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# The effect of self-regulated learning on sixth-grade Turkish students' mathematics achievements and motivational beliefs

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**Abstract:** This study examined the effect of self-regulated learning on sixth-grade Turkish students' mathematics achievements and motivational beliefs. Both quantitative and qualitative research methods were used in the study. Participants included sixth-grade students attending at TOKİ 125. Year Middle School in Nevşehir (Turkey) during the 2014–2015 academic year. Two classes of the school were randomly appointed as experimental group (6B, 22 students) and control group (6C, 23 students), respectively. The experimental process went on for 12 weeks. Instructional activities developed according to Zimmerman's cyclical model, one of the self-regulated learning models, were applied with experimental group students, meanwhile regular curriculum of MEB (Ministry of National Education) was delivered to control group students. The sub-dimensions of self-efficacy and goal orientations were included in the research under motivational beliefs aspect, which is one of the most essential aspects of self-regulated learning. The quantitative findings indicated a significant difference in favor of experimental group with regard to mathematics achievements and motivational beliefs. The qualitative data obtained through interviews and document analysis during and after the experimental process further revealed that students started to see math as fun, like it more, grasp the importance of it in everyday life, build more self-confidence, set specific targets for themselves, and monitor their learning process.

## ABOUT THE AUTHORS

Hülya Yıldızlı graduated from Elementary School Mathematics Teaching Department of Selçuk University in 2008. She pursued her MA in curriculum and instruction from Selçuk University in 2008–2011 and received her PhD in curriculum and instruction from Necmettin Erbakan University in 2012–2015. Meanwhile, she worked as a math teacher in elementary schools under the Ministry of National Education. Currently, she is an associate professor at Nevşehir Hacı Bektaş Veli University.

Ahmet Saban graduated from Ankara University in 1988. He went to the United States to do his graduate studies. In 1993 and 1997, he got his master's and PhD degrees, respectively, from Ohio University in the area of curriculum and instruction. In 1998, he was appointed as an assistant professor at Selcuk University. In 2009, he was appointed as a professor in the department of primary education at Selcuk University, and since 2012, he has been working in Necmettin Erbakan University.

## PUBLIC INTEREST STATEMENT

It is emphasized that greater changes occur in development of self-regulated learning skills, particularly in the aspects of academic achievement and motivation toward this subject among students at early stages of elementary school, and that the greatest influence of self-regulated learning activities in special academic learning areas, such as mathematics, is apparent on especially primary and elementary school students. In this regard, there is a need for comprehensive applied research with elementary school students on self-regulated learning process that largely affect learning process. This research is important in that it offers insights for teachers into how self-regulated learning settings are supposed to be and how to improve self-regulated learning skills. Especially, because the study touches on motivational situations, a dimension of self-regulated learning, it enlightens on how to render students' self-efficacy and goal orientations rather positive.

**Subjects: Assessment & Testing; Behavioral Management; Classroom Management & Organization; Classroom Practice; Continuing Professional Development; Mathematics; Middle School Education; Primary/Elementary Education; Teaching & Learning**

**Keywords: self-regulated learning; math education; mixed methods research; sixth-grade students; math achievement**

## 1. Introduction

### *1.1. Math education*

Mathematics plays a great role in assisting individuals in the development of thinking, reasoning, and problem-solving skills, and its significance within education systems gradually increases. In this regard, the questions such as "How math should be taught?", "How to make students like math?", "How to engage every student in learning math?", or "How to increase student achievement in math?" have attracted attention of many researchers worldwide. Yet, as far as math achievement is concerned, Turkey is not at the desired level in both national and international exams. At the national level, TEOG (Transition from Elementary to Secondary Education Exam) is conducted following elementary education and YGS (Transition to Higher Education Exam) is conducted following secondary education in Turkey. Besides YGS, high school graduates also need to take the nationwide Undergraduate Placement Exam called LYS. According to TEOG-2015 results, Turkey's average is 7.6 correct answers out of 20 math questions (38%). In terms of YGS-2015 results, Turkey's average is 5.2 correct answers out of 40 math questions (13%). With regard to LYS-2015 results, Turkey's average is 9.72 correct answers out of 50 math questions (19.44%) and 3.78 correct answers out of 30 geometry questions (12.6%). At the international level, TIMMS-2011 (Trends in International Mathematics and Science Study) results indicate that Turkey ranked 35th among 50 countries in grade four and 24th among 42 countries in grade eight. Again, PISA-2012 (Programme for International Student Assessment) results show that Turkey ranked 44th among 65 countries. It appears that the Turkish education system tends to train a very small number of students well in math while rendering the majority of them unsuccessful (Aydın, Sarıer, & Uysal, 2012). It is also argued that mathematics education in Turkey fails in making connections between the mathematical knowledge and skills introduced at school and daily life (Altun, 2006).

According to Turkish Ministry of National Education (Milli Eğitim Bakanlığı [MEB], 2009), basic skills targeted in math curriculum are problem-solving skills, mathematical process skills, affective skills, psycho-motor skills, and instructional technologies and communication skills. It is striking to recognize that self-regulation skills are listed under affective skills and that the significance of self-regulation is not adequately reflected on math curriculum. Furthermore, elementary students in Turkey suffer from the TEOG anxiety, and it is observed that they solely focus on passing that exam, hence perceiving mathematics as only rote-worthy subject (Baki, 2006). Through the exams of TEOG, YGS, and LYS, all Turkish students find themselves in an examination marathon which prompts a tremendous anxiety in them toward math and decreases their genuine interest in this subject. Studies conducted on elementary school children in Turkey have all shown that as students' grades increase, their levels of math anxiety also increase (Bozkurt, 2012); i.e. math is perceived as a fearsome, agonizing, and difficult subject (Polat, 2010). In this regard, there is a need for comprehensive experimental research in Turkey on the use of self-regulated learning to assess its impact on students.

