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An Investigation of the Relationships between Metacognition and Self-Regulation with Structural Equation

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ABSTRACT

The purpose of this study is to examine the relationships between metacognition and self-regulation. The sample of study consists of 422 primary education students who were enrolled in different programs at Sakarya, in Turkey. In this study, Metacognitive Learning Inventory-Science and Perceived Self-regulation Scale were used. The relationships between metacognition and self-regulation were examined using correlation analysis and the hypothesis model was tested through structural equation modeling. In correlation analysis, metacognition, and self-regulation were found positively. The model demonstrated fit ($\chi 2$= 1014.86,df=551, p=.00, RMSEA=.038, GFI=.99, AGFI=.99, CFI=.99, NFI=.99, IFI=.99, RFI=.99, SRMR=.008). According to results metacognition was predicted positively by self-regulation. Results were discussed in the light of literature

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Keywords:
Metacognition, self-regulation, path analysis

Introduction

Dewey who describes the thinking processes as ordinal incident chaining (King, Goodson, and Rohani, 1998), this productive process passes to ability processes of higher level thinking that includes individual belief and images. As a result of the thinking process, the individual can fix the confusions, rule out the obstacles, associate the differences and should be able to have the ability of solving problems. Metacognition is generally addressed as a multidimensional structure and is a common term used in relation to a series of higher-level cognitive skills. Metacognition is described as "thinking about thinking" (Thorpe & Satterly, 1990). Before the term "metacognition" had been conceptualized, Dewey and Piaget reached to the conclusion that children learns by doing something and thinking about what they are doing (Kirkpatrick, 1985). According to Flavell (2004), metacognition is described as a very efficient process for all the organisms that think too much, make mistakes and need self-regulation to correct them, want to communicate with other organisms, need to make forward planning and make decisions.

Flavell's first conceptualization is considered as the most important theory about metacognition. In his study of memory, Flavell (2004) developed a metacognitive model that includes metacognitive knowledge, metacognitive experience, objectives (or tasks) and actions (or strategies), based on Piaget's association between memory and intelligence, Brown's study and studies such as Markman's comprehension monitoring study (Larkin, 2009). Flavell's studies also set base for his metacognitive theory and the studies in relation to different aspects of metacognition and development of more detailed theoretical models. Kluwe's study in the beginning of 1980s is important in regard to highlighting cognitive management control.

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The role of metacognition in ideational function (Hertzog and Robinson, 2004) is extensively addressed in many studies (Schneider, 1998). Schneider and Pressley (1989) differentiate between procedures of the knowledge about function of the mind (metacognitive knowledge) and metacognition. Metacognitive knowledge is also considered as a factor that has an important effect on cognitive performance via a by-product of cognitive competence (Begg, Duft, Lalonde, Melnick, and Sanvito, 1989; Waters, Schneider and Borkowski, 2009) or metacognitive procedures.

It is extremely important that metacognitive skills are taught within the educational system, regarding their role in the development of students' scientific competence and raising the achievement level (Flavell, 2004); Larkin, 2009). Due to the role of metacognition in problem solving processes and its importance being comprehended more day by day, learning environments and teaching strategies, which highlight behaviors of metacognitive strategy knowledge and self-regulation regarding the problem solving process, are designed. The findings that are the result of many researches based on testing learning environments and teaching strategies put forth that there are strong bonds between teaching metacognitive strategies and progress in students' problem solving performances (Cardelle-Elawar, 1990, 1992, 1995; Garofalo & Lester, 1985; Gourgey, 1998; Kramarski, Mevarech & Arami, 2002; Mevarech & Kramarski, 1977; Schraw, 1998; Teong, 2003; Vershaffel, De Corte, Lasure, Van Vaerenbergh, Boagaerts and Ratnickx, 1999). Before developing learning environments and teaching strategies that will accelerate the development of students' metacognitive skills, the conditions that create metacognitive behaviors should be determined. In this sense, teaching and environments based on the principals that create the proper conditions can be easily designed (Hacker and Dunlosky, 2003). Learning by doing process is extremely efficient on teaching metacognitive skill in science education (Elshout, 1987). In science education, researches about the role of metacognitive in problem solving have been put forth mostly by the studies in physics education (De Jong and Ferguson-Hessler, 1984; Elio ve Scharf, 1990; Elshout, 1987; Elshout, Veenman, and van Hell, 1993; Ertmer and Newby 1996; Glaser and Chi 1998; Larkin et al., 1980; Mettes, Pilot and Roossink, 1981).

