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The Role of Metacognitive Awareness and Motivation of Prospective Primary School Teachers in Predicting Their Academic Achievement in the 'Science and Technology Laboratory Applications' Course

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Abstract

The present study aims to investigate the predictive effects of metacognitive awareness of prospective primary school teachers and their motivation to learn science subjects on their academic achievement in the 'Science and Technology Laboratory Applications' course. A total of 108 (72 females, 36 males) prospective primary school teachers participated in the study. The sample of the study consists of second-grade prospective primary school teachers attending the 'Primary School Teaching' department of a public university in the academic year of 2017-2018. The study was carried out with relational screening model, one of the descriptive research methods. As the data collection tools, metacognitive awareness scale, motivation scale for science learning, and the average grades of the prospective teachers from the science course were used. To determine the relationship between the prospective primary school teachers' academic achievements in their science courses and their metacognitive awareness and motivation for science learning, the Pearson Product-Moment Correlation Coefficient was used. Besides, multiple regression analysis was used to determine the extent to which the sub-factors of metacognitive awareness and motivation of prospective teachers accounted for the variance in their academic achievement. The study concludes the importance of the sub-factors predicting academic achievement as follows: knowledge of cognition, the motivation for research, the motivation for participation, the motivation for collaborative work, and motivation for performance. Furthermore, it has been determined that all factors accounted for 37% of the variance on academic achievement.

Keywords: Metacognitive awareness, motivation, science and technology laboratory applications, prospective primary school teachers

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INTRODUCTION

The primary objective of science education is to ensure that all individuals obtain scientific literacy during their education. Science literate individuals are expected to be individuals with psycho-motor skills who research and ask questions, make effective decisions, solve problems, have self-confidence, communicate effectively, are open to cooperation, and engage in life-long learning with the awareness of sustainable development. They are also expected to have the knowledge and skills of science and develop a positive attitude, perception, and value towards science, and an understanding of the importance of science and technology for the society and environment (Ministry of National Education, 2013). Science education enables students to learn and explore about the world and their environment, provide them with higher order thinking skills such as reasoning, problem-solving, critical thinking and creative thinking, and ensure that they acquire essential life skills and adapt to everyday life (Rowlands, 2008). Primary schools where students first encounter with science courses and where they start developing ideas about the phenomena and events around them play an essential role in ensuring that children obtain science literacy and are educated in line with the objectives of science education (Cepni, Kucuk and Ayvaci, 2003). The knowledge and skills taught at the primary school level significantly influence the future success of children. For this reason, efficient training of the primary school teachers who will take part in the science courses, which are so crucial for the students, has become more critical nowadays (Tekbiyik and Pirasa, 2009). In particular, primary school teachers should have sufficient knowledge of the science subjects at the primary school level (Uyanik, 2016). Furthermore, in addition to the knowledge of science subjects, primary school teachers should have sufficient knowledge and skills related to science and technology laboratory applications (Eryaman, 2007; Aydogdu and Buldur, 2013). As is known, a teacher equipped with adequate knowledge about the subjects he/she teaches will be more successful in ensuring his/her students achieve effective learning while those not having sufficient knowledge may fail to ensure that their students obtain an adequate understanding of the concepts being taught. Moreover, sufficient knowledge and skills related to the basic science subjects and laboratory applications will prevent misconceptions in students and ensure the correct transfer of relevant concepts to the students (Pardo and Portoles, 1995). However, when the relevant literature is examined, it is noteworthy that there are some studies suggesting that prospective primary school teachers' knowledge of science subjects and academic achievement in science courses is insufficient (Birinci-Konur and Ayas, 2008; Birinci-Konur and Ayas, 2010; Guven, Sulun and Cam, 2014; Kaptan and Korkmaz, 2001; Schoon and Boone, 1998; Tekkaya, Capa and Yilmaz, 2000).

