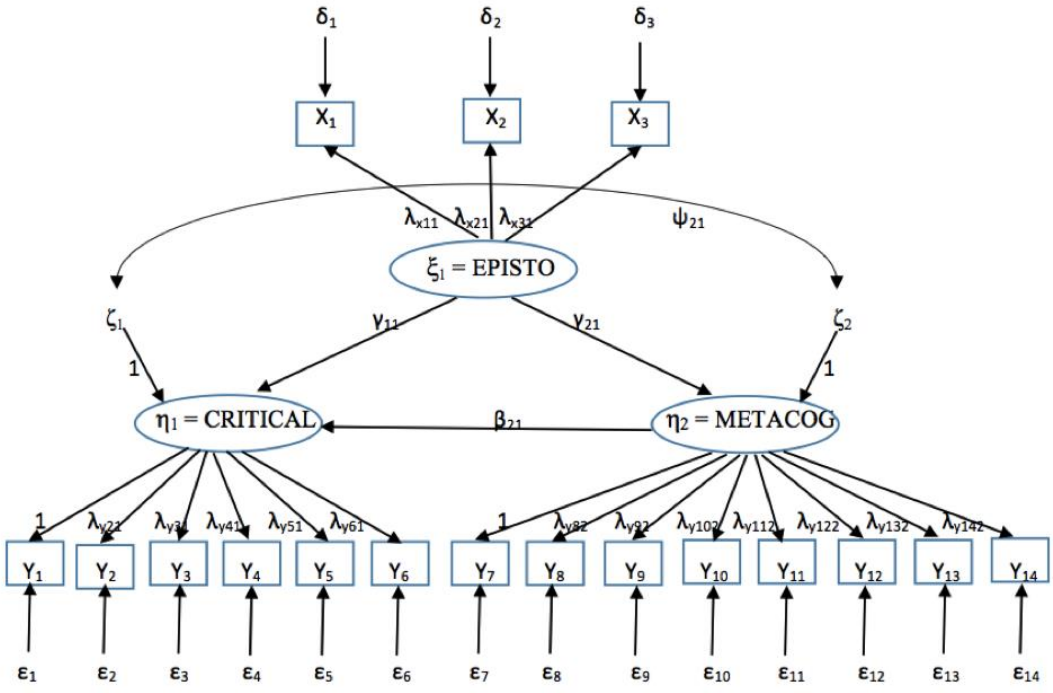


Figure 1. Structural Regression Model

Measurement Tools

In this study, three self-report inventories were used to measure the three latent variables. All three inventories are the Turkish version of preexisting inventories. The *epistemological beliefs inventory* (EBI) was adapted, from Schommer (1998), to Turkish environment by Deryakulu and Buyukozturk (2002). There are 35 polytomous items measuring three subdomains. All items are in the form of 5-point likert scale (i.e., '1 = strongly disagree' and '5 = strongly agree'). Subdomains and corresponding items are given in the middle part of the *Table 1*. Validity and reliability studies have been done by Deryakulu and Buyukozturk (2002), and internal consistency index has reported as .79. Based on the factor loadings obtained by running a CFA, some of the items (i.e., 6, 9, 12, 15, and 18) were discarded due to low loadings and item 10 moved into the second subscale although it was originally under the first subscale. Because the items in the second and third subscales were *dissenting* (i.e., obtaining a lower sum-score indicates higher epistemological beliefs and vice versa), subjects' scores on these two subscales were reverse coded. For example, since the minimum and maximum score that can be obtained from the second subscale are 9 and 45, respectively, 9 converted into 45 and 45 replaced by 9.

The *metacognitive awareness inventory* (MAI) was adapted, from the original study of Schraw and Dennison (1994), by Akin, Abaci, and Cetin (2007). This measurement instrument consists of 52 polytomous items, which are in the form of likert scale ranging from '1-never' to '5-always'. In this inventory, there are eight defined subscales. They are given in the upper part of the *Table 1* with their respective items. All items within each subscale are *affirmative* such that, for all items, '5-always' stands for high metacognitive awareness level. Thus, the sum-score within each subscale is considered to be the measure of the corresponding subdomain. Validity and reliability studies have been done by Akin, Abaci, and Cetin (2007), and internal consistency index has reported as .95.

Table 1.
The Latent Variables with Items Consisting Their Respective Subscales

Metacignitive Awareness	Items in the Inventory
Declarative Knowledge (MAI1)	5, 10, 12, 16, 17, 20, 32, 46
Procedural Knowledge (MAI2)	3, 14, 27, 33
Conditional Knowledge (MAI3)	15, 18, 26, 29, 35
Planning (MAI4)	4, 6, 8, 22, 23, 42, 45
Monitoring (MAI5)	1, 2, 11, 21, 28, 34, 41, 49
Evaluation (MAI6)	7, 19, 24, 36, 38, 50
Debugging (MAI7)	25, 40, 44, 51, 52
Information Management (MAI8)	9, 13, 30, 31, 37, 39, 43, 47, 48
Epistemological Beliefs	
Belief in Effort for Learning (EBI1)	1, 2, 3, 4, 5, 7, 8, 11, 13, 14, 16, 17
Belief in Ability for Learning (EBI2)	10, 19, 20, 21, 22, 23, 24, 25, 26
Belief in Single Truth (EBI3)	27, 28, 29, 30, 31, 32, 33, 34, 35
Critical Thinking Disposition	
Analyticity (CTDI1)	2, 3, 12, 13, 16, 17, 24, 26, 37, 38, 40, 46, 50
Open-mindedness (CTDI2)	5, 7, 15, 18, 22, 23, 26, 33, 36, 41, 43, 45, 47, 50
Inquisitiveness (CTDI3)	1, 8, 30, 31, 32, 34, 38, 39, 42, 46, 51
Systematicity (CTDI4)	8, 14, 29, 35, 39, 44, 48, 51
Self-confidence (CTDI5)	6, 11, 19, 20, 25, 27, 28, 49, 50
Truth-seeking (CTDI6)	4, 9, 10, 19, 21, 23, 44, 51