### *1.2. Self-regulated learning*

Many cognitive, metacognitive, and motivational factors may affect an individual's success in mathematics. An in-depth analysis of these factors draws attention to the concept of self-regulation. Bandura (1986) defines self-regulation as an individual's control over his/her emotions, thoughts, and behaviors during learning. For Pintrich (2000), self-regulation means an efficient and constructive process where students set their own learning goals and try to regulate their cognition, motivation, and behaviors. According to Goetz, Nett, and Hall (2013), self-regulated learning is composed of three main elements, namely *self*, *regulation*, and *learning*. *Self* means an individual's personal attempts to set and accomplish personal goals, *regulation* means processes where the individual compares the current target status with his/her main target status and motivate oneself so as to reduce the perceived controversy in between them, and *learning* means deliberate activities initiated by the individual toward acquiring knowledge and skills.

There are many models of self-regulated learning in the literature. Among them, Zimmerman's (2002) model of self-regulated learning which is based on the *Social-Cognitive Learning Theory* appears to be more widely used, and thus, also applied in the present study. This model consists of three main phases, namely *forethought*, *performance*, and *self-reflection*. In the *forethought* phase, the individual determines objectives and makes relevant plans. The individual also checks his/her faith in whether he/she may or may not be able to accomplish the task, questions why he/she wishes to do so, and identifies expectations on the outcome of the task. During the *performance* phase, the individual executes strategies on the desired task and monitors the learning process. In the *self-reflection* phase, the individual assesses learning outputs or performances and regulates behaviors accordingly. In the self-regulated learning process, various strategies, grouped in several manners, are employed. According to Pintrich (1999), individuals apply three types of strategies in the self-regulation of learning. *Cognitive strategies* include repetition, meaning, and organizational strategies on academic performance in the classroom. *Metacognitive strategies* are divided into three, namely planning, monitoring, and regulation. Planning is when the individual decides on what to do toward his/her objectives, monitoring is when the individual decides whether the strategies are effective or not, and regulation is when the individual determines whether the goals are achieved and re-regulates strategies according to the outcomes by comparing necessary standards with the results. *Resource management strategies* are those that have to do with student's control and management of his/her learning environment (e.g. controlling and managing time and efforts). Zimmerman's (2002) model of self-regulated learning strategies is assessed in 14 aspects. Zimmerman and Martinez-Pons (1990) state that of the self-regulated learning strategies, the organization, transformation, repetition, rote learning, goal setting, and planning strategies focus on optimizing personal self-regulation; self-assessment and self-finalization on developing behavioral functionality; and information gathering, recording and monitoring, environment structuring, social support seeking, and review of records strategies focus on consummating the environment. While teaching of self-regulated learning strategies, it is found that direct or indirect teaching approaches are adopted (Kistner et al., 2010). In case of direct approaches, the teacher delivers information on the strategies, creates awareness and enables practice of the theoretical knowledge. In case of indirect ones, the teacher incorporates effective use of the strategies into the learning process without offering any information on the strategies at all.

### 1.3. Math education and self-regulated learning-motivational beliefs

An attempt to integrate activities aimed at developing self-regulated learning with mathematics curriculum and to enhance students' self-regulated learning knowledge and skills by means of gains of mathematics is evident. Self-regulated learners actively utilize processes such as making analysis on self or teacher-identified tasks (problem-solving, explaining known and unknown data and the relations between such data, recalling former knowledge on the problem), solving the problem (planning, selection, implementation and assessment of strategies, checking results, abandoning defunct plans and strategies), and performance assessment (Marchis, 2011). These problem-solving skills in parallel with cognitive and meta-cognitive skills in the process of self-regulation are thought to be the most crucial skills in math teaching.

Self-regulated learning is not only the regulation of the individual learning process at cognitive and meta-cognitive levels, but also is the regulation of it at the motivation-wise basis. Motivational beliefs are among the most critical factors affecting academic achievement because they impact an individual's dedication on the task and persistence on accomplishing it (Wolters & Rosenthal, 2000). Since the number of challenges faced in math is great, students are required to resist without giving up, consider one capable of attaining targets, value the targeted task, and focus on learning throughout the process for success. These beliefs tend to affect the self-regulation process they interact with behavioral and environmental factors (Pintrich, Marx, & Boyle, 1993). This research focuses on the notions of self-efficacy and goal orientation motivational beliefs that are greatly related to academic achievement.

According to social-cognitive theoreticians, self-assessment of the individual on whether success will be attained or not makes a strong impact on one's motivation and behaviors (Bandura, 1986). Self-efficacy, that has considerable impact on motivation and behavior, is a significant motivational belief for self-regulated learning. Bandura (1986) describes the self-efficacy concept as the individual's own judgment over their capacity to organize and execute necessary activities required to deliver certain performance. Self-efficacy is one's belief about self as to how to overcome challenges and to act upon the situation by comparing own capacity with the required performance. For instance, students with low self-efficacy tend to underestimate their own achievements or potential, fail at properly determining goals, at selecting or regulating appropriate settings enabling learning, at controlling emotions during learning and at making systematic self-assessment (Zimmerman & Schunk, 2004). Self-sufficiency belief is associated with achievement in math and individuals with greater self-efficacy are observed to be more successful in mathematics (Chen & Zimmerman, 2007; Marsh, Roche, Pajares, & Miller, 1997; Pajares & Graham, 1999; Ramdass & Zimmerman, 2008). Pajares and Kranzler (1995) underline that when it comes to solving math problems, self-efficacy belief is as effective as cognitive skills. Students with higher self-sufficiency are observed to make greater efforts in learning math and solving math problems, resist against challenges, and spare more time to complete their tasks.

