Eurasian Journal of Educational Research 81 (2019) 37-56

Eurasian Journal of Educational Research
www.ejer.com.tr

Exploring the Relationship between Metavariables and Self-efficacy in Chemistry

Zubeyde Demet KIRBULUT[1]

ARTICLE INFO

Article History:
Received: 11 Nov. 2018
Received in revised form: 12 Dec. 2018
Accepted: 16 May 2019
DOI: 10.14689/ejer.2019.81.3

Keywords
metacognition, meta-affect, self-efficacy, canonical correlation analysis

ABSTRACT

Purpose: Self-efficacy plays a crucial role in achievement; and thus, it is important to determine the factors affecting self-efficacy. It has been known that one's reflections and evaluations of their thoughts, emotions, and behaviors are of paramount importance in the development of self-efficacy. Therefore, the aim of this study was to investigate the relationship between metavariables and self-efficacy in the context of chemistry.

Method: A total of 369 high school students participated in this study. Meta-Affective Trait Scale, Metaconceptual Awareness and Regulation Scale, and High School Chemistry Self-Efficacy Scale were administered to the students. Canonical correlation analysis was employed to examine the relationship between metavariables and self-efficacy.

Findings: The results of this study showed that there was a positive relationship between metavariables and self-efficacy variables except for the variable of affective awareness. Precisely, students who had high scores on the metavariables were likely to believe in their ability to use cognitive skills in chemistry and to accomplish chemistry laboratory tasks.

Implications for Research and Practice: A number of implications and recommendations for future research are given. Chemistry teachers could use instructional innovations to integrate metavariables and self-efficacy into their teaching. Teacher education programs could give importance to meta-level and self-efficacy constructs in educating teachers. Researchers could conduct studies to investigate the relations among metavariables, self-efficacy, and academic achievement.

© 2019 Ani Publishing Ltd. All rights reserved

[1] Corresponding Author, Harran University, TURKEY, e-mail: demetkirbulut@yahoo.com, ORCID: https://orcid.org/0000-0002-8972-048X

Introduction

Cognitive variables and its relation to achievement have rendered much attention in science education with little consideration of affective variables (Ferrell, Phillips, & Barbera, 2016; Fortus & Vedder-Weiss, 2014). However, cognition and affect play a prominent role in learning (Efklides, 2016). Self-efficacy, for example, has been demonstrated to influence academic achievement (Pajares, 1996; Ramnarain & Ramalia, 2018). Researchers acknowledged that self-efficacy is related to cognition and affect (Bandura, 1997; Bandura, Caprara, Barbaranelli, Gerbino, & Pastorelli, 2003). Few studies have focused on the association between metacognition and self-efficacy (Gourgey, 2001). However, to our knowledge, no study has considered the relationship among metaconceptual and meta-affective variables and self-efficacy. The sources of self-efficacy require one's reflections and evaluations of their thoughts, emotions, and behaviors (Bandura, 1997) and indeed, the self-efficacy concept houses judgments of one's capability to perform a task in itself. Collectively, this highlights the importance of metavariables in this process. Therefore, in this study, the relationship between metavariables and self-efficacy was investigated. The following sections present conceptual framework for self-efficacy, metacognition, and meta-affect.

Self-efficacy

Self-efficacy is a psychological construct that has received a lot of attention in student learning. Self-efficacy refers to "beliefs in one's capabilities to organize and execute courses of action required to produce given attainments" (Bandura, 1997, p. 3). Self-efficacy is a domain-specific construct in nature (Bandura, 1997; Pajares, 1996). For example, a student might have high self-efficacy in chemistry, but have low self-efficacy in mathematics. In the current study, student self-efficacy beliefs were considered in the context of chemistry. Enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological reactions are the four major sources of self-efficacy beliefs (Bandura, 1997). Success experiences lead to increase in self-efficacy beliefs, while failure experiences affect reversely (enactive mastery experience). Students develop self-efficacy beliefs by observing others (vicarious experience) and persuaded significant others showing that they possess the capability to master a task (verbal persuasion). Self-efficacy beliefs are also influenced by emotional arousal (physiological reactions). Generally, negative emotions like anxiety diminish self-efficacy beliefs, while positive emotions like happiness increase self-efficacy beliefs. It is acknowledged that self-efficacy beliefs play an important role in cognition, affect, behavior, self-regulation, and achievement (Bandura, 1989; Pajares & Urdan, 2006). Efficacious people persevere long enough in the face of difficulties, put much effort on a task and sustain it (Bandura, 1997). It has been revealed that self-efficacy beliefs are crucial determinants of science achievement (Bartimote-Aufflick, Bridgeman, Walker, Sharma, & Smith, 2016; Hwang, Choi, Lee, Culver, & Hutchison, 2016; Pajares, 1996; Ramnarain & Ramalia, 2018; Villafañe, Xu, & Raker, 2016). Social cognitive theory emphasized the value of self-reflection in the perceptions of self-efficacy (Bandura, 1997). Self-efficacious students tend to use more metacognitive learning strategies than others (Wolters & Pintrich, 1998). Self-efficacy also connected

with the domain of emotion (Bandura, 1997). Self-efficacy is of great importance in managing emotions. For example, students high in self-efficacy have more positive emotions (Bandura, 1997; Caprara et al., 2008).

Metacognition

"Metacognition" has first defined by Flavell (1976) as "to one's own knowledge concerning one's own cognitive processes and products or anything related to them" (p. 232). Brown (1987) referred to metacognition as "one's knowledge and control of [one's] own cognitive system" (p. 66). Nelson (1996) defined metacogniton as meta-level of cognition. It is the fact that metacognition is a multifaceted concept (Efklides, 2008). Despite the complexity of metacognition, common points shared by the definitions are awareness, monitoring, and control of cognition (Thomas, 2012). In line with its definition, there is no common understanding for the components of metacognition; however, scholars alluded two components basically: knowledge of cognition and regulation of cognition (Brown, 1987; Efklides, 2008; Schraw, 2001). Knowledge of cognition includes task, person, and strategy variables (Flavell, 1979). It also houses awareness meaning one's awareness of her/his own cognitive system (Brown, 1987). Regulation of cognition refers to planning, monitoring, and evaluation (Brown, 1987; Van der Stel & Veenman, 2010). There is agreement that metacognition has a meaningful impact on students' learning (Azevedo, Mudrick, Taub, & Wortha, 2017; Gascoine, Higgins, & Wall, 2017; Vosniadou 2003; Yuruk, Beeth, & Andersen, 2009). By considering the role of metacognition in learning, Thorley (1990) proposed the term 'metaconceptual' referring to one's knowledge and control of her/his own conceptual system. In this study, the term 'metaconceptual' was preferred since it was investigated how students could notice, monitor, and evaluate their ideas in the context of chemistry.

