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Predicting Critical Thinking Skills of University Students through Metacognitive Self-Regulation Skills and Chemistry Self-Efficacy

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Abstract

This study aimed at examining the extent to which metacognitive self-regulation and chemistry self-efficacy predicted critical thinking. Three hundred sixty-five university students participated in the study. Data were collected using appropriate dimensions of Motivated Strategies for Learning Questionnaire and College Chemistry Self-Efficacy Scale. Cronbach's alpha coefficients ranged from .77 to .88. Data were analyzed using structural equation modeling. Results indicated that metacognitive self-regulation was found to be positively and significantly related to chemistry self-efficacy for cognitive skills and chemistry self-efficacy for everyday applications. In addition, there was a positive and significant relationship between chemistry self-efficacy for everyday applications and critical thinking, whereas there was no significant relationship between chemistry self-efficacy for cognitive skills and critical thinking. Overall, the tested model explained 68.5% of critical thinking. Findings provide suggestions in order to enhance critical thinking in chemistry classes.

Key Words

Critical Thinking, Metacognitive Self-Regulation, Self-Efficacy, Structural Equation Modeling, Chemistry Education.

There is a continuous development in knowledge and changes in needs of a human being, which increases the importance of learning new skills (Halpern, 1998). Nowadays, people have to make decisions about both themselves and their society. Thereby, critical thinking has become one of the most essential skills that individuals should have to adapt to the changing world (Seferoğlu & Akbıyık, 2006). Critical thinking is also important for students because it enhances meaningful learning. Students can use critical thinking in various activities and problems (Dressel & Mayhew, 1954 as cited in Renaud & Murray, 2008; Schafersman, 1991). In the same vein, research findings indicate a positive relationship between critical thinking and academic achievement (Ip, Lee, Lee, Wootton, & Chang, 2000; Phan, 2008). On the other hand, critical thinking is low even among university students (Halpern, 1998; Kuhn, 1999; Şengül & Üstündağ, 2009). Examining the factors which take role in developing critical thinking, therefore, is important. The present study aimed to examine the extent to which metacognitive self-regulation and chemistry self-efficacy predict critical thinking. Chemistry requires higher-order thinking skills in addition to content knowledge (Milli Eğitim Bakanlığı, 2008).

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Critical thinking is defined in various ways such as reflective thinking used during decision-making process (Ennis, 1985) or use of cognitive skills necessary to achieve a desirable outcome (Halpern, 1999). According to Paul (1996), critical thinking is related to taking one's own responsibility. Linn (2000) states that critical thinking comprises of different skills as searching for source of knowledge, testing validity of knowledge, questioning reliability, and making evaluations to reach conclusions. In the current study, based on Linn's conceptualization, critical thinking is defined as student's using prior knowledge to solve a problem and making decisions and evaluations.

Critical thinking has some essential characteristics: Firstly, it is context-sensitive. Prerequisite knowledge, complexity of the event or content of the knowledge influences people's ability to draw correct conclusions (Norris, 1985). Secondly, critical thinking can be developed through effective guidance (Facione, 2000). Thirdly, it is related to metacognition (Kuhn, 1999). During critical thinking process, students monitor their own thinking, assess whether they reach their goals, and evaluate their efforts, use of time, and effectiveness of their decisions (Halpern, 1998). All of these processes involve metacognitive skills as well as cognitive ones. Accordingly, this study considers metacognitive self-regulation as a variable playing role in critical thinking. Self-regulation is defined as monitoring behavior, comparing with a criterion, and make adjustments if necessary (Senemoğlu, 2004). Self-regulation is related to several variables such as anxiety, learning strategies, and self-efficacy (Çapa Aydın, Uzuntiryaki, & Demirdöğen, 2011; Jain & Dowson, 2009). Self-efficacy is defined as people's beliefs in their capability to perform a task successfully (Bandura, 1986). People with high self-efficacy in science tend to select science-related activities or courses, show more effort to be successful, and do not give up when they face with obstacles (Bandura, 1997; Britner & Pajares, 2001). Therefore, efficacious students tend to be more successful (Andrew, 1998; Lau & Roeser, 2002). Research studies indicated a positive significant relationship between self-efficacy and self-regulatory strategies (**Çapa Aydın et al.; Ramdass & Zimmer**man, 2008; Schnoll & Zimmerman, 2001; Schunk & Ertmer, 1999, 2005; Sungur, 2007; Zimmerman, 2000). Self-efficacy is also related to critical thinking (Bandura, 1997). Students with high self-efficacy are more likely to utilize critical thinking to overcome a problem than students with low self-efficacy (Phan, 2009).