One of the science courses in the 'Primary School Teaching' departments at universities is the 'Science and Technology Laboratory Applications' course. This course aims to provide prospective teachers with basic knowledge and skills about laboratory studies, about the preparation of laboratory study projects, about the evaluation of study results, and about the application of subject matter knowledge (Karaca, Ulucinar and Cansaran, 2006). What is more, efficient laboratory courses can improve the ability of students to conduct experiments and design new experiments, help them develop conceptual learning and the ability to interpret data obtained at the end of the experiment, and equip them with the habit of working in groups (Cox and Junkin, 2002; Slayton and Nelson, 2005). Besides, the 'Science and Technology Laboratory Applications' course provides students with an environment in which they can act like scientists, develop an insight into the scientific methodology, and develop their application skills. This, in turn, makes classes more interesting and increases students' academic achievement by affecting them positively (Karatay, Dogan & Sahin, 2014). However, in addition to cognitive features, different features can be useful in increasing academic achievement in science. One of these features is metacognition, which includes both cognitive and affective features and the other is motivation, one of the features of the affective domain.

Metacognition

Although metacognition still has no clear definition and is still a matter of debate, Flavel (1979) defines it as one's knowledge concerning one's cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data. Referring to the concept of metacognition as the inner voice of an individual, Perfect and Schwartz (2002) define it as "an individual's thinking about his/her own thinking processes", or "an individual's knowledge of his/her cognition and his/her ability to influence his/her own cognition."According to Hacker and Dunlosky (2003), metacognition is the state in which an individual is aware of and controls his/her mental activities related to perception, remembering and thinking. Metacognition has two primary components: knowledge of cognition and regulation of cognition (Schraw, 1998; Schraw and Moshman, 1995). Knowledge of cognition refers to an individual's awareness of his/her own cognition, and regulation of cognition refers to the activities that help the individual to control his/her learning (Schraw, 1998; Schraw and Moshman, 1995).

Knowledge of cognition consists of three components: declarative knowledge, procedural knowledge and conditional knowledge (Jacobs and Paris, 1987). Declarative knowledge involves an individual's knowledge, beliefs and cognitive characteristics about what he/she can/cannot do. Procedural knowledge is the knowledge of what strategy to implement for a cognitive job and how to implement that strategy. Conditional knowledge relates to when, why, and how to use declarative knowledge and procedural knowledge (Schraw, 1998). Therefore, in the context of knowledge of cognition, individuals should be aware of their own cognition, be aware of their skills, and know what strategies to use in learning. Furthermore, individuals should have cognition of when, how, and when to use these strategies in learning.

Regulation of cognition consists of planning, self-monitoring, and self-assessment (Schraw, 1998). Planning is the selection of appropriate strategies, the design of the process and the method to use for successful performance. It also includes setting goals, activating prior knowledge and setting the time. Self-monitoring is the awareness of one's performance when conducting a particular job and periodic control of the process (Nietfeld, Cao & Osborne, 2005) to see if the subject is understood. Self-assessment is one's own assessment of his/her own learning products and regulation process (Schraw & Moshman, 1995). In this context, individuals determine strategies to help their learning, make plans and monitor whether these strategies work. Finally, individuals assess their own learning situations.

In short, an individual's awareness of what he/she does, how he/she does it, and what he/she gets in return is explained with the concept of metacognition (Cakiroglu, 2007). Individuals should also be aware of their metacognition and should develop their metacognition in this respect (Jones, Farquhar and Surry, 1995). This is because metacognitive awareness involves an individual's ability to know how he/she learns what, to know whether he/she has learned it, to improve the system of thinking, and to learn to learn (Cakiroglu, 2007). Thus, because individuals' metacognitive awareness is improved, individuals can have more effective learning processes. This, in turn, can increase the performance of individuals in their courses, and also increase their academic achievement (Baltas, 2004; Desoete and Roeyers, 2002; Yang and Lee, 2013). In many studies in the relevant literature, metacognitive awareness has been found to be related to students' academic achievement (Bagceci, Dos, & Sarica, 2011; Balci, 2007; Coutinho, 2007; Emrahoglu, & Ozturk, 2010; Gul, & Shehzad, 2012; Landine, & Stewart, 1998; Schraw, & Dennison, 1994; Young, & Fry, 2008). Furthermore, some studies (Young, & Fry, 2008) determined a relationship between academic achievement and knowledge of cognition, one of the components of metacognition, while others (Everson, & Tobias, 1998; Nietfeld, Cao, & Osborne; 2005; Schraw, 1994) determined a relationship between academic achievement and regulation of cognition, another component of metacognition. In this respect, Bagci (2003) explains the relationship between metacognition and academic achievement as follows: "a student's awareness of the requirements of a course, his/her increased expectations from that course, the codification of information in an organized manner, and healthy transfer of it to future experiences." Caliskan (2010) notes that students who can use metacognitive knowledge and metacognitive skills in their learning process can achieve effective learning and therefore they can be successful. In this context, metacognitive awareness can be considered a good predictor of academic achievement.

