Investigating Predictive role of Critical Thinking on Metacognition with Structural Equation Modeling

Serhat Arslan [1]

[1] serhatarslan@sakarya.edu.tr
Curriculum and Instruction,
Faculty of Education,
Sakarya University,Turkey

ABSTRACT

The purpose of this study is to examine the relationships between critical thinking and metacognition. The sample of study consists of 390 university students who were enrolled in different programs at Sakarya University, in Turkey. In this study, Critical Thinking Disposition Scale and Metacognitive Thinking Scale were used. The relationships between critical thinking and metacognition were examined using correlation analysis and the hypothesis model was tested through structural equation modeling. In correlation analysis, critical thinking and metacognition were found positively. The model demonstrated fit ($\chi 2$= 1014.86,df=551, p=.00, RMSEA=.038, GFI=.99, AGFI=.99, CFI=.99, NFI=.99, IFI=.99, RFI=.99, SRMR=.008). According to results metacognition was predicted positively by critical thinking. Results were discussed in the light of literature.

Keywords: *Critical thinking, Metacognition, path analysis*

INTRODUCTION

Critical thinking is a thinking method that involves cognitive procedures such as reasoning, analyzing, and evaluating. That thinking process consists of critical thinking, efficient problem solving and making a decision was stated by McPeck (1983). Concrete and abstract thinking processes is covered by critical thinking in order to reach a conclusion about specific pro-visions that are in balance with same sense and scientific evidences. It was stressed by Black (2005), Kuhn and Dean (2004) and Schroyens (2005) that critical thinking happens when indivuduals practice higher order thinking skills or strategies. Ennis (1985) described that critical thinking as reflective thinking stresses on determining what to do or what to believe. Bruning et al. (2004) defined reflective thinking as a reflective action in which the purpose is to comprehend the source of a problem. Moreover, the aim of critical thinking is to critisize the information, providing us to make meaningful decisions. Individual who apply critical thinking not only practise daily life ability of defining, summarizing, retrieving, analyzing, and synthesizing information (Gomez & Gomez, 2007), but also properly decide relevance and reliability of information received from the developing world. Five stages of critical thinking were described by Lynch et al., (2002). The first stage is “confused fact-finders” and referred to elemantary pupils particulary attending the classroom. Lynch et al., (2002) defined the second stage of critical thinking as named a “biased jumper” or a student who quickly comes to decision and then searching for promoting evidence.“Perpetual analyzer” is the third stage of critical thinking .Individuals in this level are not able to prioritize knowledge or find and support the solutions. The fourth stage is labeled “pragmatic performer”.The indivuduals investigate the evidence independently and draw a conclusion. The last stage of critical thinking acquisition is labelled the “strategic revisioner” (Lynch et al., 2002). That the leading supporter of the subject-specific view lays emphasis on the information of a

specific subject as the main component of critical thinking was stated by McPeck (1983). Neverthless, McPeck informs the funtions of abilities and features in the process. It is pointed out by McPeck (1983) that educating about critical thinking includes both "teaching how," which refers to methods or abilities, and "teaching to," that refers to tendecies. These abilities are dependent on a particular subject, and are not possible to be movable to other subjects. Excellent critical thinker was identified by Sternberg (2003) as a perfect problem manager; but, indivuduals sholud be instructed to shift the problem-solving skills so students learn in school to their daily real lives activities. Clever thinkers have the original skills to produce new opinions, analytical skills to decide if they are benficial ideas, and the useful skills to determine how to practise the ideas and to convince others people's the importance of their ideas.

Metacognition

Metacognition was initially introduced by John Flavell in the beginning of 1970s and he indicated that metacognition includes both watching and organizing elements. According to the definition of Flavell (1979) metacognition is knowledge and cognition about cognitive phenomenon. After this definition many researchers (Braten, 1992) started to investigate metacognition and regarded it as a multi-dimensional concept. Generally, researchers (Brown, 1987; Flavell, 1987; Metcalfe & Shimmura, 1994; Schraw 1994) assumed metacognition as a two-dimensional concept: knowledge about cognition (metacognitive knowledge) and regulation of cognition (metacognitive regulation). Reflection on learning experiences can expand metacognitive knowledge which can be defined as the knowledge, awareness, and deeper understanding of one's own cognitive processes and products. Encompassing a bunch of activities that enable students to control their learning can be regarded as regulation of cognition (Gourgey, 1998; Hartman, 1998). Even though several regulatory skills have been described in the literature, three basic skills are considered as important: planning, monitoring, and evaluation (Jacobs & Paris, 1987).

