EXAMINING THE CAUSAL EFFECTS OF THE TWO PREDOMINANT FACTORS ON CRITICAL THINKING DISPOSITION: A MULTIPLE GROUP SEM

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Abstract
Epistemological Beliefs, Meta-cognition and Critical Thinking Disposition constructs have close relationships with learning strategies, learning acquisition and related skills. Aforementioned constructs have interrelationships such that one construct has a direct or indirect effect on another one. Unveiling these direct and indirect affects and their magnitudes are among the purpose of this study. This purpose is attained through employment of Structural Equation Modeling (SEM). However, although SEM is an important technique, researchers need to make sure that latent construct measurements are invariant across subpopulations. In this research, we aim to disclose whether the effects of one construct on another differ by subpopulations. To achieve this goal, we collected data from 253 students who were enrolled one of the following undergraduate programs during 2015-2016 and/or 2016-2017 academic years: Foreign Language Education, Turkish Education, and Fine Arts. Three self-report inventories — meta-cognitive awareness inventory, epistemological beliefs inventory, and California critical thinking disposition inventory— were used for data collection. The results of a structural regression (SR) model (i.e., a model from SEM family) showed that epistemological beliefs has direct effect on both meta-cognitive awareness and critical thinking disposition. This structural regression model also indicated that meta-cognition has a direct effect on critical thinking disposition. When a Multiple-Sample Structural regression Model was run, results showed that measurements were not invariant across subsamples where two structural paths and four factor loadings were significantly different across groups.

Keywords: *Epistemological Beliefs, Metacognition, Critical Thinking, Multiple Group SEM, Structural Regression*

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Introduction

An oft-mentioned aim of higher education institutions is to produce individuals who can continually engage in higher order thinking through developing those individuals' critical thinking (Kuhn & Dean, 2004; Higbee, 2003). It can be argued that, determining and developing other factors that affect development of critical thinking in a positive way can help to produce people who are able to engage in higher order thinking. In the learning and cognition literature there are many studies explaining the interrelationships between critical thinking and the factors

influencing the acquisition of knowledge or skills. Predominantly associated factors with critical thinking are, but not limited with, epistemological beliefs, and metacognition.

Critical thinking is defined differently in the literature. For example, Ennis (1997) defined critical thinking as "reasonable reflective thinking that is focused on deciding what to believe and do" (p. 6) while Mayer and Goodchild defined it as "active and systematic attempt to understand and evaluate arguments" (Magno, 2010). The reason for this variation in the definition (or the way of conceptualization) might be due to variety on study fields. Nevertheless, in the conventional sense, critical thinking "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).

Beliefs about the nature of knowledge (certainty and simplicity of knowledge) and nature of knowing (source and justification of knowledge) are referred to as *epistemological beliefs* (Bromme, Pieschl, & Stahl, 2010). Bromme et al. (2010) argued that epistemological beliefs consists of four dimensions which are certainty of knowledge, structure of knowledge, justification of knowledge, and source of knowledge. Epistemological beliefs affect individuals' reasoning, learning, and decision-making (Schommer, 1994). The shift in epistemological beliefs of individuals from naive to sophistic, they begin to embrace knowledge as tentative and complicated rather than simple and fixed (Schommer, 1994). Individuals who has advanced epistemological views realize that there is no single authority that provide fixed knowledge. Rather, they see rational thinking as the source of knowledge. Because, when they encounter different opinions and explanations, they acknowledge the uncertainty temporarily and then, through the processes of rational thinking, they generate their own answers (Schommer, 1994).

Flavell (1976) introduced the term *metacognition* to refer the individual's own awareness and consideration about his /her own cognitive processes (Bedel, 2012). According to Winne and Perry (2000), "metacognition refers to awareness that learners have about their general academic strengths and weaknesses and of the cognitive resources they can apply to meet the demands of particular tasks, and second, to their knowledge and skill about how to regulate engagement in tasks to optimize learning process and outcomes" (Kerndl & Abersek, 2012, p.52). As it cited in Topcu and Yilmaz-Tuzun (2009), according to Brown (1978) metacognition has two components which are (1) knowledge of and (2) regulation of cognition. The knowledge of cognition covers declarative, conditional, and procedural knowledge while regulation of knowledge covers the constructs of planning, monitoring, and evaluation (Topcu & Yilmaz-Tuzun, 2009). Hofer (2004) conceptualizes epistemological beliefs as parts of metacognition. He further argues that beliefs about certainty and simplicity of knowledge can be matched with declarative metacognitive knowledge, whilst source and justification of knowledge could be assigned to metacognitive monitoring (Bromme, Pieschl, and Stahl, 2010). According to literature, metacogntion effects students' achievement (Peklaj & Pecjac, 2002; Sperling, Howard, Miller, & Murphy, 2002), reading comprehension (van Kraayenoord & Scheider, 1999), academic achievement through comprehension strategy use (Taraban, Rynearson, & Kerr, 2000). Yet, in their study, Sperling etal. (2002) found significant correlation between metacognition and achievement among some grade levels, the study did not revealed significant correlation some others grade levels though.