Self-Regulation

Self-regulation is described as a traditional concept related to monitoring and control of individual performance (Iiskala, Vauras, & Lehtinen, 2004). Hadwin and Oshige (2011) describe self-regulation as a regulation that is shared socially. In this sense, self-regulation is addressed as a concept in which the products are shared in respect of collective and regulatory processes. Self-regulation is composed of the interaction of the belief and its processes with interrelated processes. And it includes the relation between this belief and processes that produce the goals managed by metacognitive system. Self-regulation is especially described as a process that determines whether the individual will be engaged in a task and in what they will take part. When it is known the current task will be accepted, the function of thought's all other elements (in other words, metacognitive system, cognitive system and knowledge areas) should be divided or determined to a certain extent (Iiskala et al. 2004).

Self-regulated learning is described as the ability to understand and control the individual's learning environments. In this sense, the individual should first determine their goals, choose strategies that will help them realize these goals, apply these strategies and be able to monitor the progress regarding these goals (Schunk & Zimmerman, 1994). Self-regulated learning is composed of three main components: Cognitions, metacognition and motivation. Cognition is described as the process of data coding, memorizing and recalling the skills. Metacognition includes students' skills to understand and monitor metacognitive processes. And motivation consists of belief and attitude that affect the use and development of cognitive and metacognitive skills (Schraw et al. 2006). The basics of self-regulated learning come from cognitive psychology and its history goes back to Albert Bandura's (1997) social cognitive learning theory which has been applied in many environments including school learning. These applications helped the improvement of self-regulated learning theory that indicates learning is interactively managed with cognitive, metacognitive and motivational components (Butler and Winne 1995; Zimmerman 2000). According to the social cognitive perspectives of self-regulated learning, the individual goes through monitoring level, imitation level, self-controlled level and self-regulated level, and thereby acquires self-regulation skill (Schunk and Zimmerman 1994; Zimmerman 2000). Although self-regulated learning is often described and analyzed as an individual process, some researchers put forth that self-regulation processes can have an interpersonal level, regarding problem solving area in small groups (Goos, Galbraith, and Renshaw, 2002;

Iiskala, Vauras, and Lehtinen, 2004; Vauras et al. 2003; Zohar ve Dori, 2012). Cognitive regulation processes are identified as self-regulation, others and shared regulation. Self-organization is described as a traditional concept related to monitoring and control of individual performance (Iiskala et al. 2004). Hadwin and Oshige (2011) describe self-regulation as a regulation which is shared socially. In this sense, self-regulation is addressed as a concept in which the products are shared in the respect of collective and regulatory processes.

The Present Study

Studies have indicated that two of the most important internal motivational factors that correlate to academic success are metacognition and self-regulation (Arslan, 2014; Arslan & Akın, 2014 ; Arslan ,Akın, & Çitemel, 2013;Arslan & Cardak,2012; Azevedo ve Cromley, 2004; Borkowski, 1996; Blair & Razza, 2007; Paris & Paris, 2001; Schunk & Zimmerman, 1998; Tempelaar, 2006; Zimmerman & Schunk, 2001). Both metacognition and self-regulation are self-system beliefs that individuals create about themselves and their interactions with the social environment that can cause act as an interpersonal resource (Goos, Galbraith, & Renshaw, 2002 ; Iiskala, Vauras, & Lehtinen, 2004 ; Vauras et al., 2003 ; Zohar & Dori, 2012). Despite these findings, as far as our knowledge, no study has investigated the relationship between metacognition and self-regulation. Thus, the purpose of this research is to examine the relationship between the metacognition and self-regulation. Based on the interpretation of previous research, it is expected that the self-regulation would be associated positively with metacognition.