The *California critical thinking disposition inventory* (CCTDI) was adapted, from Facione, Facione, and Giancarlo (1998), by Kökdemir (2003). Although the original study defined seven subdomains under critical thinking disposition, Kökdemir (2003) claimed that six-component model was more meaningful based on the data collected via Turkish version of the inventory. This inventory consists of 51 6-point likert scale items. Validity and reliability studies have been done by Kökdemir (2003), and internal consistency index has reported as .88.

Table 2.
Gutman's λ6 and Cronbach's α Internal Consistency Coefficients with 95% CI

Mesurement			95% CI	
Inventory	Lambda6	Alpha	Lower	Upper
MAI	0.95	0.92	0.90	0.94
EBI	0.82	0.74	0.69	0.80
CTDI	0.91	0.85	0.82	0.88

Gutman's lambda 6 and *Cronbach's alpha* internal consistency (with 95% confidence interval) indices were calculated for the inventories measuring metacognitive awareness, epistemological beliefs, and critical thinking disposition. The R-package 'psych' (Revelle, 2013) was used to obtain the aforementioned reliability coefficients that are given in *Table 2*.

Data Collection

The data were collected from 234 college students who enrolled in science education, Turkish literacy education, English as a second language education, elementary school teaching, and computer education and instructional technology undergraduate programs during the Fall 2014. The sampling method applied in this study was convenient. Students' level of metacognitive awareness, epistemological beliefs, and critical thinking dispositions were measured using the respective inventories described above along with a short survey related to the demographics.

Data Screening and Preparation

After careful examination of person-by-item matrix of the data, one subject removed from the data set due to large number of missing responses. The response rate for each item in all measurement instruments was equal or higher than 95 percent. Because of the fact that each variable consists of at least four items and missing responses were not systematic, this data loss was considered as ignorable. Seeing that the data loss was missing at random (MAR), a *single-imputation method* (i.e., mean substitution) was used to replace missing responses. Then, in order to detect outliers, standardized sores as well as the scatterplots were scrutinized. Furthermore, *Mahalanobis distance* (D^2) as a common approach for multivariate data outlier detection was calculated. This careful examination suggested that 18 cases were outliers and were removed prior to the analyses. The reason for outliers was aberrant response to items in the instruments. Therefore, the analysis proceeded with a sample size of 215 participants.

Table 3.
Descriptive Statistics of the Variables Explaining Metacognitive Awareness, Epistemological Beliefs, and Critical Thinking Disposition

	MAI1	MAI2	MAI3	MAI4	MAI5	MAI6	MAI7	MAI8	EBI1	EBI2	EBI3	CTDI1	CTDI2	CTDI3	CTDI4	CTDI5	CTDI6
Minimum	21.00	8.00	11.00	16.00	17.00	13.00	10.00	22.00	28.72	18.03	11.00	35.40	22.00	29.00	16.00	11.00	15.00
1st Quartile	28.00	12.00	17.00	22.00	25.00	19.00	17.00	30.41	34.28	26.64	23.00	55.00	37.00	42.00	26.00	25.00	21.00
Median	30.35	14.00	19.00	25.00	28.67	22.00	19.00	34.00	35.71	29.02	26.00	60.00	42.00	47.66	28.00	29.00	24.00
Mean	30.43	13.64	18.95	24.60	28.09	21.46	19.08	33.36	35.35	28.53	26.50	59.34	42.46	47.41	27.76	29.67	24.63
3rd Quartile	33.49	15.00	21.00	27.00	31.00	24.00	22.00	37.00	36.74	30.82	30.00	64.30	47.00	53.00	30.00	35.00	28.00
Maximum	39.00	20.00	25.00	34.00	39.00	30.00	25.00	45.00	38.41	33.17	41.00	73.00	70.00	65.00	37.00	45.00	37.00
Stand. Dev.	3.89	2.52	2.97	3.89	4.33	3.50	3.23	4.41	1.86	2.89	5.15	6.82	8.28	7.38	3.19	6.63	4.47
Skewness	-0.20	-0.01	-0.38	0.00	-0.19	-0.17	-0.49	-0.27	-0.89	-0.85	0.15	-0.71	0.26	-0.10	-0.26	0.07	0.25
Kurtosis	2.40	2.53	2.76	2.49	2.74	2.64	2.84	2.56	3.55	3.68	3.02	3.71	3.21	2.41	3.63	2.62	2.60

The phenomenon in which two or more predictor variables in a statistical model are highly correlated is referred to as *collinearity* (or *multicollinearity)*. When this is the case, two or more variables eventually measure the same thing, which causes redundancy. Although collinearity does not affect the predictive power of a model as a whole, it devastates the validity of the results about individual predictors. Therefore, we checked *variance inflation factor* (VIF) for collinearity detection. The VIF is the ratio of total standardized variance over unique variance and less than 10.00 is favorable (Kline, 2011). In our case, the maximum VIF for the predictor variables was 2.96, which indicated that collinearity was not a problem in current study.