These aforementioned constructs are closely related to learning strategies, learning acquisition and developing skills. These three constructs —epistemological beliefs, meta-

cognition, and critical thinking disposition— either directly or indirectly affect one another. For instance, Hofer (2004), Kuhn and Dean (2004), and Spray, Scevak, and Cantwell (2013), are among the studies that suggested an interaction between epistemological beliefs and meta-cognition. Furthermore, in the learning and cognition literature, there are remarkable amount of studies that revealed interaction between epistemological belief and critical thinking disposition (see Chan, Ho, & Ku, 2011; Gallagher, 1998; and Jones, Merritt, & Palmer, 1999). Chan et al. (2011) pointed out this relationship as arguing that "sophisticated beliefs underlie flexible thinking, which is essential in the process of thinking critically" (p.68). Lastly, limited number of studies, that investigated and conformed the association between meta-cognition, can be found in the learning and cognition literature. Magno (2010), and Choy and Cheah (2009) may be given an example of those studies. Furthermore; Akbay, Akbay, and Baser Gulsoy (2017) has further investigated the relationships among these three constructs and disclosed the magnitude of the direct effects the epistemological beliefs have on meta-cognition and critical thinking disposition. They also determined the sizes of direct and indirect effects of one constructs to another using specific structural equation model (SEM).

Purpose of the Study

The purpose of the current study is, first, to unveil the direct effect of metacognitive awareness on critical thinking disposition. Second, to reveal the direct effect of epistemological beliefs on critical thinking disposition. Third, disclose the indirect effect of epistemological beliefs on critical thinking disposition taking metacognitive awareness as mediating factor between epistemological beliefs and critical thinking disposition. The ultimate goal of this research is to determine the magnitudes of each aforementioned effects and compare the magnitudes among the sample groups which were created based upon the departments of the sample.

Significance of the Study

The studies investigating the relationship among all these three latent variables were failed to disclose the magnitude and the direction of effects that one variable has on another. Most of them did not even consider these latent variables simultaneously to determine whether confounding effect exist between any of two variables due the third one. In such cases, there is a possibility to find spurious association between the two variables rather than a true association. Using a structural equation modeling (SEM) would be wise to reduce the potential for spurious association. Furthermore; multiple group SEM, which is used in this research for data analysis, enables researcher to compare magnitudes of effect in different levels of sample.

Methodology

Design

One of two main goals of a correlational study is –as reported in Frankel, Wallen, and Hyun (2012)- prediction. Frankel et al. (2012) further reported that score on one variable could be predicted given the score on another variable when these two variables have a strong relationship. As it discussed above, the purpose of the current study is to estimate the effects of one variable on another. To achieve that, this study was designed to be a correlational research.

Model Specification

A structural regression (SR) model, which presumes direct and indirect effects (through metacognitive awareness) of epistemological beliefs on critical thinking disposition, was specified. It also presumes a direct effect of metacognitive awareness on critical thinking disposition. Specified SR Model is illustrated in Figure-1 below. The *Indicator (i.e., observed)* variables associated with the latent factors are based upon three self-report inventories applied to measure these factors.

