ASSESSING THE RELATIONSHIP BETWEEN LEARNING STRATEGIES AND SCIENCE ACHIEVEMENT AT THE PRIMARY SCHOOL LEVEL

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Introduction

Self-regulated learning in relation to students' academic achievement has gained a great deal of attention in recent research. While there are several models to explain the constructs of self-regulated learning, recent models emphasize the importance of cognitive, metacognitive and motivational aspects of learning (Wolters, 2003). Students are viewed as active builders of their knowledge (Pintrich, 2004; Schunk, 2001; Zimmerman, 2002). Self-regulated learning helps students control and regulate their learning and enable them to reach achievement goals (Pintrich, 1999). Therefore, it is important to understand the dynamics of self-regulation strategies for increased learning and achievement.

Self-Regulated Learning

According to Pintrich (2004) "learners are viewed as active participants in the learning process" and that they "… can potentially monitor, control, and regulate certain aspects of their own cognition, motivation, and behaviour as well as some features of their environments" (p. 387). Individuals who are successful in self-regulation tend to have higher performance (Akyol, Sungur, & Tekkaya, 2010; Eshel & Kohavi, 2003; Pintrich, Smith, Garcia, & McKeachie, 1993; Vrugt & Oort, 2008). In self-regulation, learners construct their own meanings, goals, and strategies by using information available in their environment. However, there might be individual and contextual differences that influence regulation efforts (Pintrich, 2004; Wolters, 1998). Self-regulation is not genetically based or stable; it is developed through experience. Thus, students are able to control their behaviour in order to increase their academic achievement (Pintrich, 1995). Even though self-

Abstract. *The use of self-regulated learning strategies tend to have an impact on student learning and achievement; however, the nature of this relationship for primary science achievement needs further investigation. The purpose of this study was to examine the relationship between learning strategies used by primary students and their science achievement. The use of learning strategies was measured by the 50-item modified version of the Motivated Strategies for Learning Questionnaire (MSLQ) and the science achievement was measured by a test compiled from the released TIMSS items. Bivariate correlation analysis results showed that among the nine learning strategies that were investigated, seven of them were significantly associated with the science achievement. There were no correlations between peer learning and help seeking and achievement. Multiple regression analysis results showed that among the seven strategies, effort regulation, metacognitive self-regulation and critical thinking significantly contributed to the science achievement. Results and implications for instruction were discussed.*

Key words: *Motivated Strategies for Learning Questionnaire, primary science, self-regulated learning, TIMSS.*

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regulated learning is viewed as a personal endeavor in individuals' learning that involves self-directed processes, it has a social aspect as well, such as seeking help from peers or teachers (Zimmerman, 2002). Self-regulated learning does not only develop in a classroom context but also in other contexts such as families and play settings (Pintrich, 1999). In recent years several models were developed to identify the components of self-regulated learning. Among these, Pintrich's model has been widely used in assessing individuals' self-regulation.

According to Pintrich's model, students' motivation, their use of various learning strategies, and their achievement are interrelated (Pintrich et al., 1993). The current study will be focusing on the learning strategies and achievement relationship. Pintrich describes three types of learning strategies used by students: cognitive, metacognitive and resource management strategies. Cognitive strategies include surface level strategies such as rehearsal, where students focus on memorizing and recalling facts; deeper processing strategies, elaboration and organization, where they focus on extracting meaning, summarizing and organizing materials; and finally, critical thinking where students problem solve, reach decisions and critically evaluate. Metacognitive strategies help students focus on planning, monitoring, and controlling their cognition (Pintrich et al., 1991). Resource management strategies involve the management of time and study environment, where students schedule and plan their study time and organize their study environment; effort regulation, which refers to the ability to control one's own effort and attention despite distractions and commitment to completing study goals; the final two strategies include peer learning and help seeking where students collaborate and interact with peers and teachers (Pintrich et al., 1991).