It is extremely important to teach metacognitive skills in educational system, because they helps students develop higher order thinking process and improve their academic success (Flavell, 2004; Larkin, 2009). Because of the impact of metacognition in higher order thinking processes, its importance has increased day to day. Therefore, learning environments and teaching strategies, that put emphasis on metacognitive knowledge and regulation considering the higher order thinking process, have been designed. According to the studies which investigated learning environments and teaching strategies, there are strong relationships between teaching metacognitive strategies and progress in students' higher order thinking process (Kramarski, Mevarech & Arami, 2002; Schraw, 1998). Van der Stel and Veenman (2010) and Dignath and Buttner (2008) stated that metacognition has been conceptulized one of the most relevant predictors of accomplishing complex higher order thinking process. The conditions that develop higher order thinking process should be determined before creating learning environments and teaching strategies which support the development of students' metacognitive skills. According to Jacobs, Paris (1987) and Wittrock (1983) the use of metacognition seems to be associated with academic achievement and it improved learning outcomes. Furthermore, Watkins and Hattie (1992) indicated that higher achieving students were more likely to use strategies compatible with their own motivational states than lower achieving students. In this regard, teaching methods and learning environments based on the principals, creating the proper conditions, can be easily designed (Hacker, Dunlosky and Graesser, 1998).

The Present Study

Recently studies have indicated that two of the most important internal motivational factors that correlate to higher order thinking process are critical thinking and metacognition (Arslan, 2014; Arslan & Akın, 2014 ; Arslan ,Akın, & Çitemel, 2013;Arslan & Cardak,2012; Choy and Cheah , 2009; Coutinho et al. 2005; Kogut,2005; Kuhn and Dean, 2004; Magno,2010; Orion and Kali, 2005; Schroyens, 2005). Despite these findings, there has been limited empirical research that directly examines individual differences in the use of metacognition and critical thinking. Thus, the purpose of this research is to examine the relationship between the critical thinking and metacognition. Based on the interpretation of previous research, it is expected that the critical thinking would be associated positively with metacognition.

METHOD

In design of the study is predominantly quantitative in nature. The research design fully relied on self-report data acquired via psychometric instruments previously validated. The relationships between critical thinking and metacognition were examined using correlation analysis and the hypothesis model was tested through structural equation modeling. No causation was hypothesized.

Participants

Convenience sampling was used in the selection of participants. Participants voluntarily participated and were free to fill out the questionnaires without pressure. Completion of the questionnaires was anonymous and there was a guarantee of confidentiality. The instruments were administered to the students in groups in the classrooms. Participants of the study were 390 university students (209 (54%) were female and 181 (46%) were male in Sakarya University, Turkey. Their ages ranged from 18 to 25 years and the mean age of the participants was 21.6 years.

Measures

Critical Thinking Disposition Scale (Akın, et al.,2013).

Critical Thinking Disposition Scale is a 11-item self-report scale using a five-point Likert scale (1= strongly disagree 5= strongly agree). This scale has two sub-scales: reflective scepticism (seven items) and critical openness (four items). Results of confirmatory factor analysis have demonstrated that the items loaded on two factors.The results of confirmatory factor analysis indicated that the model was well fit (x^2=53.24, df= 40, RMSEA=.040, NNFI=.96, CFI=.97, IFI=.97, and SRMR=.048). For reliability of the Turkish version of the CTDS internal consistency coefficient was calculated. The Cronbach's Alpha internal consistency of the scale was as .68 for reflective scepticism, .75 for critical openness sub-scale, .78 for whole scale. The corrected item-total correlations of CTDS ranged from .25 to .61.

Metacognitive Thinking Scale (Arslan & Akın, 2015).