Descriptive statistics of the data are given in *Table 3*. It should be pointed out here EBI1 and EBI2 scores are the *square-root* transformed version of the original scores. Due to their positive skewness this transformation was necessary. Furthermore, these scores were re-scaled by multiplying by 5. This re-scaling was also needed to avoid having an ill-scaled covariance matrix as input for SR model. The ratio of maximum and minimum variance of observed variables should be less than 10.00 to avoid an ill-scaled covariance matrix; otherwise, model parameter estimation may not converge. After all, the maximum absolute values for *skewness* and *kurtosis* became .26 and 3.71, respectively. Simulation studies (i.e., Curran, West, and Finch, 1996) concluded that skewness and kurtosis that are larger than ±3.0 and ±10.0, respectively, indicate that data substantially deviate from normal distribution. Under these guidelines, skewness and kurtosis values calculated for the each variables used in this study indicated that univariate normality assumption was satisfied for all variables. Furthermore, examination of scatterplots and histograms confirmed that the assumption of univariate normality was not violated. The *linearity* of relations and residual *homoscedasticity* checked by simple visual scanning of *bivariate scatterplots*, which suggested that these assumptions held. In summary, based on the data screening, all of the univariate distributions were approximately normal, the bivariate relations were linear, and the residuals were homoscedastic. Because, in most cases, multivariate non-normality can be detected by examining the univariate distributions, we concluded that the assumption of multivariate normality held.

Table 4.
The Covariance Matrix

	MAI1	MAI2	MAI3	MAI4	MAI5	MAI6	MAI7	MAI8	EBI1	EBI2	EBI3	CTDI1	CTDI2	CTDI3	CTDI4	CTDI5	CTDI6
MAI1	15.17																
MAI2	5.23	6.35															
MAI3	7.26	4.37	8.80														
MAI4	8.10	5.40	6.65	15.15													
MAI5	9.52	6.32	6.48	11.73	18.76												
MAI6	8.15	5.04	6.03	9.35	10.73	12.26											
MAI7	4.38	2.63	4.21	5.32	6.36	5.51	10.46										
MAI8	9.62	5.53	7.99	11.13	12.29	10.08	7.49	19.48									
EBI1	1.71	0.84	1.52	1.70	1.81	1.00	1.09	1.57	3.46								
EBI2	0.69	0.37	0.48	0.76	-0.38	0.15	1.06	0.16	1.03	8.34							
EBI3	2.27	1.03	0.49	-0.53	0.88	0.68	-1.12	0.56	0.62	4.09	26.57						
CTDI1	10.15	4.18	6.96	7.75	8.47	7.06	4.74	8.05	4.53	5.29	1.80	46.58					
CTDI2	-5.77	0.45	-2.79	-0.47	-1.17	-1.34	-2.56	-0.07	-3.14	-6.83	-7.79	-13.03	68.54				
CTDI3	10.81	7.16	7.76	10.27	13.92	10.47	4.62	8.68	5.67	3.11	5.97	29.89	-4.58	54.51			
CTDI4	2.01	1.74	0.96	2.41	3.12	1.31	0.33	1.87	0.60	-0.14	0.00	0.87	2.50	9.78	10.15		
CTDI5	-3.55	0.04	-2.86	-4.07	-3.45	-3.29	-4.63	-3.05	-0.66	-5.36	-3.75	-4.50	25.46	-9.43	-3.19	43.90	
CTDI6	-5.24	0.08	-2.90	-1.96	-1.19	-1.91	-2.14	-1.83	-1.37	-1.16	-1.37	-9.02	16.15	-3.30	2.49	10.98	19.96

Recall that the three inventories have a total of 17 subscales (i.e., eight for MAI, three for EBI, and six for CTDI), which means that there are17 observed variables. The lower triangle of the variance-covariance matrix for the observed variables is given in *Table 4*. This lower triangle of the covariance matrix with 153 (i.e., *17(17+1)/2*) observations was the input in this study.

Analysis and Results

Because a valid measurement model is prerequisite to evaluate the structural component of the SR model, the model was respecified as a CFA model by removing the structural part from the SR model. This CFA model was estimated using Lisrel 9.1 software program. Although the model fit was initially poor; the fit was improved by letting the errors between several indicators to correlate, with respect to the *modification index (MI)*. When the CFA fitted, factor loadings of the two indicator variables (i.e., CTDI2 and CTDI4) were not significant. Thus, these two predictor variables were removed from the analysis. As the second step, structural component was added to the CFA model and model parameters were estimated. Because of the fact that the added structural component was just identified (i.e., df_M=0), the goodness-of-fit statistics remained the same as were in the CFA model.