Another motivational factor interacting with individuals' self-efficacy beliefs and affecting their achievements in a subject is goal orientation. Goal orientation is divided into two, namely learning and performance goal orientations, which are also classified as approach and avoidance goal orientations (Pintrich, 2000). While students with learning goal orientation focus on gaining new skills, making an effort to comprehend the task at hand, and increasing their skill levels, those with performance goal orientation concentrate on demonstrating their efforts to others, avoiding punishment, and getting a positive feedback from others. The literature review indicates that students with learning goal orientation attain greater academic achievement in mathematics than those with performance goal orientation (Keys, Conley, Duncan, & Domina, 2012; Niepel, Brunner, & Preckel, 2014). Research on self-regulated learning suggest that use of cognitive strategies and motivational beliefs of students has a meaningful influence on achievement in math, that students efficiently employing cognitive strategies and with high self-belief they are capable of doing math demonstrated greater academic success on math (Üredi & Üredi, 2005). The level of self-efficacy perception of the students also affect their achievement in math (Usta, 2014). It is observed that problem-solving skills, one of the prominent skills needed, have a significant and high correlation with effective use of self-regulation strategies and self-efficacy in math (Çelik, 2012). Moreover, students with firm learning targets both attain greater academic success and control self-regulation process with greater precision (van der Veen & Peetsma, 2009). Literature review also shows experimental studies suggesting that self-regulated learning activities enhance academic achievement, attitude, and self-efficacy in mathematics (Montague, 2007; Perels, Dignath, & Schmitz, 2009; Stoeger & Ziegler, 2008).

### *1.4. Purpose of the study*
This study aimed at examining the effect of self-regulated learning activities in math on sixth-grade students' academic achievements, self-efficacy perceptions, and motivational beliefs in the Turkish context. The following sub-problems were set forth in the scope of the present study:

(1) Is there a significant relationship between the attainment scores of experimental and control groups in math?
(2) Is there a significant relationship between self-efficacy posttest scores of experimental and control groups in math?
(3) Is there a significant relationship between goal orientation posttest scores of experimental and control groups in math?
(4) What are the views of students during and after the experimental process?

## 2. Method

### *2.1. Research Model*

This study is designed in the mixed method research methodology (Tashakkori & Creswell, 2007), combining both quantitative and qualitative research approaches in collecting and analyzing the study data. The quantitative approach (i.e. the experimental design) was used as a basis in this study and the qualitative approach was used to substantiate the findings of the quantitative approach. Table 1 symbolizes the experimental process of the study consisting of one experimental group and one control group. Pretests on academic achievements, self-efficacy perceptions, and goal orientations in math were conducted on both experimental and control groups. Students in the experimental group engaged in the learning activities based on Zimmerman's (2002) cyclical model of self-regulated learning, whereas students in the control group followed the current MEB curriculum without any alterations. The experimental process lasted for 12 weeks (5 lessons weekly), and the first researcher delivered teaching in both groups. Afterwards, posttests on academic achievements, self-efficacy perceptions, and goal orientations in math were conducted on both groups. In the qualitative aspect of the study, interviews and document analysis were used as data collection tools. During the experimental process, learning and homework dairies written by the experimental group of students were constantly collected and assessed by providing feedback. After the experimental process was over, students' views on it were collected by means of interviews. A semi-structured interview form was used to elicit information as to the self-regulated learning process students engaged during application phase and to what sorts of skills have been developed toward mathematics, and paired students' views on the process and their participation were collected at the end of the implementation phase via the interview form. Having students keep learning and assignment logs, they were required to keep notes on both the information they acquired on the subject content cognitively and on emotional and motivational states with regard to their learning process as well as to constantly ponder and reflect upon learning behaviors via notes on their learning behaviors.

### *2.2. Participants*

The study group is comprised of sixth-grade students at TOKİ 125. Year Secondary School in Nevşehir Province during the academic year of 2014–2015. Dependent variables and related tests were initially carried out at various secondary schools located in Nevşehir province and it was found that few groups were equal and that two of the equal groups were detected in the same school, therefore it was decided to conduct the study there. Among the two groups, experimental and control groups were impartially assigned. As a result of impartial assignment, class 6/B was determined as the experiment group and class 6/C as the control group, respectively. Twenty-two (10 female, 12 male) students participated in the experimental group and 23 (9 female, 14 male) in control group.

**Table 1. Experimental design of the study**

| Topics | Groups | Pretests | | | Experimental Process | Posttests | | |
|---|---|---|---|---|---|---|---|---|
| Integers (4 weeks) | Experimental | MAT1 | MSS1 | MGOS1 | Self-regulated learning | MAT2 | MSS2 | MGOS2 |
| | Control | MAT1 | MSS1 | | MEB curriculum | MAT2 | MSS2 | |
| Algebraic exp. (4 weeks) | Experimental | MAT1 | MSS1 | | Self-regulated learning | MAT2 | MSS2 | |
| | Control | MAT1 | MSS1 | | MEB curriculum | MAT2 | MSS2 | |
| Area (4 weeks) | Experimental | MAT1 | MSS1 | | Self-regulated learning | MAT2 | MSS2 | |
| | Control | MAT1 | MSS1 | | MEB curriculum | MAT2 | MSS2 | |

Notes: MAT: Integers, algebraic expressions, and area mathematics achievement tests. MSS: Integers, algebraic expressions, and area mathematics self-efficacy scales. MGOS: Mathematics goal orientations scale. 1: Pretest. 2: Posttest.