Metacognitive Thinking Scale. Metacognitive Thinking Scale is a 12-item self-report scale using a five-point Likert scale (1= strongly disagree 5= strongly agree). This scale has two sub-scales: metacognitive knowledge (five items) and metacognitive regulation (seven items). Results of confirmatory factor analysis have demonstrated that the items loaded on two factors. Results of confirmatory factor analysis demonstrated that the two-dimensional model was well fit (x2= 124.39, sd= 45, RMSEA= .061, NNFI=.96, NFI= .96, CFI= .97, IFI= .97, RFI= .94, GFI= .96, SRMR= .054).

Procedure

Permission for the participation of students was obtained from related chief departments and students voluntarily participated in research. Completion of the scales was anonymous and there was a guarantee of confidentiality. The scales were administered to the students in groups in the classrooms. The measures were counterbalanced in administration. Prior to administration of measures, all participants were informed about the purposes of the study. In this research, Pearson correlation coefficient and structural equation modeling was utilized to determine the relationships between critical thinking and metacognition. These analyses were carried out via LISREL 8.54 (Joreskog & Sorbom, 1996) and SPSS 17.

RESULTS

Descriptive Data and Inter-correlations

Table 1 shows the means, descriptive statistics, inter-correlations, and internal consistency

coefficients of the variables used.

Table 1. Descriptive statistics and inter-correlations of the variables

Variables	Reflective scepticism	Critical openness	Metacognitive knowledge	Metacognitive regulation
Reflective scepticism	1			
Critical openness	.59**	1		
Metacognitive knowledge	.60**	.58**	1	
Metacognitive regulation	.64**	.71**	.57**	1
Mean	25.8	15.5	20.3	27.7
Sd	4.0	2.6	2.9	3.9

**$p < .001$

Table 1 show that there are significant correlations between the critical thinking and metacognition. Subscales of the critical thinking; reflective scepticism correlated positively with metacognitive knowledge (r = .60;), metacognitive regulation (r = .64); critical openness correlated positively with metacognitive knowledge (r = .58;), metacognitive regulation (r = .71).

Before applying SEM, the assumptions of SEM were investigated. Multivariate normality tests which check a given set of data for similarity to the multivariate normal distribution were conducted via LISREL. The results of multivariate normality tests indicated that there was sufficient evidence that the data are multivariate normally distributed. Multivariate outliers were investigated using Mahalanobis distance. Influential outliers are concerning because they have potential to bias the model and to affect major assumptions. 10 cases for dimensions of burnout were a significant distance from the model. Box's M test for equality of variance-covariance matrices was used to test for homoscedasticity. Based on a statistically significant ($p<.05$) Box's M test indicates a homoscedasticity assumption violation (Stevens, 2002), it can be said that the data meets criteria of homoscedasticity.

To test the hypothesis model critical thinknig would be associated positively metacognition and structural equation modeling (SEM) was used. Using SEM, all the parameters of models can be tested simultaneously in one step. The specifications on the model were for direct paths from metacognition to critical thinknig. The results of testing whether critical thinking has a direct effect on metacognition is presented in Figure 1.