Motivation

Motivation, which is seen as a prerequisite for the realization of learning, is defined by Eggen and Kauchak (1990) as a force that directs the behavior of individuals towards a goal in education. According to Lai (2011), motivation is a concept that includes perception, belief, value, areas of interest and actions related to each other. According to Budak (2015), motivation arises from a student's perception of his/her environment and him/herself and collects the interest of the student in the educational activities intended for learning and gives the student the determination to complete these activities. Motivation is divided into two different types (Ergun, 2009): intrinsic motivation arising from an individual's sense of interest, curiosity and personal development; and extrinsic motivation arising from external factors that direct and support an individual. Intrinsic motivation involves satisfaction and pleasure from participation in an activity. In other words, the movements of individuals based on their own will result from their intrinsic motivation. Extrinsic motivation, in contrast to intrinsic motivation, is related to a wide range of behaviors within the purposes of action beyond the nature of one's activities and implies a tendency to be influenced by environmental factors (Deci and Ryan, 1985). In this direction, in the process of emergence of motivation, when personal factors are effective, intrinsic motivation occurs; when external factors are effective, extrinsic motivation occurs. However, it is difficult to say whether a behavior originates from intrinsic or extrinsic motivation (Ilgar, 2004). For, it can be argued that the motivation of intrinsic and extrinsic structures can be eliminated or re-emerged in a complex order and with changing conditions (Paris and Turner, 1994).

In this context, the students' motivation for science learning is a multidimensional structure that is influenced by the individual characteristics of teachers and students, teaching methods and techniques, learning environment and curriculum (Barlia, 1999). For this reason, motivation is the most important of the affective differences, which play an important role in students' ability to obtain effective learning from science classes (Brossard, Lewenstein and Bonney, 2005). In the literature, it is emphasized that motivation is one of the key concepts of learning and should not be neglected in teaching environments. For, motivation is one of the important factors affecting learning and success. Students with high levels of motivation tend to exert more effort and persistence in classroom activities and tasks than students with low levels of motivation (Wolters and Rosenthal, 2000). Besides, students will be willing to participate actively in classroom tasks and activities when they consider science-related concepts and activities as important and meaningful for themselves. However, when students think that the subjects to be learned are not necessary and important for themselves, permanent learning will not occur because they will prefer the method of memorization. Relevant studies have also indicated a relationship between motivation and success (Gottfried, 1990; Kaya, 1995; Taspinar, 2004). However, although the effectiveness of motivation on learning and success is known and accepted, the effect of motivation on success along with other factors is not known. It is still an issue of concern how motivation, along with metacognition, one of these factors, affects academic achievement. Studies indicate that there is a relationship between motivation and metacognition in the literature (Sperling, Howard, Staley, & DuBois, 2004; Landine, & Stewart, 1998; Pintrich, Smith, Garcia, & McKeachie; 1991). These studies indicate that motivational values such as pre-knowledge of science subjects, communication in the learning environment, expectations and values affect the choice of learning strategies, metacognition and regulation (Linnenbrink and Pintrich, 2002). In this context, this paper provides an insight into the extent to which motivation and metacognition affect and predict academic achievement. The research questions of the study are as follows:

1. Is there a statistically significant relationship between prospective primary school teachers' academic achievement in science courses and their metacognitive awareness of science courses?

2. Is there a statistically significant relationship between prospective primary school teachers' academic achievement in science courses and their motivation for science learning?