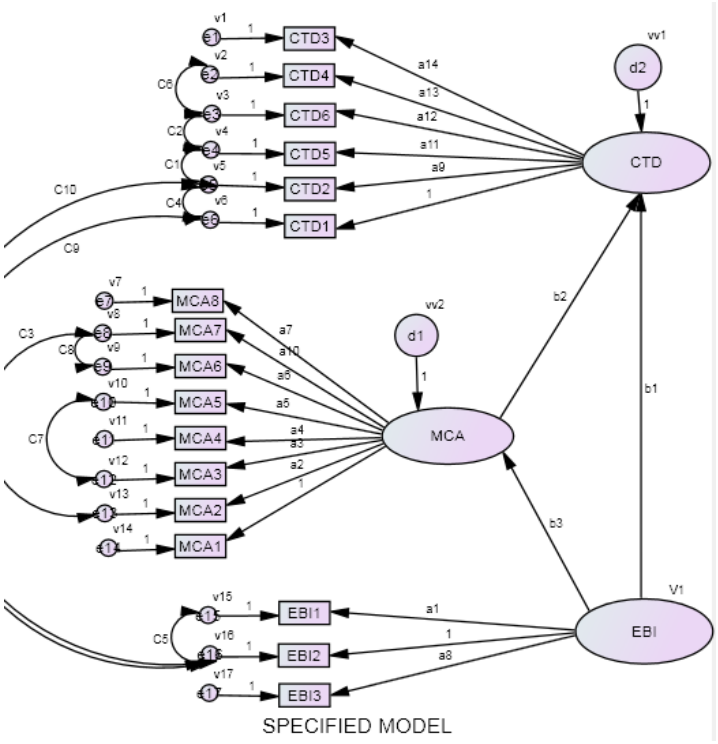

Figure 1. *Structural regression model*

Sample and Sampling Procedure

The sample consists of total 253 teacher candidates pursuing their education at Mehmet Akif Ersoy University. Of these students, 86 are majoring in Fine Arts; 94 are majoring in English as a Second Language Teaching, and 73 are majoring in Turkish Education undergraduate programs in the School of Education. Participants have been randomly selected from convenient clusters.

Data Collection Tools

The data gathered through three self-report inventories, which are *meta-cognitive awareness inventory, epistemological beliefs inventory, and California critical thinking disposition inventory.* The *epistemological beliefs inventory* (EBI) has been adapted to Turkish by Deryakulu and Büyüköztürk (2002) from the original work of Schommer (1998). There are overall 35 polytomous items that measure three subdomains. These items are in the form of 5-point likert scale (i.e., '1 = strongly disagree' and '5 = strongly agree'). The subdomains of the

inventory are Beliefs in Effort for Learning, Beliefs in Ability for Learning, and Beliefs in Single Truth. Deryakulu and Büyüköztürk (2002) conducted validity and reliability studies and reported its internal consistency as .79.

Moreover, Akın, Abacı, and Çetin (2007) adapted the *metacognitive awareness inventory* (MAI) to Turkish from the study of Schraw and Dennison (1994). This inventory consists of 52 five-point likert-scale items (i.e., '1 = never' and '5 = always'). This inventory contains eight defined subscales, which are Declarative Knowledge, Procedural Knowledge, Conditional Knowledge, Planning, Monitoring, Evaluation, Debugging, and Information Management. Validity and reliability studies were conducted by Akın et al. (2007), and an internal consistency index of .95.was reported.

Lastly, Kökdemir (2003) has adapted the *California critical thinking disposition inventory* (CCTDI) to Turkish from the original study of Facione, Facione, and Giancarlo (1998). Although, original study defined seven subdomains for critical thinking disposition construct; Kökdemir (2003) has suggested a six-component model for the Turkish version of it. These six subdomains are Analyticity, Open-mindedness, Inquisitiveness, Systematicity, Self-confidence, and Truth seeking. This inventory consists of 51 six-point liker-scale items (i.e., '1 = certainly disagree' and '6 = certainly agree'). Kökdemir (2003) reported that the inventory was valid and its internal consistency index was .88.

Data Analysis

Before evaluating the SR model, we needed valid measurement models so that we have run a CFA for three constructs. CFA and all other analyses that will be mentioned latter were conducted using AMOS 20 software program. Initial poor model-data fit was improved by allowing some of the error terms to correlate. Modification indices were the bases in this procedure. When CFA achieved an acceptable fit, SR model was run after adding the structural part to the CFA model. Goodness-of-fit statistics for this model (i.e., Chi/df=2.528; RMSE=.078; and CFI=.905) indicated an acceptable model-data fit. This initial SR model was run with whole sample (i.e., 253 candidate teachers from English, Turkish, and Fine Art education).