Method

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

Participants

Convenience sampling was used in the selection of participants. Participants voluntarily participated and were free to fill out the questionnaires without pressure. Completion of the questionnaires was anonymous and there was a guarantee of confidentiality. The instruments were administered to the students in groups in the classrooms. Participants of the study were 422 primary education students (261 (58%) were female and 190 (42%) were male in Sakarya, Turkey. Their ages ranged from 13 to 14 years and the mean age of the participants was 13.6 years.

Measures

Metacognitive Learning Inventory-Science. Metacognitive Learning Inventory-Science Revised version (Arslan & Gelisli, 2013a) is a 20-item self-report scale using a five-point Likert scale (1=never to 5= always). This scale has four sub-scales: constructivist connectivity (six items), for monitoring-evaluation-planning (five items), self-efficacy(five items), and control of concentration (four items). Results of confirmatory factor analysis have demonstrated that the items loaded on four factors. The internal consistencies of the Metacognitive Awareness Inventory, was found .91 for the entire scale and for subscales were found ranged between .73-.91. Findings also demonstrated that the corrected item-total correlation ranged from .34 to .68. For each factor and each item, the differences between mean scores of upper 27 % and lover 27 % groups are significant. Test-retest reliability coefficient of Metacognitive Awareness Inventory over three-week period was .84. Item analysis and %27 upper-lower group comparisons have been carried out in order to determine total score prediction and distinctiveness of scale items. It was seen that %27 upper-lower groups are significant ($p<0.001$) according to total score obtained from the scale and t values are significant ($p<0.001$) according to the independent t-test that is applied for the comparison of averages of item scores

Perceived self-regulation scale. Perceived Self-regulation Scale (Arslan & Gelisli, 2013b) is a 16-item self-report scale using a five-point Likert scale (1=Never to 5=Always). This scale has two sub-scales: openness (eight items) and searching (eight items). Structure validity of perceived Self-regulation Scale was analyzed with exploratory and confirmatory factor analyses. Exploratory and confirmatory factor analyses were applied on the data obtained from 604 primary school students. In the exploratory factor analysis, maximum factor number was firstly analyzed by using non-circular method for 30 items and it was

determined that the items were accumulated in 4 factors. However, the results of basic components technique and diagonal rotating factor were restricted to two factors, since the goal was to acquire a two-factor structure in the scale development process solution. As a result of this process, 14 items with factor loads under .30 were excluded from the scale and a two-factor structure that explained %54.3 of the total variance and consisted of 16 items was acquired. It was determined that the items in the first factor of the scale were rather related to individuals' self-confidence and this factor was addressed under the name of "openness" according to the circumstances they faced. The factor loads of 8 items accumulated under the "openness" factor vary between .56 and .75, and explains %28.5 of the total variance. Since the items loaded into the second factor are rather related to the pursuits associated with individuals' outer environments and social lives, this factor was called "searching". The amount of total variance explained by the two factors was 54% and factor loadings ranged from .56 to .75 for the openness and from .55 to .75 for the searching. Internal consistencies were .84 and .82 and three-week test-retest reliability estimates were .78 and .74 for two subscales, respectively. Item analysis and %27 upper-lower group comparisons have been carried out in order to determine total score prediction and distinctiveness of scale items. It was seen that %27 upper-lower groups are significant ($p<0.001$) according to total score obtained from the scale and t values are significant ($p<0.001$) according to the independent t-test that is applied for the comparison of averages of item scores. Higher scores for the openness and searching subscale indicate higher levels of self-regulation.

Procedure

Permission for the participation of students was obtained from related chief departments and students voluntarily participated in research. Completion of the scales was anonymous and there was a guarantee of confidentiality. The scales were administered to the students in groups in the classrooms. The measures were counterbalanced in administration. Prior to administration of measures, all participants were informed about the purposes of the study. In this research, Pearson correlation coefficient and structural equation modeling was utilized to determine the relationships between metacognition and self-regulation. These analyses were carried out via LISREL 8.54 (Joreskog & Sorbom, 1996) and SPSS 16.

Results

Descriptive Data and Inter-correlations

Table 1 shows the means, descriptive statistics, inter-correlations, and internal consistency coefficients of the variables used.