The reasons why the research is conducted on sixth-grade students are as follows:

- In Milli Eğitim Bakanlığı [MEB]'s (2009) mathematics curriculum, four learning areas (numbers, geometry, data, measurement) of primary school that are organized based on content spiral approach and basic concepts (numbers, geometry, probability statistics, measurement, algebra) of the elementary school are introduced at every grade and the depth of knowledge, understanding, and skills were gradually increased and scope widened in upper grades (Ersoy, 2006). Therefore, considering the fact that former learning affects subsequent learning, lacking, or wrong learning experiences obscure following ones and pre-learning is a significant factor in terms of employing cognitive and meta-cognitive strategies (Pintrich & de Groot, 1990); learning deficiencies of whole numbers, algebraic expressions, and area subjects that have not yet deepened are still correctable at grade six.
- The fact that Seidel and Shavelson (2007) underlined that the greatest impacts of self-regulated learning activities carried out in special academic learning areas such as mathematics are particularly evident on primary and elementary school students and that Dignath and Büttner (2008) emphasized that self-regulated learning strategies are much more effective on primary and secondary school students;
- A review of researches on secondary school students in Turkey (i.e. Ayan, 2014; Bozkurt, 2012; Keklikçi, 2011; Kinay, 2011) indicates that students' attitude toward mathematics decreases as grades go up, and their level of fear and anxiety increases, and considering the effect of these motivational factors on mathematics subject for the duration of the research are reasons why the research is conducted on sixth-grade students at secondary school.

### *2.3. Data collection tools*
Five data collection tools were used in the study: (1) mathematics achievement tests, (2) mathematics self-efficacy scales, (3) mathematics goal orientation scale, (4) semi-structured interviews, and (5) learning and homework diaries.

#### *2.3.1. Mathematics achievement tests*
Separate mathematics achievement tests for the subjects of integers, algebraic expressions, and area were developed because of the large number of attainments in the current MEB curriculum and due to the need for a corresponding test item as per an attainment. In drafting the test items, questions in students' workbooks and other resources were analyzed and those matching with an attainment were adopted. In the preparation of the questions, two experts in the field and three math teachers were also consulted. All the mathematics achievement tests were piloted with sixth and seventh graders attending at different elementary schools in Nevşehir province. The final *Integers Academic Achievement Test* was composed of 36 items in compliance with integers-related math attainments. The difficulty mean of the test was .43, and KR-20 reliability value was .95. The final *Algebraic Expressions Achievement Test* was composed of 34 items in compliance with algebraic expressions-related math attainments. The difficulty mean of the test was .46, and KR-20 reliability value was .92. The final *Area Achievement Test* was composed of 35 items in compliance with area-related math attainments. The difficulty mean of the test was .47, and KR-20 reliability value was .95.

#### *2.3.2. Mathematics self-efficacy scales*
*Mathematics Self-Efficacy Scales* were developed in parallel with the achievement tests on the subjects of integers, algebraic expressions and area in order to determine students' self-efficacy perceptions on these subjects. These scales were used in evaluating how sufficient students perceived themselves before and after answering the questions of the achievement tests. The literature review also indicates an abundant usage of self-efficacy scales in parallel with the achievement tests (e.g. Chen & Zimmerman, 2007). In the present study, 5-item Likert-type (1 = not confident at all, 2 = slightly confident, 3 = mildly confident, 4 = quite confident, 5 = totally confident) *Mathematics Self-Efficacy Scales* were prepared using the questions on math achievement tests. Students' self-efficacy

perceptions toward the questions were measured before they answered the questions on a given math achievement test. Pilot studies of the scales were conducted in parallel with the pilot studies of the corresponding achievement tests. Cronbach's alpha coefficients on self-efficacy scales on integers, algebraic expressions, and area were calculated to be .95, .94, and .95, respectively.

#### *2.3.3. Mathematics goal orientation scale*

To identify students' goal orientations toward math, the *Goal Orientation Scale* was used. This scale was developed by Elliot and McGregor (2001) in a 2 × 2-factor framework and translated into Turkish by Şenler and Sungur (2007). The scale contains a total of 15 items about the sub-factors of *learning approach* (3 items), *learning avoidance* (6 items), *performance approach* (3 items), and *performance avoidance* (3 items) in 5-item Likert-type. Examples of substances from the scale: Mastery approach: *I want to learn as much as possible from this math class.* Performance approach: *My goal in this math class is to get a better grade than most of the other students*. Mastery avoidance: *I worry that I may not learn all that I possibly could in this math class*. Performance avoidance: *My goal in this math class is to avoid performing poorly*. Literature review shows that the goal orientation scale is used in other classes as well. For instance, Yerdelen, Aydın, Gürbüzoğlu-Yalmancı, and Göksu (2014) used the goal orientation scale in biology class, while Pamuk (2014) used it in science class in scope of a study on middle school students. In the present study, the scale was piloted on 149 sixth- and seventh-grade students. The reliability coefficient (Cronbach's alpha) values were calculated to be .68 for the *learning approach* goal orientation, .65 for the *performance approach* goal orientation, .66 for the *performance avoidance* goal orientation, .75 for the *learning avoidance* goal orientation, and .78 for the entire scale.

#### *2.3.4. Learning and homework diaries*

The students were asked to keep learning dairies, thus urging them to take notes on both the contents of the subjects cognitively, and on emotional and motivations states of their learning process, and on their behaviors as well as to make subsequent reflections. In this way, it was aimed to contribute to the development of students' self-regulation skills (Ader, 2014). Learning dairies were basically used as data collection tools urging the students to write down their emotions and opinions on daily topics by responding to open-ended questions. Through learning dairies, what objectives students set for them on daily math class; what they learned; whether they believed they can learn the subject or not; willing or not; considered them self-sufficient to learn or not; what activities they were engaged in; whether they faced challenges in comprehending the activities and problems they had; what particular parts and why they faced those challenges; whether they eventually learned difficult topics; if yes, how; whether they made mistakes or not, and why; how they corrected their mistakes; and whether they reached their daily targets, were elicited. Learning dairies were used as data collection tools urging the students to write down their emotions and opinions on daily topics by responding to open-ended questions. Students' belief on whether they will succeed in the homework at hand; their thoughts on whether they homework is boring or not; their actions on homework; their learning from homework; challenges and how they tackled; parts they deem themselves successful/unsuccessful; why they considered themselves unsuccessful, were questioned so as to make them develop their self-regulation on their homework at home.