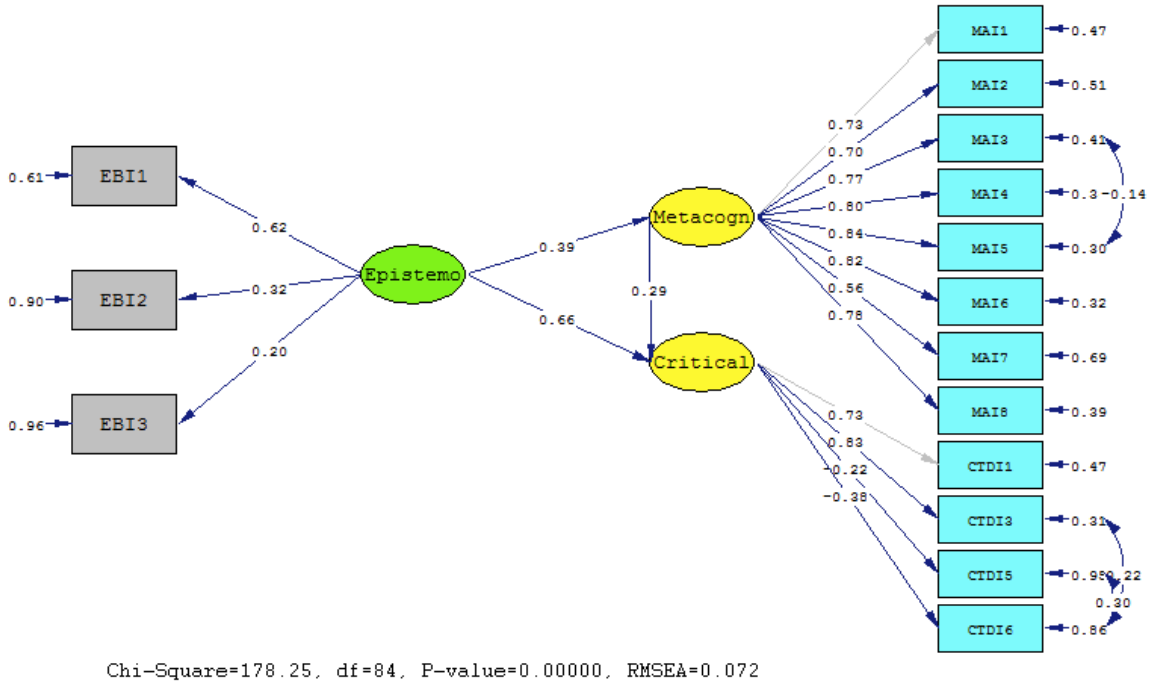


Figure 2. Standardized Solution of Structural Regression Model

The maximum likelihood ratio test chi-square fit index among the several goodness-of-fit indices suggested a poor fit (χ^2_M = 178.25, df_M = 84, p-value = .00). However, some other prevalently used fit indices suggested that the data-model fit was plausible (i.e., RMSEA = .072, which suggests reasonable error of approximation; CFI = .964, which indicates reasonably good fit of the model; and SRMR = .058, which also indicates that model adequately fits the data). Moreover, it should be noted here that because χ^2_M is affected by sample size, it could lead to rejection of the null hypothesis (i.e., H_0: model fits the data) even though the difference between the observed and estimated covariance matrices is slight. Therefore, considering the suggestions of different fit indices, the model as a whole reasonably fitted to the data. Since the parameter estimates based

on unstandardized solution are reported in Table 5, the standardized solution of the model estimation is given in *Figure 2*.

Table 5.

Parameter Estimates of the SR model Based on Unstandardized Solution

LAMBDA Y

	MAI1	MAI2	MAI3	MAI4	MAI5	MAI6	MAI7	MAI8	CTDI1	CTDI3	CTDI5	CTDI6
Metacognition												
Est.	2.83	1.76	2.28	3.11	3.63	2.88	1.80	3.45				
SE	---	0.17	0.21	0.27	0.30	0.24	0.23	0.30				
z-stat.	---	10.10	11.02	11.61	12.06	11.99	7.98	11.34				
Critical												
Est.									4.99	6.12	-1.44	-1.69
SE									---	0.71	0.51	0.38
z-stat.									---	8.69	-2.85	-4.39

LAMBDA X

	EBI1	EBI2	EBI3
Epistemology			
Est.	1.16	0.91	1.05
SE	0.21	0.25	0.44
z-stat.	5.68	3.72	2.40

BETA

	Metacognition			Critical		
	Est.	SE	z-stat.	Est.	SE	z-stat.
Metavognition	---	---	---	---	---	---
Critical	0.29	0.12	2.45	---	---	---

GAMMA

	Metacognition			Critical		
	Est.	SE	z-stat.	Est.	SE	z-stat.
Epistemology	0.39	0.11	3.40	0.66	0.16	4.25

PSI (This matrix is diagonal)

	Metacognition			Critical		
	Est.	SE	z-stat.	Est.	SE	z-stat.
	0.85	0.16	5.42	0.34	0.15	2.25

THETA-EPSILON (This matrix is diagonal)

	MAI1	MAI2	MAI3	MAI4	MAI5	MAI6	MAI7	MAI8	CTDI1	CTDI3	CTDI5	CTDI6
Est.	7.19	3.25	3.59	5.50	5.61	3.95	7.23	7.60	21.71	17.04	41.83	17.23
SE	0.75	0.34	0.41	0.61	0.70	0.45	0.72	0.83	3.05	3.98	4.08	1.81
z-stat.	9.56	9.67	8.79	9.06	8.03	8.79	10.05	9.21	7.12	4.28	10.24	9.51

THETA-DELTA

	EBI1	EBI2	EBI3
Est.	2.11	7.51	25.46
SE	0.44	0.78	2.52
z-stat.	4.75	9.68	10.11

Based on the information in Table 5, it can be seen from the GAMMA table that epistemological beliefs had a direct effect of .39 on metacognitive awareness. Likewise, epistemological beliefs had a direct effect of .66 on critical thinking disposition as well as having a total effect of .77 (i.e., .66 + (.39*.29)). Furthermore, metacognitive awareness had a direct effect of .29 on critical thinking disposition (see BETA table). Based on the PSI table, the proportion of the explained variance of metacognitive awareness by the model was calculated as 0.15 (i.e., 1-.85) and the proportion of the explained variance of critical thinking disposition was 0.66 (i.e., 1-0.34).