Meta-affect

Like metacognition, meta-affect is defined as "affect about affect, affect about and within cognition that may again be about affect, the monitoring of affect, and affect itself as monitoring" (Goldin, 2002, p. 62). Here, it should be noted that affect, emotion, and mood are used interchangeably in the educational literature (Linnenbrink & Pintrich, 2003). While emotions have a specific stimulus, moods are unspecific and enduring affective states. Even, moods are stated as low intensity emotions (Pekrun, 2006). Affect is a superordinate term including emotions and moods (Goldin, 2002). Researchers emphasized the two components of meta-affect: awareness of affect and regulation of affect (DeBellis & Goldin, 2006; Goldin, 2002; Gottman, Katz, & Hooven, 1996). The focus of this study is these two components. Awareness of affect is self-awareness of one's emotions, while regulation of affect is monitor and control of one's own emotions. Affect, cognition, and self-efficacy are interrelated (Hannula, 2011; Malmivuori, 2001). Affect is intertwined with cognition and cognition plays a vital role in meta-affect (DeBellis & Goldin, 2006). Ciompe (1991) used the terms "affect logic" and "affective-cognitive schemata" for this relationship considering Piaget's theory, and asserted that successful applications of scheme to a new situation generate more knowledge on the affective scheme and by this way meta-affect ensues.

The Current Research

A number of review studies on self-efficacy show that self-efficacy is a strong predictor of academic achievement (Honicke & Broadbent, 2016; Hwang et al., 2016; Pajares, 1996). Also, self-efficacy is an important construct in accounting for success in chemistry (Ramnarain & Ramalia, 2018; Villafañe et al., 2016). Therefore, it is important to determine the factors affecting self-efficacy. It has been acknowledged that cognition and affect are interwoven with self-efficacy beliefs (Bandura, 1986). There is a growing body of research showing the relationship between metacognition and self-efficacy beliefs (Gourgey, 2001; Uzuntiryaki-Kondakci & Capa-Aydin, 2011). Self-efficacy plays an important role in emotional experiences. It has been shown that students who had high self-efficacy beliefs also had positive emotions, and the opposite is true for those who had low self-efficacy beliefs (Linnenbrink & Pintrich, 2003; Pekrun & Perry, 2014). However, it has not yet been found any study examining the relationships among metaconception, meta-affect, and self-efficacy in the context of chemistry. Consequently, the following research question guided this study:

To what extent can students' self-efficacy beliefs in chemistry be predicted by metavariables (metaconceptual awareness, metaconceptual regulation, affective awareness, and affective regulation)?

Method

Research Design

This study aimed to investigate the relation between metavariables and self-efficacy variables. To realize this aim, explanatory correlational research design was employed. In explanatory correlational research, the relationships among several variables are examined without any manipulation (Fraenkel, Wallen, & Hyun, 2012).

Research Participants

The participants of the study (n = 369) were 12th grade Anatolian High School students (187 females, 155 males, and 27 non-respondents) with a mean age of 17.05 (SD = 0.33) from 12 different schools in the central part of Turkey. Participants were selected via convenience sampling. There are different types of public schools in formal secondary education. These are Anatolian High Schools, Anatolian Teacher High Schools, Fine Arts High Schools, Science High Schools, Social Sciences High Schools, Sport High Schools, and Vocational and Technical High Schools. Admission to Anatolian High Schools is based upon the scores on a competitive national exam called Transition from Elementary Education to Secondary Education Examination. Before secondary education, students attend eight years of compulsory primary education. Then, they complete four years of compulsory secondary education to continue to higher education. Eighth grade students take national exam in transition from elementary education to secondary education for high-quality schools. In this exam, students are responsible for Foreign Language, Mathematics, Religious Culture and Moral Knowledge, Science, Turkish, and Turkish Republic Revolution History

and Kemalism courses. Students are asked multiple-choice questions from these courses in line with the 8th grade national curriculum. For the participants of this study, placement was applied through the score comprising 70% of this exam score and %30 of the GPA averages of the 6th, 7th, and 8th grades. It should be noted that currently, there have been changes in the application of this exam. Twelfth grade Anatolian High School students pursuing heavily math- and science-based courses were included in this study since they completed advanced level courses in chemistry. These students received education in accordance with 2013 national chemistry curriculum during secondary education. They took elementary level chemistry course two-hour a week at the 9th and 10th grades, and completed 144-hour chemistry course at these grades in total. Then, they attended advanced level chemistry course four-hour a week through the 11th and 12th grades completing 288-hour chemistry course in total. The chemistry course topics for 12th grade were "Chemistry and Electricity", "Introduction to Carbon Chemistry", "Organic Compounds", and "Chemistry in Everyday Life".

Research Instruments and Procedures

High School Chemistry Self-Efficacy Scale (HSCS). Students' self-efficacy beliefs in chemistry were measured via the HSCS developed by Capa Aydin and Uzuntiryaki (2009). The HSCS comprises 16 items on a 9-point scale from 1 (very poorly) to 9 (very well) covering two dimensions: Chemistry Self-Efficacy for Cognitive Skills (CSCS, 10 items) and Self-Efficacy for Chemistry Laboratory (SCL, 6 items). The CSCS dimension reflects students' beliefs in their ability to use cognitive skills in chemistry (e.g., To what extent can you explain chemical laws and theories?). The SCL dimension refers to students' beliefs in their ability to use necessary skills in performing chemistry laboratory (e.g., How well can you interpret data during the laboratory sessions?). Cronbach's alpha reliabilities were given as .84 for the CSCS and .94 for the SCL by Capa Aydin and Uzuntiryaki (2009). In this study, confirmatory factor analysis (CFA) results revealed that the two-dimension scale showed a good fit to the data (CFI = .93; RMSEA = .076; 90% CI = .066, .085; SRMR = .063). Cronbach's alpha values for the CSCS and SCL were .87 and .90, respectively.