In order to measure students' motivational orientation and use of learning strategies, Pintrich and colleagues (Pintrich et al., 1991) developed the Motivated Strategies for Learning Questionnaire (MSLQ) (see Method section for details). Previous research that utilized MSLQ to investigate the relationship between self-regulated learning strategies and academic performance revealed mixed results. In a study with 197 college students Chen (2002) found that effort regulation had a positive effect and peer learning had a negative effect on learning computer concepts. Vrugt and Oort (2008) reported that the metacognitive strategies and resource management strategies had positive effects on college students' psychology exam scores. In another study with 472 college students Altun (2005) reported significant effects of metacognitive self-regulation, management of time and study environment, and help seeking on mathematics achievement. At the high school level, Yumusak and colleagues (2007) found significant effects of rehearsal strategy use, organization strategy use, and management of time and study environment on students' biology achievement, while there was a negative relationship between peer learning and achievement.

Most studies utilizing the MSLQ focused on college or high school populations since the original questionnaire was developed for college students. With a younger population, Akyol and colleagues (2010) found positive effects of elaboration, organization and metacognitive self-regulation strategy use on science achievement. In another study with seventh graders, Eshel and Kohavi (2003) reported significant positive effects of cognitive strategy use, namely, rehearsal and organization, on mathematics achievement. They did not include metacognitive and resource management strategies sections in their study. Among the few studies utilizing the MSLQ with primary school population, Shores and Shannon (2007) did not find significant relations between the dimensions of self-regulation (i.e., self-regulation and cognitive strategy use) and fifth grade mathematics achievement. As seen in these studies, some learning strategies such as metacognitive self-regulation and organization consistently influence student achievement but no generalizations can be made for other strategies.

Purpose of Study

The Trends in Mathematics and Science Study (TIMSS) tests representative samples of students from countries and gives information about countries' ranking in mathematics and science. Turkish students' scores are consistently below international average in TIMSS assessments (Martin, Mullis, Foy, & Stanco, 2012; Martin et al., 2008). In order to reveal the underlying factors of this phenomenon researchers investigated Turkish students' TIMSS achievement (Altun, 2007; Ceylan & Berberoğlu, 2007;

Journal of Baltic Science Education, Vol. 12, No. 4, 2013

ISSN 1648–3898   ASSESSING THE RELATIONSHIP BETWEEN LEARNING STRATEGIES AND SCIENCE
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Yayan & Berberoğlu, 2004). Accordingly, students' attitudes toward and perception of the subject are important predictors of their achievement. The influence of attitudinal and motivational beliefs on students' science achievement in the international tests has been frequently studied (e.g. Hammouri, 2004; Kaya & Rice, 2010; Yan & Leung, 2011). Another large scale international project, the Relevance of Science Education (ROSE) measured students' emotional and attitudinal beliefs about science and technology. However, this project was not focused on conceptual understanding of science (Schreiner & Sjoberg, 2004). The current study focused on science achievement of primary students in relation to learning strategies. Therefore, using TIMSS items was more appropriate.

To what extent using different learning strategies will influence science achievement at the primary level is the main concern of this study. Learning strategies are considered as central aspects of the control and regulation of students' cognition (Pintrich, 2004). Students' use of self-regulated learning strategies namely, cognitive, metacognitive and resource management skills in relation to their science achievement was examined. In the actual TIMSS assessment, student questionnaire did not include items regarding learning strategies. Therefore, the actual TIMSS data could not be used. Instead, students' science achievement was measured using a sample TIMSS test and their learning strategy use was measured by MSLQ. The findings of this study may shed some light on ways to improve students' success in future TIMSS assessments.

Methodology of Research

This study used a descriptive correlation method in order to examine the relationships between learning strategies used by primary students and their science achievement.

Participants

The participants of this study were 574 4th grade primary school students between ages 10-11, from four different schools in a northwestern province of Turkey selected based on convenience sampling method. The data were collected from 16 different classrooms (4 from each school) in these four schools. On average, there were 30 students in each classroom; 52% percent of the students were male and 48% were female.