3. To what extent do prospective teachers' metacognitive awareness and motivation for science learning predict their academic achievement in science courses?

METHOD

Research Model

In this research, relational screening model, one of the screening models, was used. The dependent variable is the academic achievement in science course while the independent variables are metacognitive awareness of and motivation for science learning.

Study Group

The sample of the study consisted of 108 second-grade students enrolled in the Primary School Teaching department of a public university in the spring semester of the 2017-2018 academic year. Of the participants, who were aged between 19 and 24, 72 (66%) were female and 36 (34%) were male.

Data Collection Tools

Metacognitive Awareness Inventory: The inventory developed by Schraw and Dennison (1994) was adapted to Turkish by Akin, Abaci, and Cetin (2007) who also performed its validity and reliability studies. The five-point Likert-type inventory with 52 items consists of two main sub-factors and their components. These factors are knowledge of cognition and regulation of cognition. The knowledge of cognition sub-factor consists of declarative knowledge, procedural knowledge and conditional knowledge components while the regulation of cognition sub-factor includes planning, monitoring, evaluation, debugging and information management. For the ' *declarative knowledge* ' component of the ' *knowledge of cognition' sub-factor, the item "I understand my intellectual strengths and weaknesses* " can be given as an example; for the 'procedural knowledge' component, the item " *I am aware of what strategies I use when I study"* can be given as an example; and for the 'conditional knowledge' component, the item "I know when each strategy I use will be most effective" can be given as an example. Furthermore, for the ' *planning* ' component of the ' *regulation of cognition' sub-factor, the item* " *I think of several ways to solve a problem and choose the best one* " can be given as an example; for the 'monitoring' component, the item " *I ask myself periodically if I am meeting my goals* " can be given as an example; for the 'evaluation' component, the item *"I summarize what I have learned after I finish"* can be given as an example; for the 'debugging' component, the item "I change strategies when I fail to understand" can be given as an example, and for the item "I try to break studying down into smaller steps" can be given as an example. The Cronbach alpha coefficient of the Turkish version of the scale was calculated as 0.95 for the entire scale. This coefficient varies between 0.66 and 0.87 for the sub-scales. Test-retest reliability was found to be 0.95 for the entire scale. The reliability coefficients of the subscales range between 0.93 and 0.98. The Cronbach's reliability coefficient for the present study was found to be 0.96. This coefficient varies between 0.71 and 0.91 for the subscales.

Motivation Scale for Science Learning: The scale consisting of 23 items was developed by Dede and Yaman (2008). The five-point Likert-type scale is scored as follows:1 point for "strongly disagree" and 5 points "for strongly agree". The scale consists of five factors: the motivation for research, the motivation for performance, the motivation for communication, the motivation for collaborative work and motivation for participation. For the *motivation for research* ' sub-factor, the item *"I like to learn the latest innovations about science* " can be given as an example; for the 'motivation for performance' sub-factor, the item *"I try hard to win the favor of my teacher in science classes"* can be given as an example; for the 'motivation for communication' sub-factor, the item *"I like to work in small groups* " can be given as an example; for the 'motivation for collaborative work' sub-factor, the item *"In group work, I don't care about other friends' ideas"* can be given as an example; and for the 'motivation for participation', the item "I'd like to suggest the best idea in class discussions" can be given as an example. These five factors account for 47.16% of the variance in all scale scores. The internal consistency reliability (Cronbach Alpha) of the whole scale was found to be 0.80. This figure varies between 0.55 and 0.75 for the sub-factors. The Cronbach Alpha internal consistency coefficient of the scale was found to be 0.82 after the test-retest method.

Average Grade from the Science and Technology Course: To determine the academic achievements of the prospective primary school teachers in the science course, their grade point averages from the "Science and Technology Laboratory Applications II" course were taken into consideration. These grades range from 0 to 100 points.

Data Collection

The collected data were related to the 'Science and Technology Laboratory Applications II' course in the second year of the Primary School Teaching department in the spring semester of 2017-2018. In the first week of the course, the participants were informed about the purpose of the research, the data collection tools to be used and where the results would be used. The data were collected during a class period in the second week.