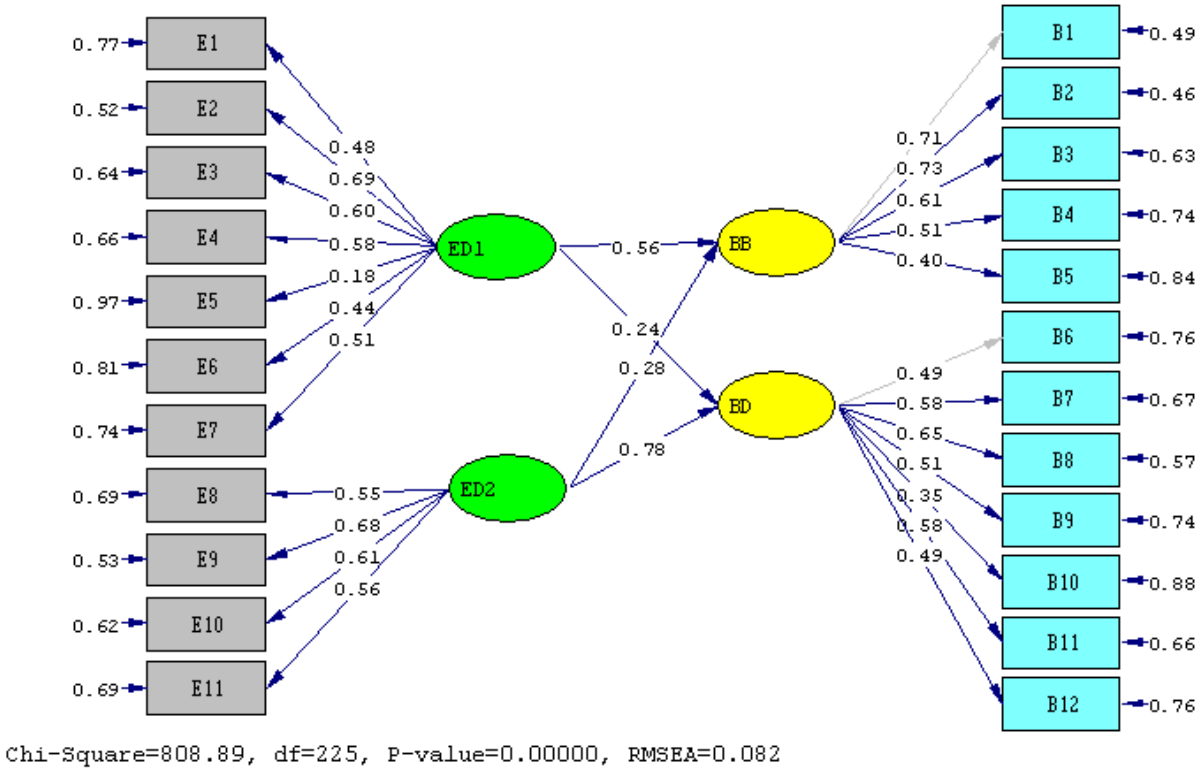

Figure 1. Path analysis between critical thinking and metacognition

ED1: reflective scepticism,ED2: critical openness,BB: metacognitive knowledge, BD: metacognitive regulation

Figure 1 showed that the model is saturated (i.e., there are no unused degrees of freedom). Consequently, the fit of the model (Hu & Bentler, 1999) is necessarily perfect ($\chi 2$= 808.89,df=225, p=.00, RMSEA=.08, NFI=.91, NNFI=.93,CFI=.93,IFI=.93, RFI=.90, SRMR=.06). It can be seen that reflective scepticism and critical openness have significant effects on metacognition

DISCUSSION

The present study examined the relationship between critical thinking and metacognition. Correlation analysis and SEM confirm the hypothesis. Indeed there is a positive relationship between metacognition and dimensions of critical thinking. Moreover, according to the goodness of fit indexes the model was acceptable and the model explained correlations among measures (Hu & Bentler, 1999). Findings show that there is a significant relationship between factors of critical thinking and metacognition. These results are in line with the findings of the previous models that indicated the association between critical thinking and metacognition (Akama 2006; Arslan, 2014; Antonietti et al. 2000;Başbay, 2013; Berardi-Coletta et al. 1995; Black, 2005; Choy and Cheah, 2009; Coutinho et al. 2005;Kogut, 2005; Kuhn and Dean, 2004; Magno, 2010; Orion and Kali, 2005; Schroyens, 2005). The important relationship between metacognition and critical thinking has been investigated in the literature, such as Kuhn's (1999) and Willingham's (2008) studies examined the relationship between metacognition and critical thinking. Moreover, according to Lipman (1991) one's metacognition must be "self-correcting' in order to qualify it as critical thinking. Even though it is necessary for a person to think about his or her thinking, if he or she is not critical in his/her thinking process, his or her thinking is not considered as critical thinking. Thus, for a successful critical thinking, previous experiences and prior cognitive development are essential. There are important studies indicating the relationship between critical thinking and metacognition. Kogut (1996) claimed that specific strategies, promoting critical thinking, are metacognitive in nature. Furthermore,