The teachers of the participating students were all female with the bachelor's degree of primary teaching and had an average teaching experience of 15 years. The study was conducted at the end of the 2011-2012 school year. None of the schools in the current study had participated in a TIMSS administration before. All the participating schools were using the national science curriculum and the same Science textbook for fourth grade at the time of study. The science curriculum in Turkey, which took effect in 2005, focused on a constructivist student-centered instruction; however, traditional teaching methods such as lecture and questioning are still prominent in primary classrooms.

Research Instruments

Science Achievement Test

The current study used the Trends in Mathematics and Science Study (TIMSS) 4th grade questions in order to measure primary students' science achievement. The TIMSS, sponsored by the International Association for the Evaluation of the Education Achievement (IEA), measures the mathematics and science achievement of nationally representative samples of students and collects background information from students, their teachers and schools on a four-year cycle (Martin et al., 2008). The TIMSS questions were preferred because these questions are developed by a panel of experts and they measure various important skills, such as the ability to recall, describe, classify, compare, contrast, use models, interpret, analyze, synthesize, draw conclusions, hypothesize, and generalize (Martin et al., 2008).

In the current study, there were 30 questions in the science achievement test of which, three were worth 2 points while 27 were worth 1 point. Therefore, the highest possible score was 33. The test is

composed of three cognitive domains: knowing, applying, reasoning; and three content domains: life, physical and earth science. The test duration was 45 minutes.

Motivated Strategies for Learning Questionnaire (Modified)

In order to measure students' motivational orientation and use of learning strategies, Pintrich and colleagues (Pintrich et al., 1991) developed an 81-item self-reporting questionnaire that is composed of two major sections: Motivation and Learning Strategies. The Motivation section includes three scales: valuing, expectancy, and affect. The Learning Strategies section is further divided into a Cognitive-Metacognitive section, which includes rehearsal, elaboration, organization, critical thinking, and metacognitive self-regulation, and a Resource Management section, which includes managing time and study environment, effort regulation, peer learning, and help seeking. Students respond to statements using 7-point ratings that range from *not at all true of me* to *very true of me*. Pintrich and colleagues (1993) stated that the scales in the MSLQ can be used together or separately depending on the researchers' interest. For the purpose of this study, the Learning Strategies section, which consists of 50 items, was used with the primary school population. The motivation section of the MSLQ instrument was not included in this study.

The Turkish adaptation of the original questionnaire was carried out by Altun (2005) and it provided guidance for the current adaptation. Milner (Milner, Templin, & Czerniak, 2011) modified the original MSLQ in that the items were scored according to a 4-point Likert-like format with 1 being 'never' and 4 being 'always'. These changes were made so that the instrument became more appropriate for 10-11 year-olds of age since the original instrument was developed for college students (Milner et al., 2011). Silva and colleagues (2005) indicate that the four-point rating format forces the clear ratings above or below the midpoint since it is an even number. It took participants 20-25 minutes to complete the questionnaire.

Validity and Reliability

Science Achievement Test

While developing the science achievement test, among 67 released TIMSS 2007 items, 30 of them were selected by two curriculum professionals and included in the science assessment. The number of questions in the tests, the numbers from each content and cognitive domain and the numbers from each question format were kept parallel with the original assessment framework. In the original assessment, there were 14 booklets of 27-30 science questions at the 4th grade level and there were approximately equal numbers of multiple choice and constructed response items (Ruddock et al., 2008). In the current study, the science test included 30 questions, 16 of which were multiple choice and 14 were constructed-response items.

All of the constructed-response items for all participants were scored by each researcher independently by using the TIMSS scoring guide. Inter-rater reliability coefficient was 0.90. Disagreements in scoring were resolved through discussion. Depending on the task the students were asked to complete, the constructed-response items were worth 1 or 2 points. These items were worth 1 point when students were asked for a brief descriptive response in science and they were worth 2 points when students were required to show their work or provide explanations (Ruddock et al., 2008).

