Exploring the Relationship between Metavariables and Self-efficacy in Chemistry

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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.

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.

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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 metacognition 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; Malinvuori, 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 metacognitive awareness and metacognitive regulation, respectively. In the present study, the fit indices of the CFA indicated an acceptable model fit (CFI = .94; RMSEA = .064; 90% CI
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).
**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 χ² 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

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

** 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 ($R^2_c$), 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

<table>
<thead>
<tr>
<th>Canonical Functions</th>
<th>Wilk’s Λ</th>
<th>F Value</th>
<th>Hypothesis DF</th>
<th>Error DF</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 2</td>
<td>.67</td>
<td>20.27</td>
<td>8.00</td>
<td>726.00</td>
<td>.000</td>
</tr>
<tr>
<td>2 to 2</td>
<td>.95</td>
<td>6.12</td>
<td>3.00</td>
<td>364.00</td>
<td>.000</td>
</tr>
</tbody>
</table>

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 ($R^2_c = .30$), and the second canonical correlation for the second function was .22 with 5% overlapping variance ($R^2_c = .05$). That is, only the first canonical function was noteworthy to report based on the $R^2_c$ values.

Table 3

<table>
<thead>
<tr>
<th>Canonical Function</th>
<th>Canonical Correlation ($R_c$)</th>
<th>Squared Canonical Correlation ($R^2_c$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.55</td>
<td>.30</td>
</tr>
<tr>
<td>2</td>
<td>.22</td>
<td>.05</td>
</tr>
</tbody>
</table>

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
Table 4

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

<table>
<thead>
<tr>
<th>Variables</th>
<th>Standardized Coefficients</th>
<th>Structure Coefficients (r_s)</th>
<th>Squared Structure Coefficient (r_s^2) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>.45</td>
<td>.74</td>
<td>55</td>
</tr>
<tr>
<td>MR</td>
<td>.55</td>
<td>.84</td>
<td>71</td>
</tr>
<tr>
<td>AW</td>
<td>-.24</td>
<td>.34</td>
<td>12</td>
</tr>
<tr>
<td>AR</td>
<td>.41</td>
<td>.71</td>
<td>50</td>
</tr>
<tr>
<td>R^2</td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Dependent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSCS</td>
<td>.93</td>
<td>.99</td>
<td>98</td>
</tr>
<tr>
<td>SCL</td>
<td>.13</td>
<td>.59</td>
<td>35</td>
</tr>
</tbody>
</table>

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
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 relationship 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, Sarıkahya, & Erkan, 2016; Yazıcı & 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 (Azvedo 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.

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References


Kimyada Üstkavram ve Üstduyuşun Özyeterlik ile İlişkisinin İncelenmesi

Atıf:

Özet
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 duyuşusal düzenleme düzeyleri kimya özyeterlik inançlarını ne derecede yardımcı olmaktadır?


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 istatistiksel anlamlılığı, kanonik korelasyon katsayılarının karesine (R²) dayalı pratik anlamlılığı ve bağımsız değişken seti gerekşizlik (redundancy) indeksine dayalı pratik anlamlılığı değerlendirme yöntemi kullanılmıştır. İstatistiksel olarak iki kanonik fonksiyon Wilks’ Lambdası değeri kullanılmış ve bu değerler her iki fonksiyonun da istatistiksel olarak anlamlı olduğunu göstermiştir (birinci fonksiyon için Wilks’ Lambda .67, F(8, 726) = 20.27, p<.001; ikinci fonksiyon için Wilks’ 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 bağımsız ve bağımsız değişken seti arasındaki varyansı daha çokuna açıklamıştır. Gerekşizlik indeksi kriterine göre, birinci fonksiyon için hesaplanan bağımsız değişken seti gerekşizlik indeksi .20 iken, ikinci fonksiyonda atıl değer .02 dir. Yani ikinci fonksiyonun yarısından daha fazlası bağımsız değişkenler tarafından açıklanmıştır. Birinci kriterlere göre birinci fonksiyonun açıklanmasını daha anlamlıdır. Birinci fonksiyon için kanonik yapı katsayıları incelendiğinde bağımsız değişkenler tarafından açıklanma=.84 en büyük katsayayı sahipken, duyuşsal farkandalık (.r = .34) en düşük değere sahiptir. Üstkavramsal farkandalık ve duyuşsal düzenleme kanonik yapı katsayıları ise sırasıyla .74 ve .71 olarak bulunmuştur. Bağmsız değişkenler açısından ise bilişsel beceriler kimya özyeterliği kanonik yapı katsayı (.r = .99), kimya laboratuvarı özyeterliği (.r = .59) için bulunan değerden daha büyüktdir. Bir değişkenin kanonik fonksiyona anlamlı katkı yapabildiği için kanonik yapı katsayısının .45’ten büyük olması beklenir. Buna göre duyuşsal farkandalık hariç tüm değişkenler pozitif ilişkili olarak birinci kanonik fonksiyona anlamlı katkıda bulunmuştur.

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