Data Analysis

The data were analyzed using SPSS 20 statistical package program. The Pearson Product-Moment Correlation Coefficient was used to test the relationship between prospective primary school teachers' academic achievement in the science course and their metacognitive awareness and motivation for science learning and to determine the direction and extent of the relationship. Also, multiple linear regression analysis was used to determine to what extent metacognitive awareness and motivation for science learning predict the academic achievement of the prospective teachers. In the analysis, sub-factors of metacognitive awareness and motivation for science learning were taken as the independent variables while the academic achievement grade was taken as the dependent variable . In the analysis of the data, the statistical significance was accepted as 0.05. In addition, the Kolmogorov-Smirnov test was used to assess the normality of the data: the data were found to have a normal distribution. Mahalanobis distance was used to determine whether the variables exhibited a multivariate normal distribution and to examine the extreme values. As a result of the analysis, there was no extreme value that disrupts the multivariate normality.

FINDINGS

Table 1 presents the results of the descriptive statistical analysis of the academic achievement grades, and metacognitive awareness and motivation scores of prospective primary school teachers enrolled in the study.

Table 1. Descriptive statistical analysis results

Variables	N	x	ss	Skewness	Kurtosis
Academic achievement grade	108	65.47	15.77	-.533	.950
Sub-factors of Metacognitive awareness					
Knowledge of cognition	108	44.39	14.74	.532	1.442
Regulation of cognition	108	93.74	29.14	.558	1.762
Sub-factors of motivation for science learning					
Motivation for research	108	20.88	5.22	-.251	-.539
Motivation for performance	108	17.45	4.62	-.154	.022
Motivation for communication	108	18.10	4.22	-.408	.509
Motivation for cooperative work	108	15.39	3.18	-.568	-.062
Motivation for participation	108	11.43	2.96	-.695	.950

When the data in Table 1 are analyzed, it can be said that the prospective primary school teachers have a moderate level of grade point averages. The average scores of the prospective primary school teachers from the sub-factors of metacognitive awareness are also at a moderate level. However, it was determined that the average scores of the prospective primary school teachers from the sub-factors of motivation for science learning are at a high level. The normality of the data was examined using a histogram graph and skewness and kurtosis values. According to George and Mallery (2013), skewness and kurtosis values between +1 and -1 are ideal, and between +2 and -2 are acceptable. The skewness and normality values of the variables also indicate the normality of the distribution. Before analyzing the research questions, the normality values of each variable were examined. Cohen (1988)'s assessment was taken into consideration for the interpretation of coefficients in the correlation analysis. Accordingly, Cohen (1988) interpreted the correlation coefficients as follows: a value between 0.10 and 0.30 "small"; a value between 0.30 and 0.50 "medium"; and a value higher than 0.50 "large".

Findings related to the first research question

To find an answer to the question of "Is there a statistically significant relationship between prospective primary school teachers' academic achievement in science courses and their metacognitive awareness of science courses?", which is the first research question, preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. The results are given in Table 2.

Table 2. Results of the correlation between prospective teachers' academic achievement and their scores from the sub-factors of metacognitive awareness

Variables		1	2	3
Academic achievement	1	1		
Knowledge of cognition	2	.505*	1	
Regulation of cognition	3	.472*	.927*	1

*p<.05

It can be inferred from Table 2 that there is a high positive correlation between the prospective primary school teachers' academic achievement in science courses and their knowledge of cognition, which is a sub-factor of metacognitive awareness [r=472, n=108, p<.05] 05]. In addition, a positive correlation was found between the prospective primary school teachers' academic achievement and their regulation of cognition [r=. achievement and regulation of cognition, which is another of the sub-factors of metacognitive 05].

Findings related to the second research question

To find an answer to the question of "Is there a statistically significant relationship between prospective primary school teachers' academic achievement in science courses and their motivation for science learning?", which is the second research question, preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. Following the assumption of normality, the Pearson Correlation Coefficient was calculated. The results are given in Table 3.