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

Variables	Constructivist connectivity	Monitoring	Self-efficacy	Control of concentration	Openness	Searching
Constructivist connectivity	1					
Monitoring	.63**	1				
Self-efficacy	.53**	.54**	1			
Control of concentration	.59**	.64**	.55**	1		
Openness	.47**	.47**	.36**	.42**	1	
Searching	.42**	.41**	.31**	.38**	.89**	1
Mean	12.38	12.36	10.44	12.28	21.52	18.1
Sd	2.5	2.5	2.1	2.7	6.4	5.6

**$p < .001$

Table 1 show that there are significant correlations between the metacognition and self-regulation. Subscales of the self-regulations; openness correlated positively with constructivist connectivity (r = .47;), monitoring (r = .47;), self-efficacy (r = .36;), control of concentration(r = .42;); searching correlated positively with constructivist connectivity (r = .42;), monitoring (r = .41;), self-efficacy (r = .31;), control of concentration (r = .38;).

Before applying SEM, the assumptions of SEM were investigated. Multivariate normality tests which check a given set of data for similarity to the multivariate normal distribution were conducted via LISREL. The results of multivariate normality tests indicated that there was sufficient evidence that the data are multivariate normally distributed. Multivariate outliers were investigated using Mahalanobis distance.

Influential outliers are concerning because they have potential to bias the model and to affect major assumptions. 10 cases for dimensions of burnout were a significant distance from the model. Box's M test for equality of variance-covariance matrices was used to test for homoscedasticity. Based on a statistically significant (p<.05) Box's M test indicates a homoscedasticity assumption violation (Stevens, 2002), it can be said that the data meets criteria of homoscedasticity.

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

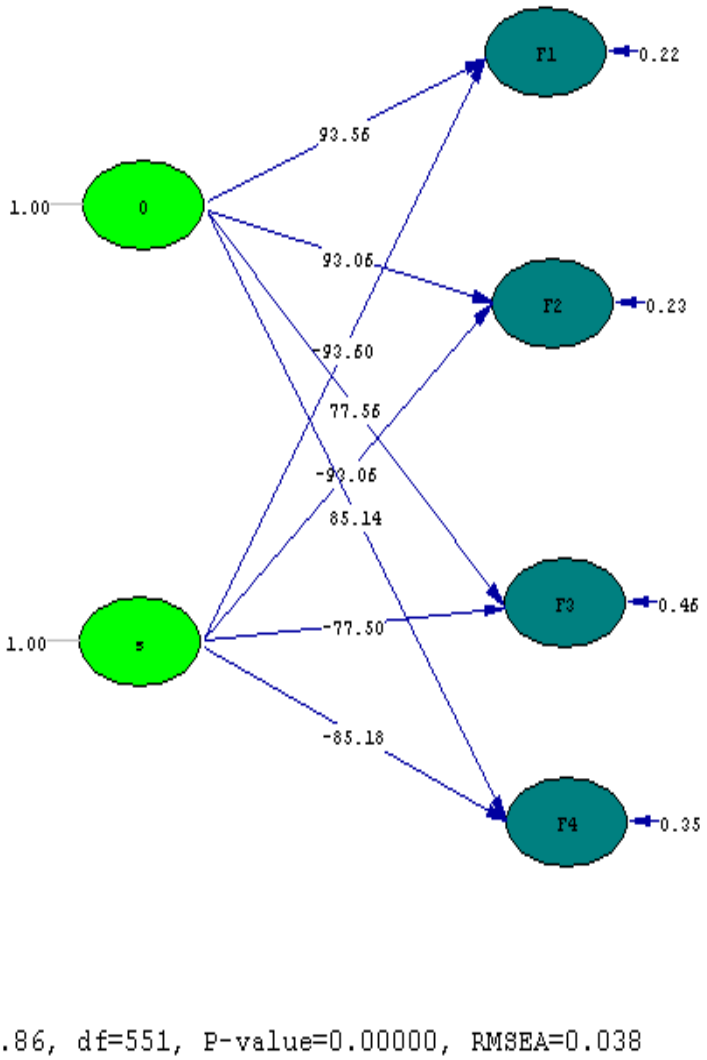


Figure 1. Path analysis between metacognition and self-regulation
F1: Constructivist connectivity,F2: Monitoring,F3: Self-efficacy, F4: Control of concentration