Motivated Strategies for Learning Questionnaire (Modified)

To measure students' use of learning strategies the second part of the MSLQ was used. This instrument was modified by Milner (see Milner et al., 2011) to fit students of 10-11 years of age. The modified version was translated into Turkish by a group of three specialists. Altun (2005) who adapted the original MSLQ into Turkish provided feedback for the modified version. Confirmatory Factor Analysis (CFA) was conducted using LISREL 8.7 to test the factor structure of the modified version. There are 50 items in the learning strategies section that are clustered under 9 scales. Goodness of fit indexes for CFA were

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examined for model fit. Among these indexes, χ2/df (Chi-Square/Degrees of Freedom), CFI (Comparative Fit Index), NNFI (Non-Normed Fit Index), RMR (Root Mean Square Residual), RMSEA (Root Mean Square Error of Approximation) values were used.

The goodness of fit indexes for the final model were $\chi^2/df= 1.70$ (p<0.001), CFI= 0.98, NNFI=0.97, RMR=0.044, RMSEA=0.037. While examining the CFA goodness of fit indexes, χ^2/df value below 2 (Tabachnick & Fidell, 2001), CFI and NNFI values above 0.95 (Hu & Bentler, 1999), RMR and RMSEA values below 0.05 (Brown, 2006) indicate a perfect fit. Therefore, the 50-item Learning Strategies Questionnaire was considered appropriate for 10-11 year-old school population in Turkey. In the original questionnaire, Pintrich and colleagues reported the Cronbach Alpha reliability coefficients between 0.52 and 0.80 (Pintrich et al., 1991). The current study found the reliability coefficients between 0.53 and 0.75.

Data Analysis

Data Analysis

Data analyses were conducted using the SPSS 15 statistical program. To examine the relationships between the Learning Strategies and the TIMSS science achievement, bivariate correlation analysis and multiple regression analysis were conducted.

Results of Research

Descriptive statistics results show that the average score on the TIMSS science test was 19.41 (SD=5.48) out of 33 points which corresponds to 59%. The minimum score was 5 and the maximum score was 30. As seen in Table 1, there were significant positive correlations between the TIMSS science score and the Cognitive and Metacognitive Strategies scales (rehearsal r=0.24, p<0.001; elaboration r=0.22, p<0.001; organization r=0.16, p<0.001; critical thinking r=0.29, p<0.001; metacognitive self-regulation r=0.31, p<0.001). Among the Resource Management Strategies, management of time and study environment (r=0.29, p<0.001) and effort regulation (r=0.31, p<0.001) were significantly correlated with the TIMSS science score whereas, there were no correlations between peer learning and help seeking and science achievement.

Table 1.   Correlations Between the Learning Strategies Scales and Science Scores.

		r with Science Scores	p	r with Semester Grade (Pintrich et. Al., 1993)
Cognitive and Metacognitive Strategies	Rehearsal	0.24	<0.001	0.05
	Elaboration	0.22	< 0.001	0.22*
	Organization	0.16	< 0.001	0.17*
	Critical Thinking	0.29	< 0.001	0.15*
	Metacognitive Self-Regulation	0.31	< 0.001	0.30*
Resource Management Strategies	Time and Study Environment	0.23	< 0.001	0.28*
	Effort Regulation	0.31	< 0.001	0.32*
	Peer Learning	0.06	0.177	-0.06
	Help Seeking	0.03	0.516	0.02

To examine the effects of self-regulated learning strategies on the TIMSS science achievement, multiple regression analysis was conducted. Table 2 shows the multiple regression results of the TIMSS science scores predicted by the self-regulated learning strategies. The scales that did not show significant correlations with the TIMSS science achievement (peer learning and help seeking) were not included in the regression analysis.

Table 2.   Multiple Regression Results of the Science Scores Predicted by the Learning Strategies.