In the present study, we examined the extent to which critical thinking is predicted by metacognitive self-regulation and chemistry self-efficacy by testing the following model:

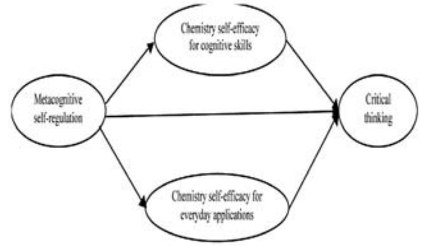

Figure 1.
Model Used to Predict Critical Thinking via Metacognitive Self-Regulation and Chemistry Self-Efficacy

Method

Research Design

This study employed correlational design. The purpose of correlational design is to examine the degree of relationship among different variables (Karasar, 2000). In the current study, we investigated the relationship among metacognitive self-regulation, chemistry self-efficacy, and critical thinking.

Participants

Employing convenience sampling, a total of 365 students from three universities in Ankara who were taking general chemistry class participated in the study voluntarily. Of these students, 236 were female (64.7%), 129 were male (35.3%). Majority of the students were freshman (96%), while others were senior students. More than half of the students (n = 232, 63.6%) were in Faculty of Science and 36.4% (n = 133) were in Faculty of Education.

Data Collection Instruments

In an effort to collect data, "Critical Thinking" and "Metacognitive Self-Regulation" dimensions of Motivated Strategies for Learning Questionnaire and "Chemistry Self-Efficacy for Cognitive Skills" and "Chemistry Self-Efficacy for Everyday Applications" dimensions of Chemistry Self-Efficacy Scale were used.

Motivated Strategies for Learning Questionnaire: This questionnaire was developed by Pintrich, Smith, Garcia and McKeachie (1991) and adapted into Turkish by Sungur (2004). It consists of 15 dimensions and 81 items on a 7-point rating scale from "not at all true of me" to "very true of me." In the present study, we used critical thinking and metacognitive self-regulation dimensions. Critical thinking dimension measures the degree to which students use their previous knowledge, analyze situations, and make decisions and evaluations. This dimension comprises of five items. The sample item is: "I often find myself questioning things I hear or read in chemistry class to decide if I find them convincing." Metacognitive self-regulation dimension assesses planning, monitoring, and regulatory processes of students with 10 items. The sample item is: "I ask myself questions to make sure I understand the material I have been studying in chemistry class." In the present study, confirmatory factor analysis was conducted to test the factor structure of the scores obtained from the dimensions of the Motivated Strategies for Learning Questionnaire. Results indicated good fit to the data with the following fit indices: χ^2 (89) = 211.307, $p < .05$; CFI = .990; NNFI = .987; RMSEA = .061. Factors loadings were found between .63 and .73 for critical thinking and .52 and .63 for metacognitive self-regulation. Cronbach alpha internal consistency coefficient was found to be .80 for critical thinking and .84 for metacognitive self-regulation.

Chemistry Self-Efficacy Scale: This scale was developed by Uzuntiryaki and Çapa Aydın (2009) to measure students' beliefs in their capability to perform chemistry tasks successfully. It consisted of three dimensions as self-efficacy for cognitive skills, self-efficacy for psychomotor skills, and self-efficacy for everyday applications. In the current study, two dimensions of the scale were used: self-efficacy for cognitive skills (12 items, sample item: "To what extent can you explain chemical laws and theories?") and self-efficacy for everyday applications (4 items, sample item: "To what extent can you propose solutions to everyday problems by using chemistry?"). Items were rated on a 9-point scale ranging from "nothing" (1) to "a great deal" (9). Findings of confirmatory factor analysis indicated acceptable fit: χ^2 (103) = 380.477, $p < .05$; CFI = .984; NNFI = .978; RMSEA = .086. Factor loadings ranged between .46 and .72 for self-efficacy for cognitive skills and between .60 and .74 for self-efficacy for everyday applications. Cronbach alpha internal consistency coefficient was .88 for self-efficacy for cognitive skills and .77 for self-efficacy for everyday applications.

Procedure

Data were collected from students on a voluntary basis during class hours by the researchers. It took approximately 10 minutes to administer the instruments.

Data Analysis

The model was tested using structural equation modeling utilizing maximum likelihood estimation via AMOS 4.0 (Arbuckle & Wothke, 1999). Latent variables were critical thinking, metacognitive self-regulation, chemistry self-efficacy for cognitive skills, and chemistry self-efficacy for everyday applications. Items were identified as manifest variables. Frequently used fit indices are chi-square statistics (c^2), comparative fit index (CFI), non-normed fit index (NNFI), and root mean square error approximation (RMSEA). Considering the limitations of chi-square statistics (Byrne, 2001), CFI, NNFI, and RMSEA were used in the present study. For acceptable fit, CFI and NNFI are recommended to be higher than .95 while RMSEA to be lower than .08 (Byrne; Hu & Bentler, 1999; Kline, 1998).