Metaconceptual Awareness and Regulation Scale (MARS). The MARS (Kirbulut, Uzuntiryaki-Kondakci, & Beeth, 2016) covering 10 items on a 6-point rating scale from 1 (never) to 6 (always) was administered to the students to assess the extent to which students can notice, monitor, and evaluate their ideas in the context of chemistry. It has two dimensions: metaconceptual awareness, which refers to students' awareness of their conceptions (4 items, e.g., I know what I did not understand about a chemistry topic) and metaconceptual regulation, which reflects students' monitoring and evaluating of their conceptions with a new concept (6 items, e.g., While learning a chemistry topic, I compare my prior knowledge with the new knowledge). Kirbulut et al. (2016) reported Cronbach's alpha values as .71 and .75 for the metaconceptual awareness and metaconceptual regulation, respectively. In the present study, the fit indices of the CFA indicated an acceptable model fit (CFI = .94; RMSEA = .064; 90% CI

= .047, .082; SRMR = .050). Cronbach's alpha values were calculated as .70 for metaconceptual awareness and .75 for metaconceptual regulation.

Meta-Affective Trait Scale (MATS). The MATS (Uzuntiryaki-Kondakci & Kirbulut, 2016) is a self-report instrument designed to assess students' meta-affective inclinations about their emotions in chemistry. It includes 17-item on a 6-point rating scale, from 1 (never) to 6 (always). It comprises two dimensions: affective awareness, which probes into students' awareness of their emotions during taking chemistry course (10 items, e.g., If I get bored while studying, I notice that feeling), and affective regulation that involves students' monitoring, evaluating, controlling, and altering their emotions in the context of chemistry (7 items, e.g., When I have to learn a topic that I am not interested in, I try to find ways to make it interesting). Uzuntiryaki-Kondakci and Kirbulut (2016) documented Cronbach's alpha values as .82 for affective awareness and .76 for affective regulation. In the current study, the two-dimension scale presented satisfactory fit indices (CFI = .90; RMSEA = .063; 90% CI = .054, .073; SRMR = .057). Cronbach's alpha values were .84 for affective awareness and .74 for affective regulation.

Procedure. Before data collection, first, permission from the ethics committee of the university was taken. Then, necessary permissions were obtained from the Ministry of National Education. The scales were administered during school time. The students participated in the study voluntarily. Informed consent forms were obtained from the students and parents/guardians. The students and parents/guardians were ensured for the confidentiality of their data. The total amount of time needed to complete the scales was about 20 minutes.

Data Analysis

In the current study, the CFA was performed for the assessment of the scales' dimensionality and validity using Lisrel 9.2 for Windows. The following fit indices with the given cut-off values in the parentheses were used in the evaluation of the model fit: root mean square error of approximation (RMSEA ≤ .08), comparative fit index (CFI ≥ .90), and the standardized root mean square residual (SRMR ≤ .08) (Browne & Cudeck, 1993; Kline, 1998). Canonical correlation analysis (CCA) was conducted to investigate the relationship between metavariable set (metaconceptual awareness, metaconceptual regulation, affective awareness, and affective regulation as independent variables) and self-efficacy variable set (CSCS and SCL as dependent variables). The CCA was performed using SPSS 20.0 for Windows with the MANOVA command. The CCA is a multivariate statistical analysis differing from multiple linear regression in that it predicts a set of multiple dependent variables from a set of multiple independent variables (Sherry & Henson, 2005; Tabachnick & Fidell, 2007). The suggested sample size for canonical analysis is 20 times the number of variables (Stevens, 2009). There are six variables in this study and the sample size (n = 369) exceeds this criterion (20x6 = 120).

Results

Preliminary Results

Before performing analyses, missing values in the data set were inspected. Missing data were less than 5% and handled by using Expectation Maximization (EM) method (Enders, 2010). Data were checked for univariate outliers by using z scores. Cases with z scores in the excess of ± 3.29 are potential outliers. Mahalanobis distance values using $p < .001$ for the corresponding $\chi 2$ value were computed to identify multivariate outliers (Tabachnick & Fidell, 2007). There were no univariate and multivariate outliers detected in the data.

Normality, linearity, homoscedasticity, and absence of multicollinearity assumptions were assessed (Tabachnick & Fidell, 2007) and no violation was observed. Table 1 shows evidence for normality of each variable. Skewness and kurtosis values ranged from -0.70 to 0.02 and -1.07 to 0.10, respectively, which were within the range of normal distribution (Finney & DiStefano, 2006). Pairs of canonical variates were plotted against each other and these scatterplots indicated linear relationship, normality, and homoscedasticity. In addition, scatterplots between residuals and predicted variables were used for screening homoscedasticity of residuals. It was seen that the residuals were nearly rectangularly distributed along the center showing that normality, linearity, and homoscedasticity assumptions were met (Tabachnick & Fidell, 2007). For multicollinearity, variables in each set and across sets should not be highly correlated (correlations up around .80 and .90), Variance Inflation Factor (VIF) should be below 10, and tolerance value should be above 0.1 (Field, 2005). Table 1 displays that all correlations between variables are below .80. VIF and tolerance values ranged from 1.31 to 1.60 and 0.63 to 0.77, respectively. Therefore, there was no multicollinearity in the data.

Table 1

Bivariate Correlations of Study Variables and Descriptive Statistics

Variables	*1*	*2*	*3*	*4*	*5*	*M*	*SD*	*Skewness*	*Kurtosis*
1. Metaconceptual awareness						4.57	0.87	-0.51	-0.12
2. Metaconceptual regulation	.42**					3.79	0.90	-0.06	-0.36
3. Affective awareness	.52**	.26**				4.95	0.78	-0.70	-0.31
4. Affective regulation	.45**	.40**	.49**			3.96	0.89	-0.21	-0.46
5. Chemistry self-efficacy for cognitive skills	.41**	.45**	.20**	.39**		5.33	1.36	-0.30	0.10
6. Self-efficacy for chemistry laboratory	.15**	.28**	-.04	.23**	.49**	4.33	2.14	0.02	-1.07

** indicates significant relationship at $p < .01$

The Results of Canonical Correlation Analysis

The CCA showed that the full canonical model was significant with a Wilks's Lambda of .67, F(8, 726) = 20.27, p<.001. 1-Wilks's Lambda represents the effect size of the full model in an R^2 metric (Sherry & Henson, 2005). In this study, by taking 1 - .67, the overall effect was found as .33, which could be considered as a medium effect size (Cohen, 1992). The analysis resulted in two canonical functions (see Table 2). While determining the number of functions to interpret, three criteria were used: i) statistical significance of the canonical functions, ii) practical significance based on the squared canonical correlation (R_c^2), and iii) practical significance based on the redundancy index of the dependent variable set (Hair, Anderson, Tatham, & Black, 1998; Tabachnick & Fidell, 2007). In terms of statistical significance criterion, the results of dimension reduction analysis (see Table 2) showed that the two canonical functions were significant with a Wilks's Lambda of .67, F(8, 726) = 20.27, p<.001 for the first function, and a Wilks's Lambda of .95, F(3, 364) = 6.12, p<.001 for the second function.