Orion and Kali (2005) examined the impact of science learning program on students' scientific thinking skills and found a relationship between critical thinking and metacognition. Besides, according to Choy and Cheah (2009) critical thinking necessitates higher level of metacognition. Magno (2010) stated that to make students think critically, it is necessary to teach them how to be aware of the underlying ways of thinking. As Ku and Ho (2010) indicated that good critical thinkers engaged in more metacognitive activities, especially higher order planning and higher order evaluating strategies. For an effective metacognitive regulation, metacognitive knowledge is important as a supporting factor. The association between critical thinking and metacognition was firstly introduced by Schoen (1983) that " a successful pedagogy that can serve as a basis for the enhancement of thinking will have to incorporate ideas about the way these representations change and resist change when new information is encountered" (p. 87). According to his explanation, the enhancement of knowledge referred to critical thinking and the process of organizing knowledge was a significant factor of metacognition (Magno, 2010). Particularly, critical thinking provides students with developing their metacognitive skills. Specifically, the use of metacognitive strategies has been asserted as a significant factor during thinking process (e.g., Facione 1990; Halpern 1998; Luckey 2003; Swartz 2003). For example, Halpern (1998) pointed out that; "When engaging in critical thinking, students need to monitor their thinking process, checking whether progress is being made toward an appropriate goal (and) ensuring accuracy…. Metacognitive monitoring skills need to be made explicit and public so that they can be examined " (p. 454). Swartz (2003) claimed in his reflection on teaching methods, which simplify metacognition that "thinking about their thinking has dramatic effects on students' learning and is usually not a difficult or complicated task for even primary-level children" (p.237). According to the findings of Başbay's (2013) study, students' critical thinking tendencies affect their epistemological beliefs and metacognition plays a partially mediating role. As Lee (2009) found that performing two metacognitive tasks strengthened the critical thinking tendencies of experimental group. According to Ku and Ho (2010) investigating individual's on-line thinking processes was useful in order to understand factors behind thinking performance better. In a study which examined thinking process of two groups of participants that were matched in terms of their cognitive ability, thinking disposition, and academic achievement, the importance of metacognitive strategies in critical thinking was revealed. Chisholm (1999) stated that there was a significant relationship between metacognitive and critical thinking skills in terms of comparing students' grades. One limitations of the current study is its sample size. In other words, future studies should investigate the same research question with a larger sample size. A larger sample size may clarify some correlations and thus increase the validity of the findings. Moreover, conducting this study in various rural areas of Turkey may represent whether these results could be generalized to a wider population. University environments put more emphasis on team work and interaction. There are many aspects of metacognition, especially social metacognition that affect student achievement. It may be useful to explore this association in terms of how these students interact with others and approach critical thinking situations. Another limitation of the current study is that the sample was composed of university students, which restricted the generalizability of the findings. Hence, it could be important to investigate the relationship of these variables in other sample groups. Other limitation is about statistical method used in analysis. In other words, correlational statistics used in the present study does not represent any causality about the findings. Further studies should consider this issue to obtain effective knowledge about the direction of causality. Another limitation is due to data collection method. In fact, data about critical thinking and metacognition was collected through self-report instruments. Future studies may use other tools to decrease subjectivity of the findings. All in all, current study states that critical thinking affects metacognition so that there is a relationship between critical thinking and metacognition. Therefore, according to the present study critical thinking may be an important predictor of the metacognition dimensions. Thus, the current findings increase our understanding in terms of the relationship between critical thinking and metacognition.

REFERENCES

Akama, K. (2006). Relations among self-efficacy, goal setting, and metacognitive experiences in problemsolving. *Psychological Reports, 98* (3), 895–907.

Akın, A., Hamedoğlu, M. A., Sariçam, H., Akin, U., İlbay, A. B., Civan, S., & Demir, T. (2013). *The validity and reliability of the Turkish version of the Critical Thinking Disposition Scale*. 2nd International Chaos, Complexity and Leadership Symposium (ICCLS 2013), 17-19 December,Ankara

Antonietti, A., Ignazi, S., & Perego, P. (2000). Metacognitive knowledge about problem solving methods. *The British Journal of Educational Psychology, 70*(1), 1–16.