Although, the predictive power of the SR model for metacognitive awareness was low, it was quite high for critical thinking disposition.

The final model and the parameter estimates confirmed that there are a direct effects of epistemological beliefs on both the metacognitive awareness and critical thinking disposition. The sizes of these direct effects are .39 and .66, respectively. Metacognitive awareness also has a direct effect on critical thinking disposition in the magnitude of .29. Therefore, metacognitive awareness is playing a mediating variable role for the association between epistemological beliefs and critical thinking disposition. This further indicates an indirect effect from epistemological beliefs to critical thinking in the size of .11.

Conclusion and Discussion

The current study is an extension of previous studies that has linked epistemological beliefs and metacognition to critical thinking. In this study, we disclosed the magnitude of the direct effects of epistemological beliefs on metacognition and critical thinking. Additionally, we tried to determine the size of direct effect of metacognition and indirect effect of epistemological beliefs (via metacognition) on critical thinking. Particularly, this study highlighted the indirect effect of epistemological beliefs on critical thinking. The results showed that these beliefs have important effects on producing cognitive abilities as well as promoting critical thinking. It leads us to expect one possessing naive epistemological beliefs to demonstrate poor critical thinking performance. It can also be inferred from the results of the study that, naive epistemological beliefs lead less-developed cognitive strategies for learning and problem solving. It can be attributed the fact that beliefs in *fixed knowledge* can be associated with a lower need for cognition. Therefore, recognition of tentativeness of knowledge along with reliance on developing cognitive skills through effortful practice can improve evaluative and critical thinking ability.

Epistemological beliefs, metacognition, and critical thinking are among the predominant factors influencing learning. Development of internet technology enabled individuals to reach plenty amount of information from unknown sources that created pluralistic knowledge age. In this regard, evaluation of information became necessary to collect trustworthy, accurate, objective, and current information for problem solving. Thinking critically is crucial for learners to avoid pseudoscientific thinking (Halpern, 1998) and to enhance conceptual understanding (Kuhn & Udell, 2007).

The results of this study suggested that fostering epistemological beliefs of learners on naive-sophisticated axis might develop their metacognitive and critical thinking skills. Therefore, whilst designing instructions with an aim of enhancing learners' critical thinking abilities, the teaching necessary thinking skills may not be sole focus. Instructional programs may be designed such that learners recognize the tentative and complex nature of knowledge. This can be achieved, according to Chan, Ho and Ku (2011), through "the experience of epistemic doubt, where one

questions the existence of absolute knowledge (Bendixen, 2002)" (2011, p.74). King and Kitchener (2002) suggested having learners to reflect and judge knowledge on ill structured problems as practical ways to induce epistemic doubt in learners. They believe that learners will beware of alternative modes of thought via these strategies.

Results of this current research, metacognitive awareness is another unignorable factor that influence critical thinking ability. Therefore, it must be taken into account in instructional design for teaching thinking skills. Kuhn, Shaw, and Felton (1997) argued that one way to enhance students' metacognitive awareness of the co-existence of multiple viewpoints is dyadic discussions of controversial issues.

Limitations and Future Direction

One limitation of this work is that the predictive power of the factor model for epistemological beliefs was quite low. It might be attributed to the measurement tools since they all were self-report instruments. Better and more accurate results could be obtained by using a more reliable measurement instrument for epistemological beliefs construct. The results of the current study showed that the continuation of research in this topic is necessary. Especially, conducting experimental researches in this area may be needed to test and to evaluate indefinite inferences the current research put forward. Then, it can be easier to make assertive suggestions on educational implications.

References

Akar, E., Tekkaya, C., Cakiroglu, J. (2011). The interplay between metacognitive awareness and scientific epistemological beliefs. *International Journal in New Trends in Education and Their Implications, 2*(3), 7-13.

Akin, A., Abaci, R., & Çetin, B. (2007). The validity and reliability of the Turkish version of the metacognitive awareness inventory. *Educational Sciences: Theory & Practice, 7*(2), 671-678.

Başbay, M. (2013). Epistemolojik inancın eleştirel düşünme ve üstbiliş ile ilişkisinin yapısal eşitlik modeli ile incelenmesi. *Eğitim ve Bilim, 38*(169).

Bedel, E. F. (2012). An examination of locus of control, epistemological beliefs and metacognitive awareness in preservice early childhood. Teachers. *Educational Sciences: Theory and Practice, 12*(4), 3051-3060.

Bendixen, L. & Rule, D. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist, 39(1),* 69-80

Brabeck, M. M. (1983). Critical thinking skills and reflective judgment development: Redefining the aims of higher education. *Journal of Applied Developmental Psychology, 4*(1), 23-34.