Table 2

Dimension Reduction Analysis Results

Canonical Functions	*Wilk's λ*	*F Value*	*Hypothesis DF*	*Error DF*	*Significance of F*
1 to 2	.67	20.27	8.00	726.00	.000
2 to 2	.95	6.12	3.00	364.00	.000

However, according to the second criterion (see Table 3), the first canonical correlation for the first function was .55 (see also Figure 1) with 30% overlapping variance (R_c^2 = .30), and the second canonical correlation for the second function was .22 with 5% overlapping variance (R_c^2 = .05). That is, only the first canonical function was noteworthy to report based on the R_c^2 values.

Table 3

Canonical Correlations and Squared Canonical Correlations for Each Function

Canonical Function	Canonical Correlation (R_c)	Squared Canonical Correlation (R_c^2)
1	.55	.30
2	.22	.05

Furthermore, regarding the redundancy index of the dependent variable, which is the amount of variance in the dependent variable set explained by the independent variable set, criterion, it was found that the redundancy index of the dependent variable set for the first canonical function was .20, while it was .02 for the second canonical function. In other words, 20% of the variance in the dependent variable set was accounted for by the independent variable set for the first canonical function. However, only 2% of the variance in the dependent variable set was explained by the independent variable set for the second canonical function. Therefore, only the first canonical function merited consideration.

Consequently, the first canonical function was interpreted in the current study. Figure 1 depicts the canonical structure coefficients and the canonical correlation between the dependent variable set (CSCS and SCL variables) and independent variable set (metaconceptual awareness, metaconceptual regulation, affective awareness, and affective regulation variables) for the first canonical function.

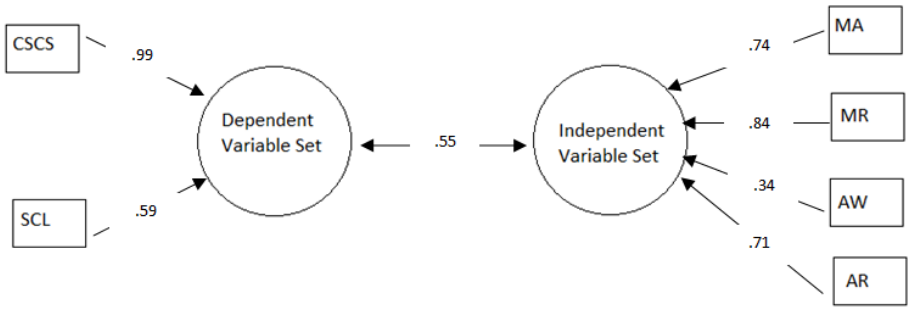

Figure 1. Canonical structure coefficients and the canonical correlation for the first canonical function

CSCS = chemistry self-efficacy for cognitive skills; SCL = self-efficacy for chemistry laboratory; MA = metaconceptual awareness; MR = metaconceptual regulation; AW = affective awareness; AR = affective regulation

In interpreting the canonical functions, canonical coefficients (canonical weights) and structure coefficients (structure correlations) are used. Canonical coefficients represent the magnitude of the contribution of the dependent or independent variables to the related canonical variate (dependent or independent variable set). However, since canonical coefficients are subject to multicollinearity, structure coefficients, which refer to bivariate correlation between an observed variable in the dependent or independent variable set and the related canonical variate, are considered more valid (Hair et al., 1998; Sherry & Henson, 2005; Tabachnick & Fidell, 2007). Table 4 presents the standardized canonical coefficients, structure coefficients, and squared structure coefficients for the first canonical function. Conventionally, structure coefficients above .45 are considered as significantly contributing variables to the related variate (Sherry & Henson, 2005). Thus, to emphasize, structure coefficients above .45 were underlined in Table 4. Looking at the standardized coefficients, it was seen that among the independent variables, metaconceptual regulation had the highest standardized coefficient, while affective awareness had the lowest standardized coefficient. For the dependent variables, the CSCS was the primary contributor to the dependent variate. This conclusion was also supported by the structure coefficients (see also Figure 1). With the exception of affective awareness, all variables contributed to the related variate significantly. Among the independent variables, metaconceptual regulation had the highest structure coefficient (r_s = .84), and thus, it had the highest squared structure coefficient (r_s^2 = 71%). Regarding the dependent variables, the CSCS had higher structure coefficient (r_s = .99) and squared structure coefficient (r_s^2 = 98%) than

the SCL had (r_s = .59 and r_s^2 = 35%). Besides, all of these significant contributors' signs of structure coefficients were positive indicating that they were all positively related. That is, students who have high scores on the metavariables, with the exception of affective awareness, are likely to believe in their ability to use cognitive skills in chemistry and to accomplish chemistry laboratory tasks.

Table 4

Canonical Analysis Results for the Relationship between Self-Efficacy and Meta-Level Variates

	1st Canonical Function		
Variables	*Standardized Coefficients*	*Structure Coefficients (r_s)*	*Squared Structure Coefficient (r_s^2) (%)*
Independent			
MA	.45	.74	55
MR	.55	.84	71
AW	-.24	.34	12
AR	.41	.71	50
R_c^2			30
Dependent			
CSCS	.93	.99	98
SCL	.13	.59	35

Note: Structure coefficients (r_s) greater than |.45| are underlined. CSCS = chemistry self-efficacy for cognitive skills; SCL = self-efficacy for chemistry laboratory; MA = metaconceptual awareness; MR = metaconceptual regulation; AW = affective awareness; AR = affective regulation