Arslan & Akın (2015). *The validity and reliability of the Turkish version of the Metacognitive Thinking Scale*. Sakarya University Journal of Education Faculty,in press.

Arslan, S. & Akın, A. (2014). Metacognition: As a predictor of one's academic locusof control. *Educational Sciences: Theory&Practice - 14*(1), 1-8.

Arslan, S. & Çardak, M. (2012). Meta-cognition, self-efficacy and learning processes inventory-science: A study of validity and reliability. *Energy Education Science and Technology Part B: Social and Educational Studies, 4*(SI-1),739-742.

Arslan, S. (2014). An Investigation of the relationships between Metacognition and Self Regulation with structural equation. *International Online Journal of Educational Sciences, 6* (3), 603-611.

Arslan, S.,Akın,A. & Çitemel, N. (2013).The predictive role of grit on metacognition in Turkish university students. *Studia Psychologica, 55*(4). 311-320

Başbay, M. (2013).Analysing the relationship of Critical Thinking and Metacognition with epistemological beliefs through structural equation modeling. *Education and Science, 38*, 169.

Berardi-Coletta, B., Buyer, L. S., Dominowski, R. L., & Rellinger, E. R. (1995). Metacognition and problemsolving: a process-oriented approach. *Journal of Consulting and Clinical Psychology, 21*, 205–223.

Black, S. (2005). Teaching students to think critically. *The Education Digest, 70*(6), 42–47.

Braten, I. (1992). Vygotsky as precursor to meacognitive theory: III. Recent metacognitive research within a Vygotskian framework. *Scandinavian Journal of Educational Research, 36*(1), 3-19.

Brown, A. L. (1987). *Metacognition, executive control, self-regulation, and other even more mysterious mechanisms*. In Weinert, F.E. & Kluwe, R.H. (eds.) Metacognition, motivation and understanding (s. 64-116). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bruning, R. H., Schraw, G. J., Norby, M. M., & Ronning, R. R. (2004). *Cognitive psychology and instruction* (4th ed.). Upper Saddle River, New Jersey: Pearson Prentice Hall.

Chisholm, M.J. (1999) . *The Effects of Metacognition, Critical Thinking, Gender, and Gender Role Identification on Academic Achievement in the Middle Years*. Mount Saint Vincent University, Masters o f Arts in School Psychology.

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.

Coutinho, S., Wiemer-Hastings, K., Skowronski, J. J., & Britt, M. A. (2005). Metacognition, need for cognition and use of explanations during ongoing learning and problem solving. *Learning and Individual Differences, 15*(4), 321–337.

Dignath, C., & Buttner, G. (2008). Components of fostering self-regulated learning among students. A metaanalysis on intervention studies at primary and secondary school level. *Metacognition and Learning, 3*, 231–264.

Ennis, R. H. (1985). A logical basis for measuring critical thinking skills. *Educational Leadership, 43*(2), 44-48.

Facione, P. A. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction—executive summary of the delphi report*. Millbrae: California Academic Press.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. *American Psychologist, 34(*10), 906–911.

Flavell, J. H. (1987). *Speculations about the nature and development of metacognition*", In F. E. Weinert and R. H. Kluwe (Eds). Metacognition, motivation, and understanding (s. 21-29), Hillsdale, NJ: Lawrence Erlbaum.

Flavell, J. H. (2004). Theory of the mind development: Retrospect and prospect. *Merrill Palmer Quarterly, 50*(3), 274-290.

Forrest-Pressley, G. E. MacKinnon, & T. G. Waller (Eds.), *Metacognition, cognition, and human performance*: Vol. 2. Instructional practices, Orlando: Academic Press.

Gomez, L. M. & Gomez, K. (2007). Reading for learning: Literacy supports for 21st-century work. *Phi Delta Kappan, 89*(3), 224-228.

Gourgey, A. F. (1998). Metacognition in basic skills instruction. *Instructional Science, 26*(1- 2), 81-96.

Hacker, D., Dunlosky, J., & Graesser, A. C. (Eds.) (1998). *Metacognition in educational theory and practice*. Mahwah, NJ: Lawrence Erlbaum.