Results

Table 1 presents means, standard deviations, and correlations among the variables. Findings indicated significant positive relationship between variables.

Table 1.
Mean, Standard Deviation, and Correlation among Variables

Variables	*M*	*SD*	1	2	3
1. Self-efficacy for cognitive skills	5.87	1.13			
2. Self-efficacy for everyday applications	5.57	1.38	.77**		
3. Metacognitive self-regulation	4.54	1.09	.47**	.44**	
4. Critical thinking	4.09	1.25	.44**	.46**	.67**

N = 365. ***p* < .01

Findings of structural equation modeling showed acceptable fit to the data (χ^2 (429) = 1101.23, $p < .05$; CFI = .978; NNFI = .974; RMSEA = .066). Figure 2 displays standardized coefficients. All factor loadings were significant and ranged between .46 and .75.

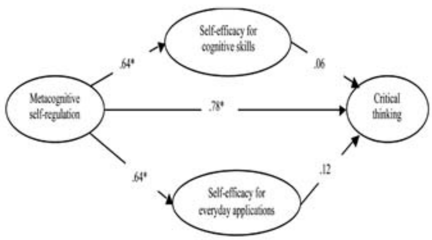

Figure 2.
Findings of Structural Equation Modeling

Findings indicated significant and positive relationship between metacognitive self-regulation and self-efficacy for cognitive skills (γ= .64, p<.05) and metacognitive self-regulation and self-efficacy for everyday applications (γ=.64, p<.05). In addition, there was a significant positive relationship between metacognitive self-regulation and critical thinking (γ=.78, p<.05). However, there was no significant relationship between self-efficacy for cognitive skills and critical thinking (γ=.06) and self-efficacy for everyday applications and critical thinking (γ=.12). The model tested explained 68.5% variance in critical thinking. Direct, indirect, and total effects are presented in Table 2. While critical thinking was predicted directly by metacognitive self-regulation, it was not predicted indirect through self-efficacy.

Discussion

The present study examined the degree to which critical thinking was predicted directly or indirectly by metacognitive self-regulation and chemistry self-efficacy using structural equation modeling. The model was found to be acceptable and explained 68.5% variance. The most striking finding was that metacognitive self-regulation plays a key role in critical thinking. Accordingly, students higher in metacognitive self-regulation monitor and evaluate their learning process and in this way they observe their progress. This process helps them think critically. There are empirical findings supporting this claim in literature (Phan, 2010; Pintrich, Smith, Garcia, & McKeachie, 1993). On the other hand, metacognitive self-regulation did not predict indirectly critical thinking via chemistry self-efficacy.

Another finding was the significant relationship between metacognitive self-regulation and chemistry self-efficacy (self-efficacy for cognitive skills and for everyday applications). Students who take responsibility of their own learning, in other words, students using self-regulatory strategies effectively, tend to be higher in efficacy. These students believe in their capabilities to both explain fundamental chemistry concepts and connect chemistry with everyday life. Similar findings were found both in national and international studies (Çapa Aydın et al., 2011; Jain & Dowson, 2009; Ramdass & Zimmerman, 2008; Schnoll & Zimmerman, 2001; Schunk & Ertmer, 1999; Sungur, 2007).

Although efficacious students are expected to be higher in critical thinking (Bandura, 1997; Phan, 2010), there are inconsistent findings in literature. For example, Phan (2009) found positive and significant relationship between efficacy and critical thinking in a cross-sectional and longitudinal study, whereas he did not find any relationship in 2007. However, self-efficacy was treated as one-dimensional in these studies. The findings of the present study were consistent with those of Phan (2007).

The current study provides insights to better understand critical thinking of students. On the other hand, as the study utilized correlational design and did not use random sampling, findings should be evaluated cautiously. Experimental or longitudinal studies should be conducted in future to imply cause-and-effect relationship. Furthermore, academic achievement might be added to the model as an outcome variable in different disciplines. Thereby, findings would have implications for enhancing student achievement.

Table 2.
Standardized Direct, Indirect, and Total Effects

Predictors	Criterion variables	Direct effect	Indirect effect	Total effect
Metacognitive self-regulation	Self-efficacy for cognitive skills	.64*	-	.64*
	Self-efficacy for everyday applications	.64*	-	.64*
	Critical thinking	.78*	.04	.82*
Self-efficacy for cognitive skills	Critical thinking	.06	-	.06
Self-efficacy for everyday applications	Critical thinking	.12	-	.12

* $p < .05$

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