Discussion, Conclusion and Recommendations

This study sought to address the relationship between metavariables and self-efficacy variables in the context of chemistry. The results of this study provided an evidence for the positive relationship between metavariables, except for affective awareness, and self-efficacy variables. High scores on metaconceptual awareness, metaconceptual regulation, and affective regulation reflected students' self-efficacy for cognitive skills and chemistry laboratory. Simply put, students who are aware, monitor and evaluate their conceptions, and who reflect, control, and adapt their emotions are likely to believe their ability to use cognitive skills in chemistry, and to utilize necessary skills in implementing chemistry laboratory. A considerable amount of research has emphasized the importance of self-efficacy for students' achievement in chemistry (Dalgety & Coll, 2006; Ramnarain & Ramalia, 2018; Uzuntiryaki-Kondakci & Senay, 2015; Villafañe et al., 2016). In this respect, it is important to increase students' self-efficacy in chemistry. The findings of this study highlighted the metavariables as significant factors in facilitating self-efficacy in the context of

chemistry. There are a few studies showing the relationship between metacognition and self-efficacy (Crippen & Earl, 2007; Nietfeld, Cao, & Osborne, 2006). For example, Nietfeld et al. (2006) studied with undergraduate educational psychology students and illustrated that the use of metacognitive activities in educational psychology course influenced students' self-efficacy. However, to our knowledge, no prior studies have considered metaconceptual variables in examining the relation with self-efficacy. This study showed that metaconceptual variables were influential on self-efficacy. One of the sources of self-efficacy is the psychological state. According to Bandura (1997), students judge their ability based on their emotions. A number of studies have also suggested that there is an association between self-efficacy and emotions (Caprara et al., 2008; Pekrun & Perry, 2014). The current study provided support for this relation and went beyond the literature by examining this relationship considering metavariables and chemistry as a context. Among the metavariables, metaconceptual regulation and affective regulation were primary contributors to the independent variate; however, affective awareness did not make any contribution. That is, when students monitor and evaluate their conceptions and control their emotions, they have increased self-efficacy in chemistry. As aforementioned, meta-level variables are multifaceted and several mechanisms enact these processes (Efklides, 2016). Therefore, more research is required to understand the roles of awareness and regulation dimensions in self-efficacy. In terms of dependent variate, the CSCS variable contributed to the variate with a very high structure coefficient compared to the SCL. One plausible explanation for this result could be insufficient teaching of chemistry laboratory. As has been previously reported in the literature, in Turkey, teachers who teach science courses generally prefer traditional teaching and use laboratory in teaching rarely due to lots of reasons such as inadequate instruction materials and facilities, university exam, crowded classrooms, and incompetence in the use of laboratory (Balbag, Leblebicier, Karaer, Sarikahya, & Erkan, 2016; Yazici & Ozmen, 2015).

This study has its limitations. First, the CCA was employed in this study and this does not provide evidence for causation. Second, self-report measures were used to represent metavariables and self-efficacy variables. Therefore, care should be taken in using these results since off-line methods could not be sufficient to manifest all aspects of the constructs that were investigated. Third, the findings of this study are limited by sample size and the context studied.

Despite its limitations, the current study has several implications and recommendations for future research. Chemistry teachers could integrate metavariables and self-efficacy beliefs into their teaching. Metacognitive approaches such as self-explanation prompts could be utilized to increase self-efficacy in chemistry (Crippen & Earl, 2007). Instructional innovations such as intelligent tutoring systems (Azevedo et al., 2017) could be used to integrate cognition and affect into teaching and learning. Chemistry teachers could also help their students to control their emotions, which in turn may lead to increase their students' self-efficacy. Teacher education programs could be aware of the effect of metaconceptual and meta-affective constructs on self-efficacy, and give importance to them in educating teachers. In this study, self-

report measures were used to detect the relationship between metavariables and self-efficacy. Researchers could employ on-line methods in addition to off-line methods to give a more comprehensive perspective on these relations. Since self-efficacy is a domain-specific construct, investigations of these relations could be carried out within other subject areas such as biology and physics. Besides, scholars could employ research designs to investigate the relationship among metavariables, self-efficacy, and academic achievement in related disciplines.

Acknowledgements

I would like to thank Prof. Dr. Esen Uzuntiryaki-Kondakci for her support of this research and constructive comments on the earlier versions of this manuscript.

References

Azevedo, R., Mudrick, N., Taub, M., & Wortha, F. (2017). Coupling between metacognition and emotions during STEM learning with advanced learning technologies: A critical analysis, implications for future research, and design of learning systems. *Teachers College Record, 119*(13). Retrieved from http://www.tcrecord.org/Content.asp?ContentId=21922.

Balbag, M. Z., Leblebicier, K., Karaer, G., Sarikahya, E., & Erkan, O. (2016).Türkiye'de fen eğitimi ve öğretimi sorunları [Science education and teaching problems in Turkey]. *Egitim ve Ogretim Arastırmaları Dergisi, 5*(3), 12-23.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44*(9), 1175-1184. doi: 10.1037/0003-066X.44.9.1175

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W. H. Freeman.

Bandura, A., Caprara, G. V., Barbaranelli, C., Gerbino, M., & Pastorelli, C. (2003). Role of affective self-regulatory efficacy in diverse spheres of psychosocial functioning. *Child Development, 74*(3), 769-82. doi: 10.1111/1467-8624.00567

Bartimote-Aufflick, K., Bridgeman, A., Walker, R., Sharma, M., & Smith, L. (2016). The study, evaluation, and improvement of university student self-efficacy. *Studies in Higher Education, 41*(11), 1918-1942. doi: 10.1080/03075079.2014.999319

Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65-116). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136-162). Newbury Park, CA: Sage.

Capa Aydin, Y., & Uzuntiryaki, E. (2009). Development and psychometric evaluation of the high school chemistry self-efficacy scale. *Educational and Psychological Measurement, 69*(5), 868-880. doi: 10.1177/0013164409332213

Caprara, G. V., Di Giunta, L., Eisenberg, N., Gerbino, M., Pastorelli, C., & Tramontano, C. (2008). Assessing regulatory emotional self efficacy in three countries. *Psychological Assessment, 20*(3), 227-237. doi:10.1037/1040-3590.20.3.227

Ciompi, L. (1991). Affects as central organising and integrating factors. A new psychological/biological model of the psyche. *The British Journal of Psychiatry, 159*(1), 97-105. doi: 10.1192/bjp.159.1.97

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*, 155-159. doi:10.1037/0033-2909.112.1.155

Crippen, K. J., & Earl, B. L. (2007). The impact of web-based worked examples and self-explanation on performance, problem solving, and self-efficacy. *Computers & Education, 49*(3), 809-821. doi: 10.1016/j.compedu.2005.11.018

Dalgety, J., & Coll, R. K. (2006). Exploring first-year science students' chemistry self-efficacy. *International Journal of Science and Mathematics Education, 4*(1), 97-116. doi: 10.1007/s10763-005-1080-3.

DeBellis, V. A., & Goldin, G. A. (2006). Affect and meta-affect in mathematical problem solving: A representational perspective. *Educational Studies in Mathematic, 63*(2), 131-147. doi: 10.1007/s10649-006-9026-4

Efklides, A. (2008). Metacognition: Defining its facets and levels of functioning in relation to self-regulation and co-regulation. *European Psychologist, 13*(4), 277-287. doi: 10.1027/1016-9040.13.4.277

Efklides, A. (2016). Metamemory and affect. In J. Dunlosky & U. Tauber (Eds.), *The Oxford handbook of metamemory* (pp. 245-267). New York, NY: Oxford University Press.