Bromme, R., Pieschl, S., & Stahl, E. (2010). Epistemological beliefs are standards for adaptive learning: A functional theory about epistemological beliefs and metacognition. *Metacognition and Learning, 5* (1), 7-26.

Cano, F. & Cardelle-Elawar, M. (2008). Family environment, epistemological beliefs, learning strategies, and academic performance: A path analysis. In M.S. Khine (Eds.), *Knowing, knowledge and beliefs: Epistemological studies across diverse cultures.* (pp. 219-239). New York, NY: Springer Science Business Media

Chan, N., Ho, I. T. & Ku, K.L.Y. (2011). Epistemic beliefs and critical thinking of Chinese students. *Learning and Individual Differences, 21*, 67-77.

Choy, S.C. & Cheah, P.K. (2009). Teacher perceptions of critical thinking among students and its influence on higher education. *International Journal of Teaching and Learning in Higher Education, 20(2),* 198-206

Curran, P. J., West, S. G., & Finch, J. F. (1996). The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. *Psychological methods*, *1*(1), 16.

Deryakulu, D. and Büyüköztürk, Ş. (2002). Epistemolojik inanç ölçeği'nin geçerlik ve güvenirlik çalişmasi. *Eğitim Araştırmaları, 2(8)*, 111-125.

Ennis, R. (1987). A taxonomy of critical thinking dispositions and abilities. In Joan Baron and Robert Sternberg (Eds.) Teaching Thinking Skills: Theory and Practice. New York: W.H. Freeman.

Facione, P. A., Facione, N. C., & Giancarlo, C. A. F. (2001). *California critical thinking disposition inventory: CCTDI*. California Academic Press.

Gallagher, S. A. (1998). The road to critical thinking: The Perry scheme and meaningful differentiation. NASSP Bulletin, 82(595), 12−20.

Garner, R. (1990). When children and adults do not use learning strategies: Toward a theory of settings. *Review of Educational Research, 60(4),* 517-629

Halpern, D.F. (1998). Teaching critical thinking across domains: Dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist, 53(4),* 449-455

Hofer, B. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist 39*(1), 43-55.

Jacobs, J.E. & Paris, S.G. (1987). Children's metacognition about reading: Issues in definition, measurement, and instruction. *Educational Psychologist, 22,* 225-278

Jones, P. C., Merritt, J. Q., & Palmer, C. (1999). Critical thinking and interdisciplinarity in environmental higher education: The case for epistemological and values awareness. Journal of Geography in Higher Education, 23(3), 349−357.

King, P. M., & Kitchener, K. S. (2002). The reflective judgment model: Twenty years of research on epistemic cognition. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 37–61). Mahwah, NJ: Lawrence Erlbaum.

Kline, R.B. (2011). *Principles and practice of structural equation modeling* (3rd ed.). New York: The Guilford Press.

Kuhn, D., & Dean, D. (2004). Metacognition: A Bridge Between Cognitive Psychology and Educational Practice. Theory into Practice 43(4), 268-273.

Kökdemir, D. (2003). Belirsizlik durumlarında karar verme ve problem çözme. *Yayınlanmamış doktora tezi*. Ankara Üniversitesi, Sosyal Bilimler Enstitüsü, Ankara

Ku, K. Y. L., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. Metacognition and learning, 5.3, 251- 267.

Kuhn, D., Shaw, V., & Felton, M. (1997). Effects of dyadic interaction on argumentive reasoning. *Cognition and Instruction*, *15*(3), 287-315.

Kuhn, D., & Udell, W. (2007). Coordinating own and other perspectives in argument. *Thinking and Reasoning*, *13*, 90–104.

Magno, C. (2010). The role of metacognitive skills in developing critical thinking. Metacognnition Learning, 5, 137-156.

Metcalfe, J. & Shimamura, A.P. (1994). *Metacognition: Knowing about knowing.* Cambridge, MA: MIT Press/Bradford

Nelson, T. O. (1999). Cognition versus metacognition. *The nature of cognition*, 625-641.

Paulsen, M.B. & Wells, C.T. (1998). Domain differences in the epistemological beliefs of college students. *Research in Higher Education, 39(4),* 365-384

Pulmones, R. (2010). Linking students' epistemological beliefs with their metacognition in a Chemistry Classroom. *The Asia-Pacific Education Researcher, 1 (19),* 143-159.

Revelle, W. (2013) psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, USA, http://CRAN.R-project.org/package=psych Version = 1.4.2.

Sadeghi, B., Hassani, M. T., & Rahmatkhah, M. (2014). The relationship between efl learners' metacognitive strategies, and their critical thinking. *Journal of Language Teaching & Research*, *5*(5).

Schoen, D. A. (1983). The Reflective Practitioner, How Professionals Think In Action. Basic Books: New York

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review, 6(4),* 293-319

Schommer, M. (1998). The influence of age and education on epistemological beliefs. *British Journal of Educational Psychology*, *68*(4), 551-562.

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science, 26,* 113-125

Schraw, G. & Dennison, R.S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19,* 460-475.