Table 3. Correlation Values between the Sub-factors of Academic Achievement and Motivation for Science Learning

Variables		1	2	3	4	5	6
Academic achievement grade	1	1					
MfR	2	.469*	1				
MfP	3	.403*	.699*	1			
MfC	4	.394*	.717*	.758*	1		
MfCW	5	.360*	.569*	.542*	.667*	1	
MfPa	6	.386*	.564*	.754*	.694*	.660*	1

MfR: Motivation for Research; MfP: Motivation for Performance; MfC: Motivation for Communication; MfCW: Motivation for Collaborative Work; MfPa: Motivation for Participation

It can be inferred from Table 3 that there is a moderate positive relationship the prospective primary school teachers' academic achievement in science courses and their motivation for research [r=.469, p<.469, p<.their motivation for performance [r=.403, p<.005], their motivation for communication [r=.394, p<.05], their motivation for cooperative work [r=360, p<..05], and their motivation for participation [r=..386, p<.05]

Findings related to the third research question

To find an answer to the question of "To what extent do prospective teachers' metacognitive awareness and motivation for science learning predict their academic achievement in science courses?", which is the third research question, multiple linear regression analysis was performed. The results of the analysis are given in Table 4.

Table 4. Results of multiple linear regression analysis

Variables	B	Standard Error	β	t	p	Binary r	Partial r
Constant	19.579	6,880		2.816	.006		
Knowledge of cognition	.434	.233	.406	1.865	.045	.505	.183
Regulation of cognition	-.004	.117	-.007	-.034	.973	.472	-.003
MfR	.693	.381	.230	1.821	.032	.469	.179
MfP	.031	.512	.009	.060	.012	.403	.006
MfC	-.387	.544	-.104	-.712	.478	.394	-.071
MfCW	.599	.583	.121	1.026	.030	.360	.102
MfPa	.855	.728	.160	1.174	.024	.386	.117

*p<.05 MfR: Motivation for Research; MfP: Motivation for Performance; MfC: Motivation for Communication; MfCW: Motivation for Collaborative Work; MfPa: Motivation for Participation

When the binary and partial correlations between the predictive variables in Table 4 for predicting the academic achievement of prospective primary school teachers and the independent variables are examined, significant relationships attract attention between all other variables and the dependent variable except between regulation of cognition and motivation for communication from the sub-factors of motivation for science learning. Academic achievement has a strong positive correlation with knowledge of cognition but a weak negative correlation with the regulation of cognition. Furthermore, academic achievement has moderate positive correlations with motivation for research, motivation for performance, motivation for collaborative work and motivation for participation, but a moderate negative correlation with motivation for communication. According to standardized regression coefficient (β), the relative importance of predictive variables on academic achievement is as follows: knowledge of cognition, motivation for research, motivation for participation, motivation for collaborative work, and motivation for performance. The variables of regulation of cognition and motivation for communication have no significant effect.

The results of the multiple linear regression model according to Table 4 can be shown as follows.

Academic achievement=(0.855*MfPa) + (0.693*MfR) + (0.599*MfCW) + (0.434*Knowledge of cognition) +(0.03*1MfP) + (-19.579)

Table 5. Summary of Regression Analysis Results

Model	R	R^2	Adjusted R^2	Standard error of estimate	F	p	D-W
Academic achievement	.612	.374	.343	12.778	12.194	.000*	1,962

*p<.05

To determine whether there are multiple connections between the predictive variables, correlation (r), VIF (variance inflation factor) and CI (condition index) values were examined (Buyukozturk, 2015) through the multiple linear regression analysis (Buyukozturk, 2015). The conformity of the scores of the predictive variables with the regression model was determined by the determination of the Durbin-Watson d value (D-W=1.962). A Durbin-Watson d value of 1.5-2.5 indicates no auto-correlation. Lack of multiple linear connection problems means that VIF values are below 10 and tolerance values are not very close to 0 (Gujarati, 1995). It was also found that CI values are not higher than 30. According to these results, in the regression model, there are no multiple linear connection problems and no auto-correlation; therefore, the model is reliable. In this respect, the prospective primary school teachers' knowledge of cognition and motivation for science learning are a significant and moderate predictor of their academic achievement in science courses (R=0.656, $R^{2}=$ 0.374, $p< .05$). As a result of the regression analysis, it was determined that predictive variables accounted for 37% of the academic achievement variance.