#### *2.3.5. Semi-structured interviews*

Semi-structured interview forms were drafted in order to elicit students' views on their self-regulated learning strategies used throughout the application process and what skills they built in math class and through the form students' views on the process and themselves were elicited in groups of two in the aftermath of the application process. The main reason why interviews were conducted in pairs is that students seemed unwilling when alone. Following questions were addressed via semi-structured interview forms to gather student views: (1) What are student views on goal orientation? (2) What are student views on self-efficacy? (3) What are student views on strategies used in class? (4) What are student views on strategies used at home while doing homework? (5) What are student views on what emotions and skills toward math emerged, developed, or changed as a result of the application process? The questions were initially submitted to the attention of experts upon whose comments necessary modifications were made. Interviews were conducted by addressing the prearranged questions and additional questions (drilling) were also asked in order to gather further details. Interviews lasted about one hour and it was attempted to collect detailed information. Data were recorded in voice recorder, detailed reports were written, and direct citations were included.

#### *2.3.6. The experimental process*

Reviewing the rich literature on studies aiming at developing students' self-regulated learning skills, it was found that teaching applications influence academic performance (Dignath, Buettner, & Langfeldt, 2008; Dignath & Büttner, 2008; Fuchs et al., 2003; Masui & Corte, 2005; Perels, Gürtler, & Schmitz, 2005). It was also found that teaching methods were divided into two categories, namely approaches based on direct and indirect teaching (Kistner et al., 2010). In direct teaching, teachers administer self-regulated learning by teaching its strategies in two different manners: implicit and explicit approach. In case of implicit approach, the applications are covertly executed by un-informing the students on the strategies they are using; while in explicit approach, teachers explain the meaning and importance of the strategies to the students clearly and properly and pre-inform them on which strategies to use in activities (Brown, 1996). In indirect teaching, the learning environments (settings) are modified so as to enable students to develop self-regulated learning skills. This process does not only cover teachers and students, but also involve learning contents, tools and mediums, and teaching methods (Kistner et al., 2010). In this present study combining direct and indirect methods, the application phase went on for 12 weeks, 5 lessons weekly, involving intra- and extra-curricular activities based on Zimmerman's (2002) model of self-regulated learning. At the application phase, the first researcher delivered classes in both experimental and control groups. For direct instruction, focus group interviews were based on multiple teaching scenarios and real-life stories concerning the use, significance, and raising awareness of some self-regulated learning strategies (goal setting, planning, self-efficacy, goal orientation, environment setting, social support seeking, self-assessment, self-finalization). Therefore, students were briefed on the strategies and ensured active implementation of these strategies in class and while doing homework by means of in-class activities, and homework diaries and checklists. In scope of the present research, it was ensured that students efficiently used in their learning process, the cognitive strategies in scope of mathematics class by means of indirect teaching approach.

Cognitive strategies have to do with cognitive processes and behaviors adopted during learning by students in order to complete a task or realize an objective in an academic subject (Boekaerts, 1999). Such cognitive processes and behaviors require students to be more active during learning and divert them to activities that demand high-level thinking skills rather than mere transfer of knowledge (Sünbül, 2011). In this research, active learning environments were set up for students and under guidance of the first researcher, activities enabling self-learning by students were tried to be applied throughout class periods. Moreover, realistic learning settings were also presented to the students by constantly considering relation of mathematics with real life. In order to give meaning to information at hand, students were asked to summarize what they learned in class and learning dairies in their own words, to comment on worksheets, to use note-taking techniques, to make use of cognitive images, to associate recent information with former ones. In order to organize information at hand, students were asked to group information according to similarities and differences, to draw charts–tables–schemes, and to employ problem-solving strategies (figures, diagrams, 3-D materials, table or graphics formation, pattern seeking, problem simplifying, solve similar problems, and reasoning). Therefore, by presenting information to students in a multifaceted manner by means of multiple resources, tools, and instruments, they were assisted to reorganize their cognitive models and interpret information at hand. Ensuring multi-faceted presentation of information is only viable through multiple resources, tools and instruments are introduced in learning environment. Furthermore, through effective communication between home and school and group activities at school, it was tried to attain learning environments, then enhanced communication among students, reduced competition and encouraged exchange of opinions. It was also attempted to create learning environments that helped develop self-regulated learning skills of students, since all of the above-mentioned processes concurrently enable efficient use of planning, monitoring, regulation, and reflection strategies by the students.

#### *2.3.7. Data analysis*
Academic achievement tests on integers, algebraic expressions, and area subjects, self-efficacy scales on those subjects and mathematics goal orientation scale were used as data collection tools in line with the research problems. SPSS 21 software was used in the analysis of data obtained via these quantitative data collection tools. For statistical analysis, ".05" was taken as the level of significance. Descriptive analysis method was used in the analysis of data collected through interviews conducted before, during, and after application phase and from learning and homework dairies. Data gathered in scope of this approach are supposed to be summarized and interpreted according to predetermined themes. The objective of this sort of analysis is to present findings to the reader in an organized and explicated format. In order to dramatically reflect the views of the individuals, direct citations are frequently made as observed or as elicited (Yıldırım & Şimşek, 2006).

## 3. Findings

### *3.1. Mathematics achievement*
Data collected through the academic achievement tests were compared so as to determine which of the teaching approaches was more effective. In the comparison of mathematics attainment scores, independent samples *t*-test was run. Table 2 shows the attainment mean scores of the academic achievement tests on the subjects of integers, algebraic expressions, and area in both the experimental and control groups.