Enders, C. K. (2010). *Applied missing data analysis.* New York: Guilford.

Ferrell, B., Phillips, M. M., & Barbera, J. (2016). Connecting achievement motivation to performance in general chemistry. *Chemistry Education Research and Practice, 17*, 1054-1066. doi: 10.1039/c6rp00148c

Field, A. (2005). *Discovering statistics using SPSS* (2nd ed.). Thousand Oaks, California: Sage.

Finney, S. J., & DiStefano, C. (2006). Non-normal and categorical data in structural equation modeling. In G. R. Hancock & R. O. Mueller (Eds.), *Structural equation modeling: A second course* (pp. 269-314). Greenwich, CT: Information Age.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Eds.), *The nature of intelligence* (pp. 231-235). Hillsdale, NJ: Erlbaum.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*(10), 906-911. doi:10.1037/0003-066X.34.10.906

Fortus, D., & Vedder-Weiss, D. (2014). Measuring students' continuing motivation for science learning. *Journal of Research in Science Teaching, 51*(4), 497-522. doi: 10.1002/tea.21136

Fraenkel, J., Wallen, N., & Hyun, H. (2012). *How to design and evaluate research in education* (8th ed.). Columbus: McGraw-Hill Higher Education.

Gascoine, L., Higgins, S., & Wall, K. (2017). The assessment of metacognition in children aged 4-16 years: A systematic review. *Review of Education, 5*(1), 3-57. doi: 10.1002/rev3.3077

Goldin, G. A. (2002). Affect, meta-affect, and mathematical belief structures. In G. C. Leder, E. Pehkonen, & G. Torner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 59-72). Dordrecht, the Netherlands: Kluwer Academic Publishers.

Gottman, J. M., Katz, L. F., & Hooven, C. (1996). Parental meta-emotion philosophy and the emotional life of families: Theoretical models and preliminary data. *Journal of Family Psychology, 10*(3), 243-268. doi: 10.1037/0893-3200.10.3.243

Gourgey, A. F. (2001). Metacognition in basic skills instruction. In H. J. Hartman (Eds.), *Metacognition in learning and instruction* (pp. 17-32). Netherlands: Kluwer Academic Publishers.

Hair, J. F., Jr., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Hannula, M. (2011). The structure and dynamics of affect in mathematical thinking and learning. In M. Pytlak, T. Rowland, & E. Swoboda (Eds.), *Proceedings of the Seventh Congress of the European Society for Research in Mathematics Education* (pp. 34). Rzeszów, Poland: University of Rzeszów.

Honicke, T., & Broadbent, J. (2016). The influence of academic self-efficacy on academic performance: A systematic review. *Educational Research Review, 17*, 63-84. doi: 10.1016/j.edurev.2015.11.002

Hwang, M. H., Choi, H. C., Lee, A., Culver, J. D., & Hutchison, B. (2016). The relationship between self-efficacy and academic achievement: A 5-year panel analysis. *Asia-Pacific Educational Research, 25*(1), 89-98. doi: 10.1007/s40299-015-0236-3

Kirbulut, Z. D., Uzuntiryaki-Kondakci, E., & Beeth, M. E. (2016). Development of a metaconceptual awareness and regulation scale. *International Journal of Science Education, 38*(13), 2152-2173. doi:10.1080/09500693.2016.1230791.

Kline, R. B. (1998). *Principles and practice of structural equation modeling*. New York: Guilford.

Linnenbrink, E. A., & Pintrich, P. R. (2003). The role of self-efficacy beliefs in student engagement and learning in the classroom. *Reading &Writing Quarterly, 19*(2), 119-137. doi: 10.1080/10573560308223

Nelson, T. O. (1996). Consciousness and metacognition. *American Psychologist, 51*(2), 102-116. doi: 10.1037/0003-066X.51.2.102

Nietfeld, J. L., Cao, L., & Osborne, J. W. (2006). The effect of distributed monitoring exercises and feedback on performance, monitoring accuracy, and self-efficacy. *Metacognition and Learning, 1*, 159-179. doi: 10.1007/s10409-006-9595-6

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*(4), 543-578. doi: 10.3102/00346543066004543

Pajares, F., & Urdan, T. (2006). Foreword. In F. Pajares, & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (pp. ix-xii). Greenwich, CT: Information Age Publishing.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review, 18*(4), 315-341. doi: 10.1007/s10648-006-9029-9

Pekrun, R., & Perry, R. P. (2014). Control-value theory of achievement emotions. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 120-141). New York: Routledge.

Ramnarain, U., & Ramalia, S. (2018). The relationship between chemistry self-efficacy of South African first year university students and their academic performance. *Chemistry Education Research and Practice, 19*(1), 60-67. doi: 10.1039/c7rp00110j

Schraw, G. (2001). Promoting general metacognitive awareness. In H. J. Hartman (Ed.), *Metacognition in learning and instruction* (pp. 3-16). Netherlands: Kluwer Academic Publishers.

Sherry, A., & Henson, R. (2005). Conducting and interpreting canonical correlation analysis in personality research: A userfriendly primer. *Journal of Personality Assessment, 84*(1), 37-48. doi: 10.1207/s15327752jpa8401_09

Stevens, J. P. (2009). *Applied multivariate statistics for the social sciences* (5th ed.). New York, NY: Routledge.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston, NY: Allyn and Bacon.

Thomas, G. P. (2012). Metacognition in science education: Past, present and future considerations. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 131-144). Dordrecht: Springer.

Thorley, N. R. (1990). *The role of the conceptual change model in the interpretation of classroom interactions*. (Unpublished doctoral dissertation). University of Wisconsin-Madison, Wisconsin, USA.

Uzuntiryaki-Kondakci, E., & Capa-Aydin, Y. (2011). Predicting critical thinking skills of university students through metacognitive self-regulation skills and chemistry self-efficacy. *Educational Sciences: Theory and Practice,13*(1), 666-670.

Uzuntiryaki-Kondakci, E., & Kirbulut, Z. D. (2016). The development of meta-affective trait scale. *Psychology in the Schools, 53*(4), 359-374. doi:10.1002/pits.21910.