DISCUSSION AND CONCLUSION

The present study was conducted to investigate the relationship between prospective primary school teachers' academic achievement in the 'Science and Technology Laboratory Applications' and their metacognitive awareness and motivation. Furthermore, the study aimed to determine to what extent the prospective primary school teachers' metacognitive awareness and motivation affect their academic achievement.

In the study, first of all, a strong positive relationship [r=.505, n=108, p<.05] was found between the prospective teachers' academic achievement in the "Science and Technology Laboratory Applications" course and knowledge of cognition, which is one of the sub-factors of metacognitive awareness, and a positive moderate relationship [r=.472, n=108, p<.05]was found between their academic achievement and regulation of cognition, which is another of the sub-factors of metacognitive awareness. In this context, the strong positive relationship between the prospective teachers' academic achievement in the 'Science and Technology Laboratory Applications' course and their knowledge of cognition indicates that the prospective teachers are aware of their own cognition in their learning processes, are aware of their own skills, and are more successful in science courses when they know which strategies to use for their own learning. Furthermore, the moderate positive relationship between their academic achievement in the ‘Science and Technology Laboratory Applications’ course and their regulation of knowledge indicates that when the prospective teachers determine specific learning strategies for themselves and plan accordingly, when they monitor whether these strategies are helpful, and when they assess their own learning, they can learn effectively. Unal (2010) argues that the academic achievement of the students increase as their metacognitive awareness increases. Ulgen (2001) expresses the importance of metacognition on academic achievement as follows: “this skill allows the student to know what he/she knows and what he/she doesn’t know (strengths/weaknesses)”. Thus, the student can know his/her own learning, concentrate on what he/she does not know and direct his/her learning and thinking process in this direction (Namlu, 2004). Also, metacognition plays a vital role in helping students solving social problems outside of school life as it helps students discover their own learning methods, identify their strengths/weaknesses, and evaluate themselves. Metacognitive awareness is vital in the learning process as it enables successful students to manage their cognitive skills better and to evaluate and regulate their own learning by providing them with new cognitive skills (Schaw, 1998). Therefore, it can be said that metacognition can have an impact on students’ conceptual understanding and academic achievement. When the relevant studies are examined, it is seen that metacognition has an effect on students’ conceptual understanding, supports conceptual change and is an essential variable of academic achievement (Bagceci, Dos, & Sarica, 2011; Balci, 2007; Coutinho, 2007; Dunning, Johnson, Ehrlinger, & Kruger, 2003; Emrahoglu, & Ozturk, 2010; Gul, & Shehzad, 2012; Landine, & Stewart, 1998; Schraw, & Dennison, 1994; Yangin, 2014; Young, & Fry, 2008; Yuruk, 2005; Yuruk, Beeth, & Andersen, 2009; Yuruk, Selvi, &Yakisan, 2011).