According to Table 2, attainment mean scores of the achievement test on integers are $\bar{x} = 18.54$ in the experimental group and $\bar{x} = 9.47$ in the control group, and a comparison of the attainment mean scores indicates a significant difference [$t(43) = 5{,}949$; $p < 0.05$] in favor of the experimental group. Attainment mean scores of the achievement test on algebraic expressions are $\bar{x} = 18.41$ in

**Table 2. Results of the achievement tests on integers, algebraic expressions, and area**

| | | Groups | *N* | $\bar{x}$ | ss | sd | *t* | *p* |
|---|---|---|---|---|---|---|---|---|
| Integers | Pretest | Experimental | 22 | 8.95 | 3.34 | 43 | .660 | .513 |
| | | Control | 23 | 8.21 | 4.08 | | | |
| | Posttest | Experimental | 22 | 27.50 | 6.36 | 43 | 4.930 | .000 |
| | | Control | 23 | 17.69 | 6.95 | | | |
| | Attainment | Experimental | 22 | 18.54 | 5.10 | 43 | 5.949 | .000 |
| | | Control | 23 | 9.47 | 5.11 | | | |
| Algebraic expressions | Pretest | Experimental | 22 | 8.50 | 2.97 | 43 | 1.117 | .270 |
| | | Control | 23 | 7.34 | 3.86 | | | |
| | Posttest | Experimental | 22 | 26.91 | 7.21 | 43 | 5.727 | .000 |
| | | Control | 23 | 14.78 | 6.99 | | | |
| | Attainment | Experimental | 22 | 18.41 | 5.96 | 43 | 6.139 | .000 |
| | | Control | 23 | 7.43 | 6.02 | | | |
| Area | Pretest | Experimental | 22 | 7.54 | 3.14 | 43 | .568 | .573 |
| | | Control | 23 | 6.78 | 4.05 | | | |
| | Posttest | Experimental | 22 | 27.22 | 5.42 | 43 | 4.268 | .000 |
| | | Control | 23 | 19.73 | 6.29 | | | |
| | Attainment | Experimental | 22 | 19.81 | 5.50 | 43 | 4.076 | .000 |
| | | Control | 23 | 12.95 | 5.77 | | | |

the experimental group and $\bar{x} = 7.43$ in the control group, and a comparison of the attainment mean scores indicates a significant difference [$t(43)$ = 6,139; $p < 0.05$] in favor of the experimental group. Attainment mean scores of the achievement test on area are $\bar{x} = 19.81$ in the experimental group and $\bar{x} = 12.95$ in the control group, and a comparison of the attainment mean scores indicates a significant difference [$t(43)$ = 4,076; $p < 0.05$] in favor of the experimental group. As a result, one may claim that self-regulated learning activities applied in the experimental group are more effective when compared to the current MEB curriculum-based activities followed in the control group.

### 3.2. Self-Efficacy Beliefs

Data collected through the self-efficacy scales in the experimental and control groups were compared to determine whether posttests means of inter-groups are significant. In the comparison of mathematics self-efficacy perceptions, independent samples *t*-test was run. Table 3 shows comparisons of posttest mean scores of self-efficacy scales on the subjects of integers, algebraic expressions, and area run on the experimental and control groups.

According to Table 3, posttest mean scores of the self-efficacy scale on integers are $\bar{x} = 4.72$ in the experimental group and $\bar{x} = 4.25$ in the control group, and a comparison of posttest mean scores of the self-efficacy scale on integers indicates a significant difference [$t(43)$ = 3,944; $p < 0.05$] in favor of the experimental group. Posttest mean scores of the self-efficacy scale on algebraic expressions are $\bar{x} = 4.42$ in the experimental group and $\bar{x} = 3.56$ in the control group, and a comparison of posttest mean scores of the self-efficacy scale on integers indicates a significant difference [$t(43)$ = 2,971; $p < 0.05$] in favor of the experimental group. Posttest mean scores of the self-efficacy scale area are $\bar{x} = 4.41$ in the experimental group and $\bar{x} = 3.52$ in the control group, and a comparison of posttest mean scores of the self-efficacy scale on area indicates a significant difference [$t(43)$ = 2,973; $p < 0.05$] in favor of the experimental group. Accordingly, it can be claimed that self-regulated learning activities applied in the experimental group boosted self-efficacy beliefs of students more when compared to the current MEB curriculum-based activities followed in the control group.

### 3.3. Goal Orientations

Data collected through the goal orientation scale in the experimental and control groups were compared to determine whether posttest means of inter-groups are significant. In the comparison of mathematics goal orientations, independent samples *t*-test was run. Table 4 shows comparisons of posttest mean scores of goal orientation scale run on the experimental and control groups.

According to Table 4, posttest mean scores of the goal orientation scale in the case of the experimental group, the *learning approach* goal orientation posttest mean is $\bar{x} = 4.72$, of *performance approach* is $\bar{x} = 3.39$, of *learning avoidance* is $\bar{x} = 2.55$, and of *performance avoidance* is $\bar{x} = 2.53$. According to posttest mean scores of the goal orientation scale in the case of the control group, the *learning approach* goal orientation posttest mean is $\bar{x} = 4.20$, of *performance approach* is $\bar{x} = 4.05$, of *learning avoidance* is $\bar{x} = 3.55$, and of *performance avoidance* is $\bar{x} = 3.79$. A comparison of posttest means of the goal orientation scale indicates a significant difference [$t(43)$ = 2,372; $p < 0.05$] at

**Table 3. Results of the self-efficacy scales on integers, algebraic expressions, and area**

| Groups | | *N* | $\bar{x}$ | ss | sd | *t* | *P* |
|---|---|---|---|---|---|---|---|
| Integers | Experimental | 22 | 4.72 | 12.39 | 43 | 3.944 | .000 |
| | Control | 23 | 4.25 | 16.37 | | | |
| Algebraic expressions | Experimental | 22 | 4.42 | 22.78 | 43 | 2.971 | .005 |
| | Control | 23 | 3.56 | 40.72 | | | |
| Area | Experimental | 22 | 4.41 | 23.93 | 43 | 2.973 | .005 |
| | Control | 23 | 3.52 | 43.05 | | | |