Then, multiple-sample version of the same model was run where three sets of model parameters obtained for the three subsamples. Goodness-of-fit statistics for this model (i.e., Chi/df=1.612; RMSE=.049; and CFI=.870) indicated a slightly better model-data fit in terms of Chi/df and RMSE although the fit was poor in terms of CFI. Comparison of constraint model (i.e., initial model, which forces all parameters to be equal for three groups) and unconstraint model (i.e., multiple-group, which estimates three sets of parameters for three subsamples) yielded a statistically significant difference (i.e., df=34, $\Delta\chi^2$=76.716, and p-value=.000). This result meant that at least one path is different across the subgroups. Then, we individually tested every path to figure out where groups differ.

Results and Discussion

Figure 2 presents standardized solution path coefficients of Turkish education group. This indicates that effect of Epistemological Belief (EB) on Metacognitive Awareness (MA) is .37. Also, EB has a direct effect of .42 and an indirect effect of .10 (i.e., .37*.28) on Critical Thinking Disposition (CTD). Also, MA has also a direct effect of .28 on CTD. Because these path

coefficients are based on standardized solutions, they are in the same scale so that they are comparable.

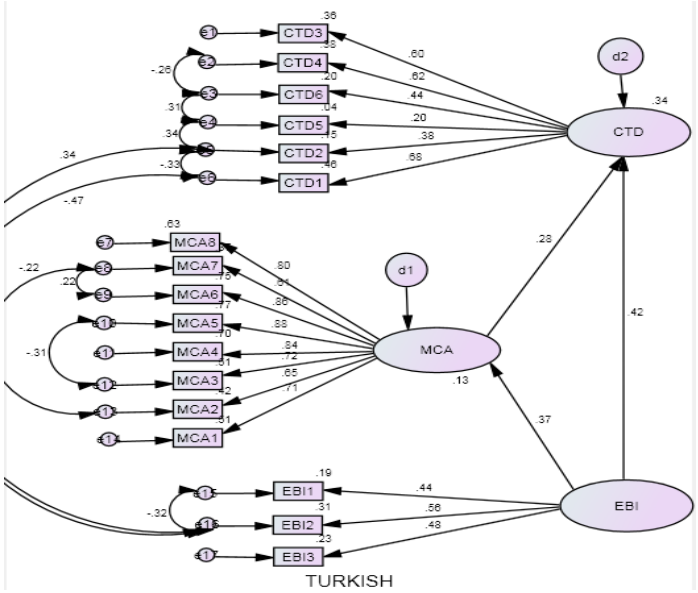

Figure 2. *Structural regression model for Turkish education group*

Figure 3 and 4 show the path coefficients obtained from English education and fine-art education groups, respectively. Based on Figure 3, EB has a direct effect of .56 and an indirect effect of .17 (i.e., .31*.44) on CTD. Direct effect of MA on CTD is .44. Lastly, direct effect of EB on MA is .31. Path coefficient between EB and CTD in Figure 4 is .42. Direct effect of EB on MA in the same figure is .32. Then indirect effect of EB on CTD becomes .10. Last path in this figure is the direct effect shows direct effect of MA on CTD, which is reported to be .32.

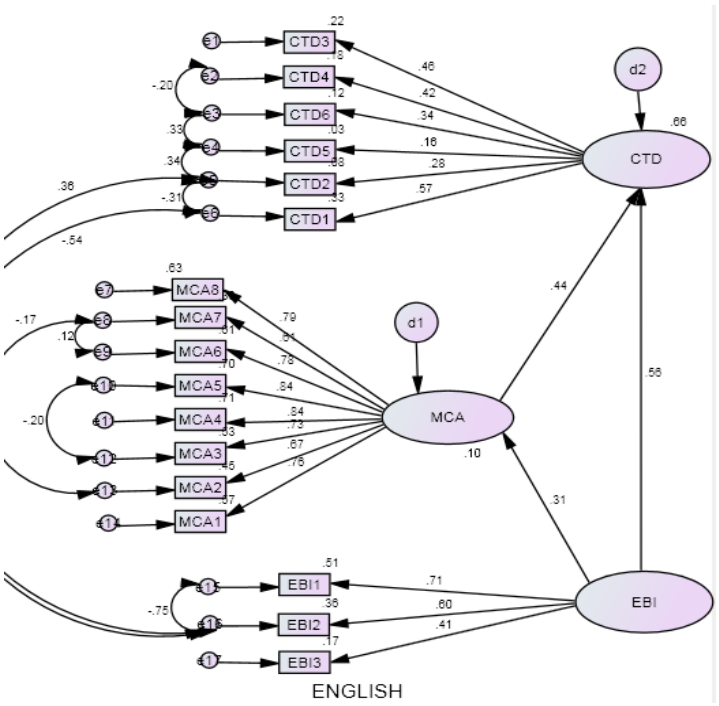

Figure 3. *Structural regression model for English education group*

In order to decide the paths that are statistically different across groups, we have run a series of structural-weight models in each of which only one path allowed to be free across groups while all others were forced to be equal across all subsamples. Then, all these structural-weight models were compared against constraint model where all parameters in the model forced to be equal across all groups. Model comparison results are given in Table 1.