Uzuntiryaki-Kondakci E., & Senay A. (2015). Predicting chemistry achievement through task value, goal orientations, and self-efficacy: A structural model. *Croatian Journal of Education, 17*(3), 725-753. doi: 10.15516/cje.v17i3.1555

Van der Stel, M., & Veenman, M. V. J. (2010) Development of metacognitive skillfulness: A longitudinal study, *Learning and Individual Differences, 20*(3), 220-224. doi:10.1016/j.lindif.2009.11.005

Villafañe, S. M., Xu, X., & Raker, J. R. (2016). Self-efficacy and academic performance in first-semester organic chemistry: Testing a model of reciprocal causation. *Chemistry Education Research and Practice, 17*(4), 973-984. doi: 10.1039/c6rp00119j

Vosniadou, S. (2003). Exploring the relationships between conceptual change and intentional learning. In G. M. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 377-406). Mahwah, NJ: Erlbaum.

Wolters, C. A., & Pintrich, P. R. (1998). Contextual differences in student motivation and self-regulated learning in mathematics, English, and social studies classrooms. *Instructional Science, 26*(1-2), 27-47. doi: 10.1023/A:1003035929216

Yazici, E. K., & Ozmen, H. (2015). Fen ve teknoloji öğretim programında yer alan deney ve etkinliklerin uygulanabilirliğine ilişkin öğretmen görüşleri [The view of teachers about applicability of activities and experiments found in science and technology curriculum]. *Amasya Universitesi Egitim Fakultesi Dergisi, 4*(1), 92-117.

Yuruk, N., Beeth, M. E., & Andersen, C. (2009). Analyzing the effect of metaconceptual teaching practices on students' understanding of force and motion concepts. *Research in Science Education, 39*(4), 449-475. doi:10.1007/s11165-008-9089-6

Kimyada Üstkavram ve Üstduyuşun Özyeterlik ile İlişkisinin İncelenmesi

Atıf:

Kirbulut, Z. D. (2019). Exploring the relationship between metavariables and self-efficacy in Chemistry. *Eurasian Journal of Educational Research,* 81, 37-56, DOI: 10.14689/ejer.2019.81.3

Özet

Problem Durumu: Fen eğitiminde akademik başarının bilişsel değişkenlerle olan ilişkisi üzerine birçok çalışma olduğu halde duyuşsal değişkenlerle ilişkisini inceleyen çalışmalar azdır. Ancak öğrenmede biliş ve duyuş birlikte çok önemli bir rol oynar. Özyeterlik, biliş ve duyuşla ilişkili önemli bir değişkendir. Özyeterlik, kişilerin belli bir performansa ulaşabilmelerini sağlayacak eylemleri örgütleme ve sergileme becerileriyle ilgili yargıları olarak tanımlanmaktadır. Özyeterlik alana özgüdür. Örneğin, kimya dersinde yüksek özyeterliğe sahip bir öğrenci, matematik dersinde düşük özyeterliğe sahip olabilir. Özyeterlik, kişinin duygu, düşünce ve davranışları ile ilgili özyansıtma ve değerlendirmelerde bulunmasını gerektirir. Bu durum, özyeterlikle üstbiliş arasındaki ilişkiyi yansıtır. Üstbiliş karışık bir kavram olup alanyazında birçok tanımı bulunmaktadır. Bu tanımların ortak noktaları, üstbilişin, kişinin bilişsel sisteminin farkında olması, izlemesi ve kontrol etmesi olduğu üzerinedir. Aynı şekilde, üstbilişin boyutları üzerinde de tartışmalar olmakla birlikte üstbilişsel farkındalık ve üstbilişsel düzenleme ortak boyutlardandır ve bu çalışmada da bu boyutlara odaklanılmıştır. Üstbilişin tanımı ve boyutları hakkında farklı görüşler olmasına rağmen, üstbilişin öğrenme üzerindeki olumlu etkisi, üzerinde hemfikir olunan bir durumdur. Üstbiliş birçok süreç ve beceriyi içeren kapsayıcı bir kavram olduğundan kişinin kendi kavramsal sistemini bilmesi ve kontrol edebilmesi bağlamında "üstkavram" terimi kullanılmaktadır. Bu çalışmada da öğrencilerin kimya bağlamındaki kavramlarının farkında olmaları, izlemeleri ve değerlendirmeleri anlamında "üstkavram" üzerine odaklanılmıştır. Özyeterlik duyguların yönetilmesinde de önemlidir. Genellikle endişe gibi olumsuz duygular özyeterliği azaltırken, coşku gibi olumlu duygular özyeterliği arttırır. Buradan hareketle bu çalışmada üstduyuş kavramı üzerinde durulmuştur. Üstduyuş, duyuş hakkında duyuş, biliş hakkında duyuş ve duyuşun izlenmesi anlamına gelmektedir. Üstduyuşta öne çıkan ve bu çalışmada da kullanılan iki boyut; duyuşun farkındalığı ve duyuşun düzenlenmesidir. Özyeterliği yüksek olan kişiler güçlüklere karşı azimlidirler ve bir ödev üzerinde daha fazla çaba sarf ederler. Özyeterliğin akademik başarıyı etkileyen önde gelen değişkenlerden olduğu ortaya konulmuştur. Bu anlamda özyeterliği etkileyen faktörleri belirlemek önemlidir. Özyeterliğin üstbiliş ve duyguyla ilişkisine yönelik çalışmalar vardır ancak üstkavram ve üstduyuş özelinde çalışmalarla karşılaşılmamıştır. Dolayısıyla, özyeterlik ile üstbiliş ve üstduyuş arasındaki ilişkiyi ortaya koyacak çalışmaların bu alanda yol gösterici olacağı düşünülmektedir.

Araştırmanın Amacı: Bu çalışmada özyeterlik ile üstbiliş ve üstduyuş arasındaki ilişki kimya bağlamında incelenmiştir. Bu anlamda aşağıdaki araştırma sorusu bu çalışmaya rehberlik etmiştir:
Lise öğrencilerinin kimya dersindeki üstkavramsal farkındalık, üstkavramsal düzenleme, duyuşsal farkındalık ve duyuşsal düzenleme düzeyleri kimya özyeterlik inançlarını ne derecede yordamaktadır?