	B	Std Error B	β	t	p
Constant	3.861	1.807		2.136	0.033
Rehearsal	0.122	0.135	0.050	0.907	0.365
Elaboration	-0.143	0.110	-0.083	-1.305	0.192
Organization	-0.157	0.124	-0.066	-1.262	0.207
Critical Thinking	0.315	0.121	0.149	2.602	0.010
Metacognitive Self-Regulation	0.184	0.078	0.166	2.354	0.019
Time and Study Environment	-0.010	0.080	-0.007	-0.120	0.905
Effort Regulation	0.482	0.146	0.178	3.300	0.001

$R=0.362,\ R2=0.131,\ F=12.216,\ p<0.001$

Analysis results show that, among the Cognitive and Metacognitive Strategies there are significant positive effects of critical thinking (t=2.602; p<0.05) and metacognitive self-regulation (t=2.354; p<0.05) on the TIMSS science achievement. On the other hand, rehearsal (t=0.907; p>0.05), elaboration (t=-1.305; p>0.05) and organization (t=-1.262; p>0.05) strategies had no significant influence on the science achievement. For the Resource Management Strategies, only the effort regulation significantly predicted the TIMSS science achievement (t=3.30, p<0.05).

When standardized (β) values were examined, it is seen that the order of the predictive validity of the scales were the effort regulation (β = 0.18) followed by metacognitive self-regulation (β=0.17) and critical thinking (β=0.15) respectively. The model explained approximately 13% of the variance in science scores.

Discussion

The purpose of this study was to investigate the contribution of self-regulated learning strategies to primary students' science achievement. The decriptive analysis of science achievement test which was based on TIMSS items showed that the average score was about 59%. This score is somewhat low but so was the achievement of Turkish fourth graders in 2011 TIMSS assessment. In 2011, Turkey participated in TIMSS at the fourth grade level for the first time and became 36th among 50 countries with an average score of 463, 37 points below the international average. According to TIMSS 2011 teacher reports, Turkish teachers reported that 75% of their students received instruction on all of the topics that are assessed by the TIMSS. This ratio was above the international average (Martin et al., 2012) which indicates that the science curriculum in Turkey is compatible with the TIMSS content. However, this standing is not reflected into achievement.

The findings revealed that there are relationships between some of the learning strategies used by primary students and their science achievement. Bivariate correlation analysis results showed that among the nine strategies that were investigated, seven of them were significantly associated with the science achievement. The findings were similar to those of Pintrich and colleagues (1993) with the original MSLQ. They found the highest correlations between the college semester grade and effort regulation, followed by metacognitive self-regulation. In the current study too, the highest correlations were between the TIMSS science achievement and these two aforementioned scales. Different from the original study, the current study found significant correlation between the rehearsal strategies and the TIMSS science scores. There were no correlations between peer learning and help seeking and achievement.

Not finding any relations between peer learning and science achievement might be surprising since it is considered a promising teaching strategy in primary schools (Rohrbeck, Ginsburg-Block, Fantuzzo,

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& Miller, 2003). Rohrbeck and colleagues (2003) reported in their meta analysis study that younger primary students (grades 1-3) benefit from peer learning more than older students (grades 4-6) with respect to achievement. Another factor is the competitive nature of Turkish education system. Although a constructivist science program took effect in 2005 in Turkey, many teachers still prefer teacher-centered methods and they teach to the test (Berberoglu, 2010).

In order to investigate the predictive validity of the seven variables that showed significant correlations with the science achievement, multiple regression analysis was conducted. Among the seven variables, critical thinking, metacognitive self-regulation and effort regulation significantly contributed to the science achievement. On the other hand, rehearsal, elaboration, organization and the management of time and study environment did not predict the science achievement.

Among the strategies that significantly affected the science achievement, effort regulation had the highest predictive validity. Pintrich and colleagues (1991) highlight the importance of effort regulation for academic achievement since it indicates the goal commitment and regulates the learning strategy use. Students who are good at effort regulation are able to control their effort despite distractions in the environment and uninteresting tasks. Wolters (1999) indicated that supporting students' motivational regulation is crucial in their persistence and effort in completing a task. In a recent study, Schwinger and colleagues (2009) found positive effects of motivational regulation strategies on students' effort regulation.