**Table 4. Results of the goal orientation scale**

| | | *N* | $\bar{x}$ | Ss | sd | *T* | *p* |
|---|---|---|---|---|---|---|---|
| Learning approach | Experimental | 22 | 4.72 | 1.65 | 43 | 2.372 | .022 |
| | Control | 23 | 4.20 | 2.65 | | | |
| Performance approach | Experimental | 22 | 3.39 | 3.26 | 43 | −2.294 | .027 |
| | Control | 23 | 4.05 | 2.53 | | | |
| Learning avoidance | Experimental | 22 | 2.55 | 3.60 | 43 | −2.981 | .005 |
| | Control | 23 | 3.55 | 3.48 | | | |
| Performance avoidance | Experimental | 22 | 2.53 | 7.07 | 43 | −4.074 | .000 |
| | Control | 23 | 3.79 | 5.27 | | | |

the *learning approach* goal orientation, [$t(43) = -2{,}294$; $p < 0.05$] at the *performance approach* goal orientation, [$t(43) = -2{,}981$; $p < 0.05$] at the *learning avoidance* goal orientation, and [$t(43) = -4{,}074$; $p < 0.05$] at the *performance avoidance* goal orientation in favor of the experimental group. Accordingly, it can be claimed that self-regulated learning activities applied in the experimental group are more effective on goal orientations when compared to the current MEB curriculum-based activities followed in the control group.

### *3.4. Student views during the experimental process*

Throughout the experimental process, students' views were collected by means of learning and homework dairies. Through the learning diaries, students were asked to reflect on what their daily objectives in math class were, what they learned, whether they believed they could learn the subject, whether they considered themselves sufficient or not, whether they faced difficulty in understanding the subject, how they tackled the challenges they faced during class, and whether they reached their targets or not. An analysis of the learning dairies indicates that students set objectives during class, made intra- and extra-class plans, kept their motivations high to learn the subject, were aware of the need for self-esteem in achieving goals, liked to learn math subjects in class, enjoyed the games in class rendering math rather entertaining, learned better through materials used in class, noticed that math is not only a subject at school but is an integral part of daily life, felt mildly anxious at the beginning yet tackled it due to the entertaining lessons, constantly questioned themselves during class, reflected on where and why they made a mistake and how they corrected it at the end of lessons, and were pleased with the fact that their self-confidence was enhanced. For example: "I learned to do addition in algebraic expressions today. I understood everything without difficulty. I already believed in myself and I was keen on learning the subject. For instance, if my mother gave two Apples, three Oranges and 15 TL (Turkish Liras), I can express this as 2A + 3O + 15. I think I learned this topic, and solving the questions accurately is the biggest proof of it."

Through the homework dairies, students were asked to express how they felt about their homework, what they did to complete the homework, and whether they thought they failed at completing the homework or not. An analysis of the homework dairies indicates that in general, students believed they could do their homework, they were aware of the proceedings and negative aspects of their homework, thought on how to tackle those negative facets, comfortably pinpointed deficiencies in their homework, gained awareness as to how to correct deficiencies, efficiently selected appropriate strategies for themselves, did homework with greater details by making an in-depth analysis of the results, were aware that homework is a tool to reinforce the subject, and felt happier and more confident upon successfully completing their homework. For example: "I did my homework at my aunt's home today. It was crowded there; so I was distracted, but I took a lesson out of it. I asked myself: Why did I go to visit my aunt when there is so much homework to do? I will ask my teacher tomorrow to do it from scratch."

### *3.5. Student views after the experimental process*
Considering their participation in the experimental process, students were in interaction with their friends which triggered a positive ambiance in the class toward learning rather than competition, their achievement rate increased for being goal oriented and did not delay handling negative situations during learning, delivered correct answers deliberately, better controlled themselves, tried every method since they aimed at perfect learning, and thought doing homework accurately was more important than getting good grades. For example: "I used to do my homework to avoid negative consequences and I would just scribble some sloppy answers in my notebook to trick the teacher into believing I did my work. But, I am no longer going to do that again. We did not earn scores out of completed homework, but to comprehend the subject only; it is not nice to threaten us with low grades if we do not do our homework."

Considering student views on self-efficacy perceptions, it was found that they were more confident in themselves because they set goals, made plans and knew what to do, were capable of delivering tasks because they better learned the subjects, constantly self-checked of their self-esteem during class and at home, and tackled their anxiety over math with the boost in their self-esteem. For example: "During this process, I never thought: I cannot do it. I needed self-confidence to lay firm foundations. My self-esteem increased because I kept writing 'I learned this, I learned that' on my dairies. My dairies are like my friends now."

Considering student views on how lessons were delivered in class, it was noted that students actively participated, learned better through activities enabling autonomous learning, and used learning strategies more effectively. Multi-dimensional presentation of information by means of multiple tools and instruments gave them greater learning opportunities. For instance: "I believe I learned the subjects better through different learning activities. It was not like that before. Before, we used to write on notebooks only. The teachers would write something on the board, and we would copy it. When we asked our teachers for alternative methods before, they would say: Do not confuse your mind, this is the single most practical way."

An analysis of homework checklists, learning dairies, and homework dairies indicated that students did more repetitions at home, better determined what they learned or not, better controlled learning procedures at home, began doing their homework more regularly, their goal orientation was inclined toward doing homework, and their self-confidence increased. For instance: "I did these things during this procedure and I noted I got successful. I looked into the mirror, I got dressed in my mother's clothes, put on makeup and I directed your questions into the mirror. Imitating the role of a teacher in front of a mirror was so much fun, so I started studying this way."

Considering student views on what emotions and skills toward math emerged, developed or changed, it was found that students were no longer afraid of math, perceived math as an entertaining subject, their sympathy toward math increased, better understood how much mathematics was integrated in daily life, their self-esteem enhanced, set targets in both classroom and at home for mathematics and made subsequent plans, constantly monitored and assessed themselves, managed to select what is suitable for themselves, and enjoyed cooperating with peers in class without the pressure of competition. For instance: "I find math more entertaining now and understand how much more educational it is. My point of view on math has changed. I started liking myself because through self-questioning I started noticing I am successful."