Araştırmanın Yöntemi: Bu çalışmada keşfedici ilişkisel araştırma deseni kullanılmıştır. Çalışmaya 12. sınıfta öğrenim gören 369 Anadolu Lisesi öğrencisi (187 kız, 155 erkek ve 27 yanıt vermeyen öğrenci) katılmıştır. Veriler, Lise Kimya Özyeterlik Ölçeği (LKÖÖ), Üstkavramsal Farkındalık ve Düzenleme Ölçeği (ÜFDÖ) ve Üstduyuşsal Özellik Ölçeği (ÜÖÖ) kullanılarak toplanmıştır. LKÖÖ, öğrencilerin kimya özyeterlik inançlarını, ÜFDÖ, öğrencilerin kimya ile ilgili kavramlarının ne kadar farkında olduklarını, izlediklerini ve değerlendirdiklerini ve ÜÖÖ de öğrencilerin kimyadaki duygularıyla ilgili üstduyuşsal yönelimlerini ölçmek için kullanılmıştır. Bu çalışmada özyeterlik ile üstbiliş ve üstduyuş arasındaki ilişki kanonik korelasyon analizi (bağımsız değişken seti; üstkavramsal farkındalık, üstkavramsal düzenleme, duyuşsal farkındalık ve duyuşsal düzenleme ve bağımlı değişken seti; bilişsel beceriler kimya özyeterliği ve kimya laboratuvarı özyeterliği) ile incelenmiştir. Kanonik korelasyon analizi, en az iki değişken içeren bağımlı ve bağımsız iki değişken seti arasındaki ilişkiyi inceleyen çok değişkenli bir analizdir.

Araştırmanın Bulguları: Kanonik korelasyon analizi sonucunda özyeterlik ile üstbiliş ve üstduyuş arasındaki ilişkiye dair iki kanonik fonksiyon elde edilmiştir. Anlamlı kanonik fonksiyonların belirlenmesinde üç kriter kullanılmıştır. Bunun için kanonik fonksiyonların istatistiki anlamlılığı, kanonik korelasyon katsayılarının karesine (R_c^2) dayalı pratik anlamlılığı ve bağımlı değişken seti gereksizlik (redundancy) indeksine dayalı pratik anlamlılığı değerlendirilmiştir. İstatistiki anlamlılık için kanonik fonksiyonların Wilks's Lambda değerleri kullanılmış ve bu değerler her iki fonksiyonun da istatistiksel olarak anlamlı olduğunu göstermiştir (birinci fonksiyon için Wilks's Lambda .67, $F(8, 726) = 20.27$, $p<.001$; ikinci fonksiyon için Wilks's Lambda .95, $F(3, 364) = 6.12$, $p<.001$). Kanonik korelasyon katsayılarının karesine bakıldığında ilk fonksiyon için .30 ve ikinci fonksiyon için .05 olduğu bulunmuştur. Buna göre ilk fonksiyon bağımlı ve bağımsız değişken seti arasındaki varyansın daha çoğunu açıklamıştır. Gereksizlik indeksi kriterine göre, birinci fonksiyon için hesaplanan bağımlı değişken seti gereksizlik indeksi .20 iken, ikinci fonksiyona ait değer .02'dir. Yani ikinci fonksiyonla kıyaslandığında, birinci fonksiyonda bağımlı değişken setindeki varyansın daha fazlası bağımsız değişkenler tarafından açıklanmıştır. Bu kriterlere göre birinci fonksiyonun açıklanması daha anlamlıdır. Birinci fonksiyon için kanonik yapı katsayıları incelendiğinde bağımsız değişkenler içinde üstkavramsal düzenleme ($r_s = .84$) en büyük katsayıya sahipken, duyuşsal farkındalık ($r_s = .34$) en düşük değere sahiptir. Üstkavramsal farkındalık ve duyuşsal düzenleme kanonik yapı katsayıları ise sırasıyla .74 ve .71 olarak bulunmuştur. Bağımlı değişkenler açısından ise bilişsel beceri kimya özyeterliği kanonik yapı katsayısı ($r_s = .99$), kimya laboratuvarı özyeterliği ($r_s = .59$) için bulunan değerden daha büyüktür. Bir değişkenin kanonik fonksiyona anlamlı katkı yapabilmesi için kanonik yapı katsayısının .45'ten büyük olması beklenir. Buna göre duyuşsal farkındalık hariç tüm değişkenler pozitif ilişkili olarak birinci kanonik fonksiyona anlamlı katkıda bulunmuştur.

Araştırmanın Sonuçları ve Önerileri: Bu çalışma duyuşsal farkındalık hariç üstkavramsal farkındalık, üstkavramsal düzenleme ve duyuşsal düzenleme ile özyeterlik değişkenleri arasında pozitif bir ilişki olduğunu göstermiştir. Yani öğrencilerin kimya dersindeki üstkavramsal farkındalıkları, üstkavramsal düzenlemeleri ve duyuşsal düzenlemeleri arttıkça kimyadaki bilişsel beceri ve laboratuvar özyeterliklerinin de arttığı söylenebilir. Alanyazında yapılan çalışmaların özyeterliğin öğrencilerin akademik başarıları üzerinde en etkili değişkenlerden biri olduğunu gösterdiği düşünüldüğünde, özyeterliği etkileyen faktörlerin açığa çıkarılmasının önemi daha iyi anlaşılmaktadır. Bu çalışma da kimya özyeterliğini etkileyebilecek üst-düzey (meta-level) değişkenleri işaret etmektedir. Alanyazında, üstkavramsal ve üstduyuşsal değişkenlerin özyeterlik üzerindeki etkisi anlamında bir çalışmayla karşılaşılmadığından bu çalışma bu anlamda alanyazına yeni bir katkı sağlamaktadır. Çalışmadaki üst-düzey değişkenler arasından bağımsız değişken setine en önemli katkıyı üstkavramsal ve duyuşsal düzenleme yapmıştır. Ancak duyuşsal farkındalık anlamlı bir katkı sağlamamıştır. Üstkavram ve üstduyuş çok boyutlu ve karmaşık kavramlardır. Dolayısıyla farkındalık ve düzenleme boyutlarının özyeterlik üzerindeki etkilerinin nasıl gerçekleştiğinin belirlenmesine yönelik nitel ve nicel çalışmalara ihtiyaç vardır. Bağımlı değişken setine bakıldığında ise bilişsel beceri kimya özyeterliği, laboratuvar özyeterliğine göre daha büyük katkı sağlamıştır. Bunun muhtemel sebebi öğretmenlerin sınav sistemi ve malzeme yetersizliği gibi nedenler dolayısıyla daha az laboratuvar kullanmalarından olabilir. Bu çalışmanın sonuçlarına göre kimya öğretmenleri derslerinde özyeterlik için üst-düzey değişkenleri dikkate alabilirler. Bunun için zeki öğretim sistemleri gibi öğretimde yeni yaklaşımları dersleriyle bütünleştirebilirler. Ayrıca öğretmen eğitimi programları da üst-düzey değişkenlerin özyeterlik üzerindeki etkisini dikkate alabilirler.

Anahtar Kelimeler: üstbiliş, üstduyuş, özyeterlik, kanonik korelasyon analizi.