Some strategies are recommended by research in terms of supporting students' efforts to complete a task. For instance, reducing distractions in the environment (Purdie & Hattie, 1996), and manipulating the task to make it more challenging and interesting (Sansone et al., 1999) tend to boost students' desire to complete a task. Therefore, classroom practices and environment in science classrooms can be reorganized to foster motivation and effort. Research suggests that when students are encouraged to utilize inquiry process skills when solving problems they are more likely to regulate their effort in science learning (Velayutham & Aldridge, 2013). In addition, teachers need to highlight to students the goals and importance of each activity in order to help them to put in greater effort towards completing a learning task (Schunk & Zimmerman 2007; Velayutham & Aldridge, 2013)

The second influential learning strategy on primary science achievement was metacognitive self-regulation. Research indicates that there is usually less instruction of learning strategies in primary school level, therefore primary students, especially in their early years, lack metacognitive knowledge (Perry et al., 2004). However, even very young students can develop metacognitive skills when training is provided (Dignath et al., 2008). For instance, at the primary school level, Desoete and colleagues (2003) found the positive effects of metacognitive training in which students received explicit training on prediction, procedural calculation, and mental representation. These students made significant gains in metacognitive skills as well as cognitive problem-solving skills. Dignath and colleagues (2008) emphasize that students need to be provided with knowledge about strategy application and its benefits as well as the instruction of metacognitive strategies itself. Fuchs and colleagues (2003) reported positive effects of a 16-week metacognitive learning strategies instruction on third graders' problem solving skills. Similar findings were reported for fifth graders' reading comprehension (Mason, 2004). In terms of science learning, primary students can be recommended to use metacognitive strategies such as planning a science activity, predicting the outcomes of an activity or experiment, asking themselves questions whether they understood the problem or the main idea and evaluating their understanding and performance. It seems that the effects of self-regulated learning strategies training on primary students' science achievement is an area for new research, since this subject was investigated less frequently compared to the others.

Another significant predictor of the science achievement in this study was critical thinking. This might be due to the nature of TIMSS items. Especially for application and reasoning items, students are expected to use important critical thinking skills such as analyzing, synthesizing, drawing conclusions, generalizing and evaluating (Martin et al., 2008). Students who are better in critical thinking are likely to succeed in TIMSS assessments. Hence, teachers might focus on evaluating and fostering students' critical thinking skills. Kuhn (1999) argues that for improved critical thinking skills development of metacognitive understanding is necessary "because critical thinking by definition involves reflecting

on what is known and how that knowledge is justified" (p. 23). Therefore, supporting students' meta-cognitive skills might not only influence science achievement directly, but also contribute to success by means of critical thinking.

Using science inquiry might be an effective way of improving critical and scientific thinking in primary students (Burns, 2009). Science inquiry involves conducting activities with students in which they construct scientific ideas and understand how scientists study (National Research Council, 1996). Teachers are encouraged to engage students in meaningful activities, let them manipulate materials, and provide opportunities to investigate, experiment, and problem solve for effective science inquiry instruction (National Research Council, 1996). For example, Milner and colleagues (2011) investigated the influence of an inquiry-based life science laboratory and a traditional science classroom on primary students' motivation and learning strategy use. In science laboratories students collaboratively ask questions, make decisions, design, plan, create, present and defend products. Student motivation and learning strategy use were higher in the life science classroom than in the regular classroom. Yet, the authors did not investigate the learning strategy use and achievement relationship.

Conclusions

As the current study and other studies show, learning strategies are related to student success. Therefore, providing students with knowledge and skills about how to utilize these strategies is a crucial issue for educators. As Pintrich (2004) highlights, learning strategies have critical roles in controlling cognition and learning. Specific to this study, teachers might consider focusing on students' effort regulation, metacognitive and critical thinking strategy use for increased science achievement. However, other strategies cannot possibly be ignored. The findings of this study are limited to the characteristics of the sample and the achievement test. Cultural and test related factors might have influenced the results. This study relied on self-reported data while measuring learning strategy use. Future research might focus on evaluating the strategy use by means of multimethod analyses, both quantitatively and qualitatively.

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