Secondly, a moderate positive relationship was found between the prospective teachers’ academic achievement in the ‘Science and Technology Laboratory Applications’ and their motivation for research (MfR) [$r=.469$, $p<.05$], motivation for performance (MfP) [$r=.403$, $p<.05$], motivation for communication (MfC) [$r=.394$, $p<.05$], motivation for collaborative work (MfCW) [$r=.360$, $p<.05$], and motivation for participation (MfPa) [$r=.386$, $p<.05$]. This result indicates that when prospective primary school teachers actively participate in the experiments in science classes, conduct research on the experiment, participate in the cooperative learning process, communicate with both their teachers and their group mates, and achieve high-level of performance in conducting and finalizing the experiment, effective learning can take place and their academic achievement in the course will increase. In this respect, Yenice, Saydam and Telli (2012) pointed out that as students’ motivation levels increase, they devote more time to science courses and that the students with a high level of motivation have more academic achievement in science courses. Besides, Stipek (1998), Wolters and Rosental (2000) stated that students with higher levels of motivation learned more and had more positive thoughts about themselves. Considering that motivation is a force necessary for an individual to begin an action for a goal, this force refers to the internal factors that drive the individual and the external factors that encourage behavior (Walterman, 2005). Therefore, motivation can be considered as a force necessary for the initiation and continuation of the learning action. Because motivation makes students enthusiastic, excited and determined, it is seen as an important variable in ensuring that students participate in classroom activities, perform their tasks/assignments, achieve effective learning, and increase their academic achievement. In courses such as “Science and Laboratory Applications”, the participation and willingness of students are important. Students’ effective participation in experiments and their integration of experiences from experiments with scientific knowledge also play an important role in increasing their academic achievement in science courses. Therefore, it can be argued that motivation is an important variable in increasing academic achievement in laboratory applications. Some studies in the relevant literature also reported a positive relationship between motivation and academic achievement (Cakir, Sahin, & Sahin, 2000; Henderlong, & Lepper, 1997; Gottfried, 1990; Karsenti, & Thibert, 1995; Kaya, 1995; Taspinar, 2004).

Thirdly, it was determined that the prospective teachers' knowledge of cognition and their motivation for science learning are a significant and moderate predictor of their academic achievement in science courses (R= $^{0.656,\ R2=0.374}$, *p*<.05). Moreover, it was found out that the knowledge of cognition, one of the sub-factor of metacognitive awareness, and motivation for research (MfR), motivation for performance (MfP), motivation for collaborative work (MfCW), and motivation for participation (MfPa) variables, which are the sub-factors of motivation for science learning, account for 37% of the change in the academic achievement of prospective primary school teachers in science courses. The significance of the effect of these predictive variables on the academic achievement in science courses is as follows: motivation for participation (MfPa) (β=0.160), motivation for research (MfR) (β=0.230), motivation for collaborative work (MfCW) (β=0.121), knowledge of cognition (β=0.406), and motivation for performance (MfP) (β=0.009). In addition, when the test results of the *p*< .05 significance level of the regression coefficients are examined, it can be seen that motivation for participation (MfPa) (p <.05), motivation for research (MfR) (*p* <.05), motivation for collaborative work (MfCW) *(p*< .05), knowledge of cognition (p <.05), and motivation for performance (MfR) (p*p* <.05) are significant predictors of the academic achievement in science courses. This result indicates that prospective teachers have increased academic achievement in the 'Science and Technology Laboratory Applications' course when they are aware of their own cognition and of their own skills and when they know which strategies to use in their own learning processes (i.e. when they have a knowledge of cognition). In addition, it can be concluded that high-level of motivation is a significant predictor of their participation in laboratory applications, of their conducting research, of their engaging in collaborative work, and of their achieving high-level performance. A thorough search of the relevant literature indicates that studies have reported metacognitive awareness (Ugras, 2018), motivation, self-regulation and metacognition (Demir and Budak, 2016), and motivation (Aktan, 2012) as the predictors of academic achievement. In addition, some studies reported that there are relationships between academic achievement, metacognition and motivation. These studies indicated that there is a positive relationship between metacognition and motivation (Landine, & Stewart, 1998; Pintrich et al., 1991; Sperling et al., 2004); between motivation and academic achievement (Gottfried, 1990; Karsenti, & Thibert, 1995; Kaya, 1995; Taspinar, 2004); and between metacognition and academic achievement (Bagceci, Dos, & Sarica, 2011; Balci, 2007; Coutinho, 2007; Emrahoglu, & Ozturk, 2010; Gul, & Shehzad, 2012; Landine, & Stewart, 1998; Schraw, & Dennison, 1994; Young, & Fry, 2008). To sum up, studies have mostly highlighted the positive relationship between metacognition and motivation variables and academic achievement. Therefore, and in the light of the results of the present study, we recommend that activities that will improve the metacognition of prospective primary school teachers should be included in the curricula to increase their academic achievement in science courses (Cakir, Guven, & Ozdemir, 2018). Furthermore, we believe that motivational factors should also be taken into consideration in planning these courses.

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