Figure 1 showed that the model is saturated (i.e., there are no unused degrees of freedom). Consequently, the fit of the model (Hu & Bentler, 1999) is necessarily perfect (χ2= 1014.86,df=551, p=.00, RMSEA=.038, GFI=.99, AGFI=.99, CFI=.99, NFI=.99, IFI=.99, RFI=.99, SRMR=.008). It can be seen that openness and searching have significant effects on metacognition.

Discussion and Recommendations

This study investigated the relations of metacognition with self-regulation. Correlations and SEM confirm hypothesis and show that metacognition is positively associated with dimensions of self-regulation. Also the goodness of fit indexes indicated that the model was acceptable and that correlations among measures were explained by the model (Hu & Bentler, 1999).

Metacognition was predicted positively by self-regulation. The positive correlation between metacognition and self-regulation is in line with the findings of Canca (2005) and Ciftçi (2012) study. As a result of Canca's (2005) study in which he analyzed the effect on academic success of university students considering self-regulation dimensions of repetition, detailing, organization, critical thinking and cognitive awareness from cognitive and metacognitive learning strategies based on self-regulation, it was put forward that cognitive and cognitive awareness learning strategies had a significant effect on the mathematical success when they were used together. In his study in which he researched the development of a tool that will support students' metacognition and its effect on students' self-regulations, metacognitive awareness and success in web based teaching environments, also Ciftçi (2012) observed that metacognitive mapping tool included in web based learning environments had a positive effect on students' self-regulatory skills and success (Winne, 1997, 2001). In the first stage of Winne and Hadwin's model, students scan the information in their environments to create an idiosyncratic profile of the task and blend "objective" perceptions with emotional perceptions (Pintrich, 2003) and other motivational information such as decisions associated with self-efficacy. The result of this stage is addressed as an idiosyncratic definition of the task as seen by the student. After framing the task, students determine the goals and can form task study according to the frame determine at the first stage (Pintrich, 2003). Students in the stage of realizing the learning task look through and then use their tactics and strategies to take steps according to their goals. Aviles (2007) found that with appropriate education environment, creative thinking skills can be improved. Furthermore, cognitive awareness strategies that are given in this education provide an advantage on students' self- regulation and control skills. Similarly, according to the study of Vuk (2008), which investigated the effects of metacognitive skills, self- sufficiency, and exam anxiety on self- regulation skills of ninety nine university students; cognitive awareness skills, and help play an important role on university students' self- regulation. Oruç (2012) conducted a research on the effects of learning with self- regulation on students' reading comprehension, attitudes towards Turkish lesson, and metacognitive thinking skills.

This study has several implications for future research. Firstly, further research investigating the relationships between metacognition, self-regulation and other psychological constructs are needed are needed, to reinforce the findings of this study. Also future studies can examine these relationships with structural equation modeling, establishing a mediating or latent variable.

The results of this study should be interpreted in light of a number of limitations. First of all, because this research was intended to build a model rather than test a model that already exists, the findings from the research are of explanatory quality. Therefore, if these findings are not tested on another sample, it is wise to avoid interpreting the findings as definite. Secondly, as the samples presented here were limited to primary education students, this restricts the generalizability of the findings. For that reason, it is also important to investigate the variables studied in this research on sample groups than primary education students. Besides, even though structural equation modeling suggests results related to causality, it is difficult to give a full explanation related to causality among the variables examined in the research, because correlational data were used. In conclusion, this research reports that self-regulation affects metacognition. So, the current findings increase our understanding of the relationships between metacognition and self-regulation.

In conclusion, the present research demonstrates that the self-regulation may be an important predictor of the dimensions of metacognition. Thus, the current findings increase our understanding of relationships between self-regulation and metacognition. Individuals with higher levels of self-regulation may experience higher levels of metacognitive skills and processes. This research also suggests that the interventions devised for enhancing self-regulation processes could be highly beneficial for the development of metacognitive skills.

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