Spray, E., Scevak, J., & Cantwell, R. (2013). Personal epistemological and metacognitive awareness in first year preservice education students. *Australian Journal of Educational & Developmental Psychology, 13, 44-57.*

Uzun Özet

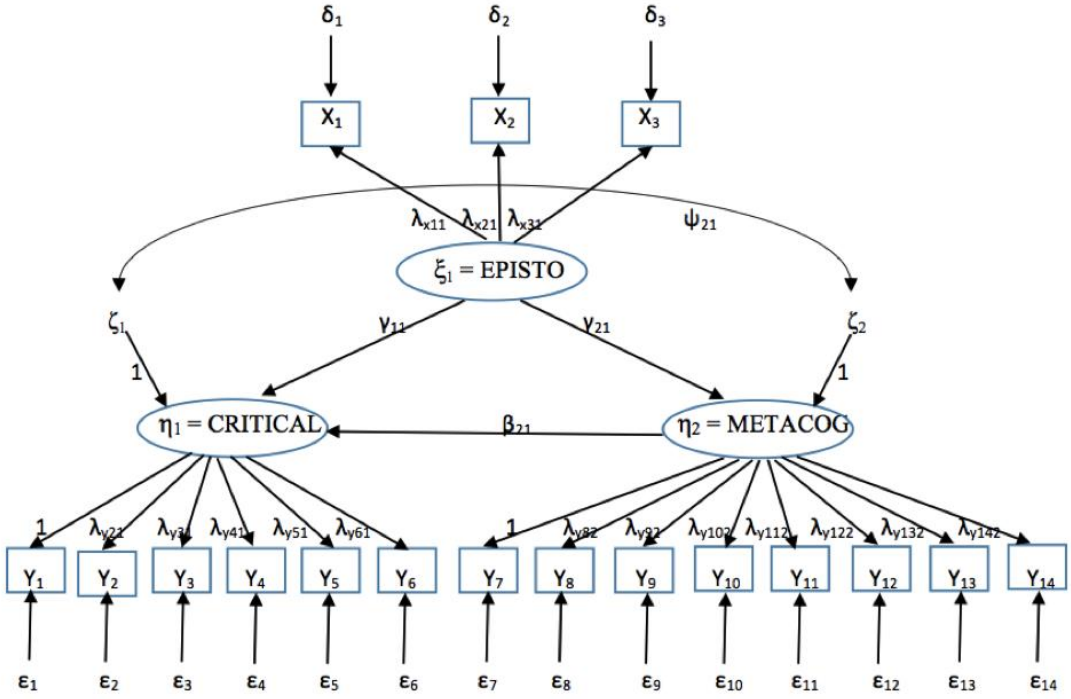
Giriş

Cano ve Cardelle-Elewar (2004) ile Paulsen ve Wells'in (1998) çalışmaları epistemolojik inanç ile öğrenme stratejileri arasındaki ilişkileri ortaya koyan araştırmalara örnektir. Bromme, Pieschl, ve Stahl (2010) bireyin epistemolojik inançlarının naiften karmaşığa doğru bir gelişim içerisinde olduğunu iddia etmektedirler. Alanyazında, epistemolojik inanç, üstbiliş ve eleştirel düşünme arasındaki karşılıklı ilişkinin bulunduğunu ve bu değişkenlerin öğrenmeyi ve bilişi doğrudan veya dolaylı olarak etkilediğini gösteren yine birçok çalışma yer almaktadır.

Bu çalışmanın temel amacı epistemolojik inancın üstbiliş ve eleştirel düşünceye olan doğrudan etkisinin büyüklüğünü ortaya koymaktır. Bunun yanında, üstbilişin doğrudan, epistemolojik inancın ise üstbiliş üzerinden dolaylı olarak eleştirel düşünceye etkisinin büyüklük derecesini kestirmektir. Bu amacı gerçekleştirebilmek için 234 üniversite öğrencisinden veri toplanmış olup, yapısal eşitlik modellemesi ile analiz edilmiştir.

Model Tanımlama

Alanyazından yola çıkarak, epistemolojik inancın üstbiliş ve eleştirel düşünceye doğrudan etkisi olduğu ve üstbilişin de eleştirel düşünceye doğrudan etkisinin olduğu, dolayısıyla üstbilişin bir aracı değişken rolü oynayarak epistemolojik inancın eleştirel düşünceye olan dolaylı etkisini yansıtan bir yapısal regresyon modeli tanımladık. Tanımlanan model Şekil-1'de görülebilir.



Şekil 1. Yapısal Regresyon Modelinin Standart Çözümleri

Ölçme Araçları

Bu çalışmada yer alan üç farklı örtük değişkeni ölçebilmek için üç adet öz-bildirim envanteri kullanılmıştır. Bu üç envanterde, önceden oluşturulmuş ölçeklerin Türkçe versiyonlarıdır. Epistemolojik inanç envanteri Schommer (1998) tarafından geliştirilmiş olup Deryakulu ve Büyüköztürk (2002) tarafından uyarlaması yapılmıştır. Üstbiliş farkındalık envanteri ise Schraw ve Dennison'un (1994) çalışmasından Akin, Abaci, ve Cetin (2007) tarafından uyarlanmıştır. Kaliforniya eleştirel düşünce envanteri ise Facione, Facione, ve Giancarlo (1998) tarafından geliştirilmiş ve Kökdemir (2013) tarafından uyarlanmıştır.

Örneklem

Çalışmada kullanılan veriler Sonbahar 2014 döneminde Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi fen bilgisi, Türkçe, İngilizce, sınıf öğretmenlikleri ve bilgisayar ve öğretim teknolojileri eğitimi anabilim dalından birisine kayıtlı olarak öğrenimini sürdüren 234 öğrenciden uygun örnekleme yöntemiyle elde edilmiş.