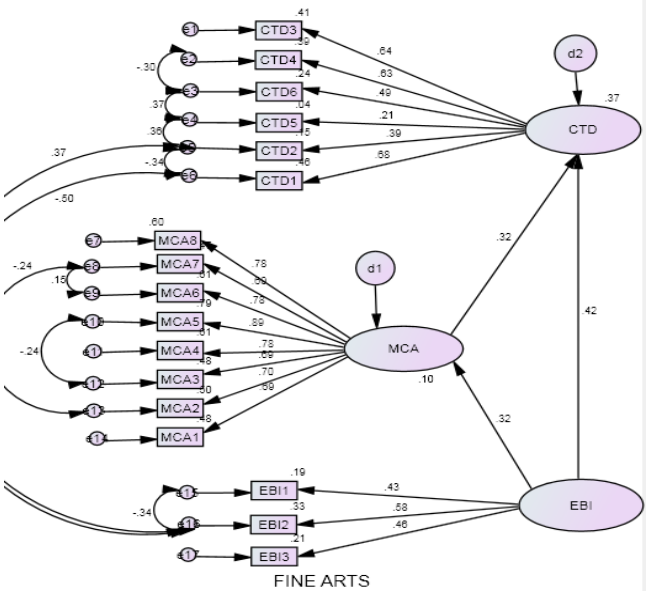

Figure 4. *Structural regression model for Fine-art education group*

Table 1.
Model comparison results

Structural Weight				
Models	**DF**	**$\Delta\chi^2$**	**p-value**	
b_1 equal	2	17.438	0.000	**
b_2 equal	2	4.155	0.002	**
b_3 equal	2	3.247	0.197	
a_1 equal	2	0.103	0.950	
a_2 equal	2	4.320	0.115	
a_3 equal	2	4.738	0.094	
a_4 equal	2	0.947	0.623	
a_5 equal	2	1.873	0.392	
a_6 equal	2	1.373	0.503	
a_7 equal	2	1.255	0.534	
a_8 equal	2	7.541	0.023	*
a_9 equal	2	10.440	0.005	**
a_10 equal	2	0.052	0.974	
a_11 equal	2	8.662	0.013	*
a_12 equal	2	14.313	0.001	**
a_13 equal	2	4.423	0.110	
a_14 equal	2	2.429	0.297	

Table 1 indicates that six parameters (i.e., *b*1, *b*2, *a*8, *a*9, *a*11, and *a*12) are statistically significant, meaning that these parameters are not equal (or not invariant) across groups. Here *b*1 and *b*2 path coefficients are the direct effects from EB to CTD and from MA to CTD, respectively. Coefficient *b*1 is .42 for Turkish and fine-art groups education groups while it is .56 for English group. This result implies that one standard deviation increase in EB scores of English education group will improve their CTD (i.e., .56 standard deviation) more than the increase that may be observed in other two groups (i.e., .42 standard deviation). When we consider *b*2, a similar result is seen so that this result may be interpreted in the same way. Lastly, it was also observed that several factor loadings (i.e., *a*8, *a*9, *a*11, and *a*12) were not invariant across these groups. Three of the variant factor loadings are between CTD and its indicator variables while one of them is between EBI and its one indicator variable.

Conclusion

Critical thinking allow students to avoid pseudoscientific thinking (Halpern, 1998), foster conceptual understanding (Kuhn & Udell, 2007), and enhance higher order thinking. These abilities are important for learning and academic success because, in technology era, people are exposed to lots of information from unknown sources. To evaluate information and select trustworthy, accurate, objective information to construct knowledge requires advanced critical thinking skills. As the study indicated, more sophisticated epistemological beliefs as well as

heightened awareness on metacognition helps to improve critical thinking skills. Therefore, besides including necessary skills in the teaching program; instruction should be designed such a way that students questions fixed knowledge through ill-structured problems, and realize co-existence different viewpoints through dyadic discussion.

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