Hartman, H. J. (2001). Teaching metacognitively. In H. J. Hartman (Ed.), *Metacognition in learning and instruction: Theory, research and practice* (pp. 149-172). Dordrecht: Kluwer Academic Publishers.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structural analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1−55.

Jacobs , J.E ., & Paris,S.G .(1987). Children's metacognition about reading: issues indefinition, measurement, and instruction. *Educational Psychologist, 22*, 255-78.

Joreskog, K.G., Sorbom, D., (1996). *LISREL 8: User's reference guide.* Chicago, IL: Scientific Software International.

Kogut, L. S. (1996). Critical thinking in general chemistry. *Journal of Chemical Education, 73*(3), 218.

Kramarski, B., Mevarceh, Z.R., ve Arami, M. (2002).The effect of metacognitive instruction on solving mathematical authentic tasks. *Educational Studies in Mathematics, 49,* 225-250.

Ku, K. Y. L., & Ho, I. T. (2010). Dispositional factors predicting Chinese students' critical thinking performance. *Personality and Individual Differences, 48*, 54–58.

Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher, 28*(2), 16-46.

Kuhn, D., & Dean, D. (2004). Metacognition: a bridge between cognitive psychology and educational practise. *Theory into Practise,43* (4), 268-274.

Larkin,S. (2009). *Metacognition in young children*. New York, NY: Routledge.

Lee, T.S. (2009). *Examining the Relationships between Metacognition, Selfregulation and Critical Thinking in Online Socratic Seminars for High School Social Studies Students*. The University of Texas at Austin, Doctor of Philosophy.

Lipman, M. (1991). *Thinking in education*. Cambridge: Cambridge University Press.

Luckey, G. M. (2003). *Critical thinking in colleges and universities: A model.* In D. Fasko (Ed.), Critical thinking and reasoning (pp. 253–271). Cresskill: Hampton Press.

Lynch, C. L., Wolcott, S. K., & Huber, G. E. (2002). *Steps for better thinking*: A developmental problem solving process.

Magno,C. (2010). The role of metacognitive skills in developing critical thinking. *Metacognition Learning, 5*:137–156. DOI 10.1007/s11409-010-9054-4

McPeck, J.E (1983). Critical thinking and education. *Teachers College Record, 85* (1), 154-157.

Metcalfe, J., & Shimamura, A. P. (1994). *Metacognition: Knowing about knowing.* Cambridge, MA: Massachusetts Institute of Technology Press.

Orion, N., & Kali, Y. (2005). The effect of an earth-science learning program on students' scientific thinking skills. *Journal of Geoscience Education, 53*, 387–394.

Schoen, D. (1983). *The reflective practitioner*. San Francisco: Jossey-Bass.

Schraw, G. (1994). The effect of metacognitive knowledge on local and global monitoring. *Contemporary Educational Psychology 19*: 143–154.

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

Schroyens, W. (2005). Knowledge and thought: an introduction to critical thinking. *Experimental Psychology, 52*(2), 163–164.

Sternberg, R. J. (2003). Four alternative futures for education in the United States: It's our choice. *School Psychology Quarterly, 18*(4), 431–445.

Stevens, J. (2002). *Applied multivariate statistics for the social sciences.* Mahwah, New Jersey: Lawrence Erlbaum Associates.

Swartz, R. (2003). *Infusing critical and creative thinking into instruction in high school classrooms*. In D. Fasko (Ed.), Critical thinking and reasoning (pp. 293–310). Cresskill: Hampton Press.

Van der Stel, M., & Veenman, M. V. J. (2010). Development of metacognitive skillfulness: a longitudinal study. *Learning and Individual Differences, 20,* 220–224.

Watkins,D.,& Hattie,J.(1992).The motive-strategy congruence model revisited. *Contemporary Educational Psychology, 17*,194-98.

Willingham, D. (2008). Critical thinking: Why is it so hard to teach. *Arts Education Policy Review, 109*(4), 21-29.

Wittrock, M . (1983). *Students' thought processes*. In M.C . Wittrock (Ed.),Handbook of Research on Teaching. (3 rd ed.) (pp. 297-314). New York : Macmillan Publishing Company.