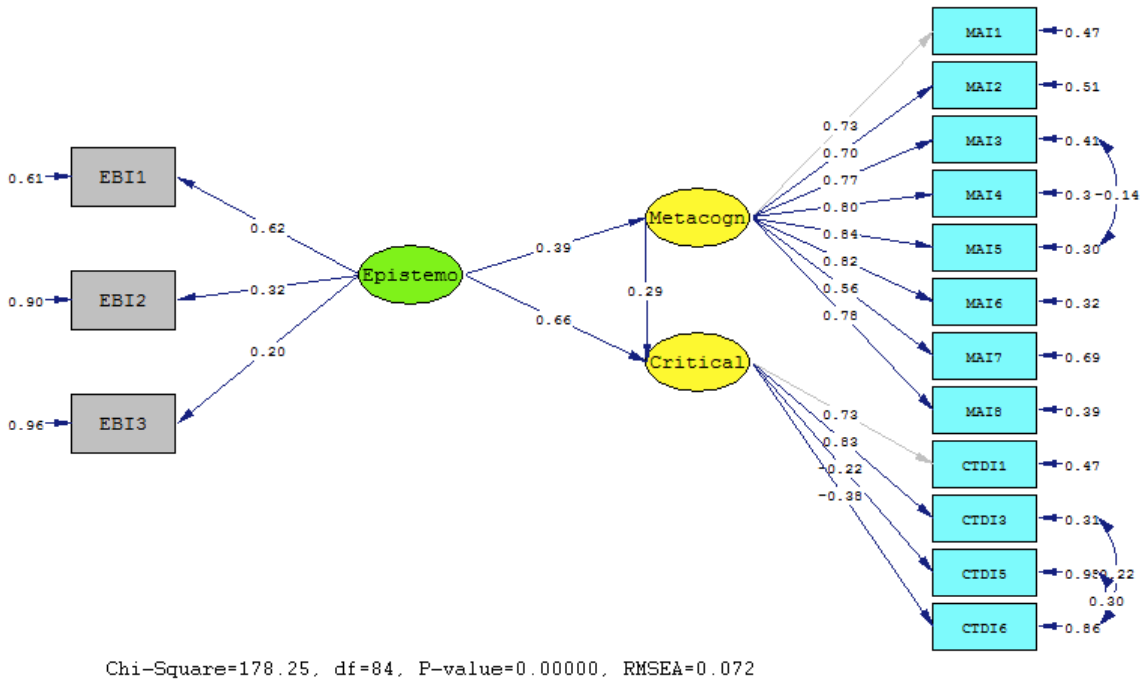
Analiz

Yapısal regresyon modelinde yer alan yapısal kısmın değerlendirilebilmesi için geçerli bir ölçme modeli ön koşul olduğundan, yapısal kısmın yapısal regresyon modelinden çıkarılarak model DFA olarak yeniden özgünleştirildi. Bu DFA modeline dayanarak Lisrel 9.1 programı kullanılarak parametre kestirimleri yapıldı.

Sonuç ve Tartışma

Model parametre kestirimleri epistemolojik inancın hem üstbilişe hem de eleştirel düşünceye direkt etkisi olduğunu göstermektedir. Model parametre kestirimleri Şekil 2'de verilmiştir. Bu direkt etkilerin boyutları sırasıyla .39 ve .66'dır. Ayrıca üstbilişin eleştirel düşünce üzerine .29 büyüklüğünde bir direkt etkiye sahip olduğu görülmüştür. Bu durumda epistemolojik inancın eleştirel düşünceye olan toplam etkisi .77'ye (yani, .66 + (.39*.29)) ulaşmaktadır. Model tarafından üstbiliş ve eleştirel düşünce değişkenlerinin toplam varyansın, sırasıyla, %15'ini ve %66'sını açıkladığı düşünülmektedir.

MCA'nın CTD üzerine .29 oranında bir direk etkisi olduğu bulunmuştur (BETA tablosuna bkz.). PSI tablosunda görüleceği gibi model MCA'ın varyansının .15 oranını açıklamaktadır (yani 1-.85) ve CTD'ın açıklanan varyans oranı .66 olarak bulunmuştur (yani, 1-.34). MCA üzerinde SR modelin yordama gücü düşük olmasına rağmen, bu durum CTD için oldukça yüksektir.



Şekil 2. Yapılandırılmış Regresyon Modelinin Standart Çözümü

Sonuçlar göstermiştir ki epistemolojik inançlar bilişsel yetenekleri geliştirmeye ve eleştirel düşünceyi ilerletmeye yönelik doğrudan etki sahibidir. Bu durumda, yüksek epistemolojik inançlar puanına sahip bireylerin eleştirel düşünme düzeyinin yüksek olacağını ve aynı şekilde, düşük epistemolojik inanca sahip olanların zayıf eleştirel düşünceye sahip olacağını düşünebiliriz. Dolayısıyla, düşük epistemolojik inanç sahibi olanların öğrenme ve problem çözmeye yönelik bilişsel stratejilerinin daha az gelişmiş olmasını bekleyebiliriz. Bu çalışma sonuçları öğrencilerin epistemolojik inançlarını naiften karmaşığa doğru geliştirmenin onların üstbilişsel ve eleştirel düşünceye sahip olma becerilerini de geliştireceğini ortaya koymaktadır.