## 4. Discussion
According to the findings on the first sub-problem of the research, attainment scores on integers, algebraic expressions, and area in case of experimental group students are quite higher than those in control group. These findings correspond with similar studies in this field. For instance, Darr and Fisher's (2004) four-week-long study on seventh-grade students concerning rational numbers and percentages, it was found that as a result of students' observation of mathematical problem-solving processes and teachers acting as role models, motivation was attained, math subjects were

associated with daily life, that learning processes urging students to come up with original solutions to problems were created, thought processes were recorded by students, and that mathematical thinking skills emerged in learning environment, and the attitude of observing and reflecting those skills increased. It is underlined that self-regulated learning activities effectively support students in learning mathematics. Likewise, as a result of a six-week-long experimental study by Leidinger and Perels (2012) on grade four students, their achievement rate in math significantly increased. It was found out in Arsal's (2009) study on fourth graders presenting a math curriculum integrating self-regulated learning strategies for fractions and decimal fractions subjects that students' academic achievement in math increased. In a study by Pennequin, Sorel, Nanty, and Fontaine's (2010) study on primary school students with low achievement rates in math, the effects of meta-cognitive skills on problem-solving and on academic achievement in math were evaluated; and as a result of the experimental procedure, it was found that problem-solving skills and academic achievement rates of the students enhanced. It was found out in Perels et al. (2009) study on sixth graders integrating self-regulated learning strategies into math classes that students' academic achievement in math increased. Stoeger and Ziegler (2008) found in their study on grade four students that self-regulated learning strategies increased students' academic achievement in math. Montague (2007), in a study on elementary school students with learning disabilities, concluded that self-regulated learning strategies (self-assessment, self-instruction, self-reinforcement, self-monitoring) boost academic success of students in mathematics. As a result of interviews with students, it was concluded that materials used in class facilitated students' learning; an entertaining learning environment reduced anxiety and fear toward math, thus increased resistance against challenges; summarizing details of self-regulation helped better control learning in mathematics; group works were beneficial in terms of exchange of view, modeling through sharing of cognitive processes of thought, time-saving, joy of being together with peers; they attained results in a rather confident and comfortable manner since they select appropriate strategies during problem-solving phase with greater ease; by associating math with daily life, their anxiety levels dropped and learned more comfortably; and that they utilized problem-solving procedures more efficiently and consciously. In summary, self-regulated learning activities adapted to mathematics significantly increase students' academic achievement in mathematics. The present study also gathered that students identified objectives on their learning and relevant strategies while controlling their motivation levels, executed the strategies they planned beforehand, monitored learning procedures during application phase, determined and resisted against challenges, assessed the output and products of learning at the end of application phase and regulated the proceedings accordingly. Students' academic achievement in math was increased by offering students opportunities for personal learning, creating rich learning settings, enabling them to learn by utilizing high-level thinking skills, modifying classroom environment so as to enable learning and promoting peer cooperation within learning environment.

According to the findings on the second sub-problem of the research, self-efficacy levels on integers, algebraic expressions, and area in case of experimental group students are quite higher than those in control group. In their experimental studies, Kang (2010), Lavasani, Mirhosseini, Hejazi, and Davoodi (2011), and Yetkin (2006) found out that self-efficacy levels of experimental group students, who learn in environments furnished with self-regulated learning activities, are significantly higher than those in control group. Chen and Zimmerman (2007) and Hong and Park (2012) also found positive and meaningful correlation between self-regulated learning and self-sufficiency. Zimmerman, Bonner, and Kovach (1996) stressed on the fact that development and maintenance of self-regulated learning skills in students bring about success, which then increases self-efficacy belief in an individual. In other words, effective self-regulated learning activities help build a strong perception of self-sufficiency in students (Pajares, 2008). In line with student views in scope of the present study, it was noted that success was attained when students were motivated to consider themselves sufficient, thus they learned how not to be afraid of math and to overcome their anxiety. Besides, better focusing on learning procedures increased self-belief in students and they began liking math more as they began considering themselves sufficient. Participants stated that intra-class group activities, learning-homework dairies, student-centered classroom settings, and supportive teacher behavior all boosted their self-efficacy, as well.

According to the findings on the third sub-problem of the present research, learning goal orientation mean in case of experimental group students is significantly higher and performance approach, learning avoidance, and performance avoidance goal orientation mean is lower than that in control group. In other words, learning environments aiming at developing self-regulated learning skills to be used in mathematics do make an impact on learning approach, performance approach, and performance avoidance goal orientations, yet no impact on learning avoidance goal orientation. Furthermore, it was found that learning approach goal orientation among students increased in the aftermath of the application phase. One may deduce that experimental group students used cognitive and meta-cognitive strategies in math more effectively during the application, made better observation and assessment of learning procedures, and better controlled their motivation. It was also concluded that performance goal orientation among students decreased, which may be interpreted that their anxiety toward math declined, they achieved meaningful learning and did not hesitate at all when in need of assistance. Meanwhile, no change occurred in learning avoidance goal orientation, which may mean that students sometimes do not tend to avoid challenges preventing them from studying. Performance avoidance goal orientation dropped, meaning that students were more determined to learn during application period, studied in a planned manner with increased self-regulation and more assistance from others, did not compete with others, did not refrain from self-assessment and had high motivation rates. Literature review shows that in research on seventh and eighth graders, Patrick, Ryan, and Pintrich (1999) and Wolters, Shirley, and Pintrich (1996) concluded that students with learning goal orientation had higher levels of self-efficacy and academic achievement and that they used cognitive and meta-cognitive strategies rather efficiently. In their study, Cury, Elliot, Da Fonseca, and Moller (2006), Grant and Dweck (2003), Özkal (2013), and van der Veen and Peetsma (2009) found out that students with stronger learning objectives used deeper learning strategies and those with learning goal orientation were more successful in achievement tests when compared to those with performance goal orientation. In light of views collected in scope of the present research, students stated that prior to implementation period, they did not consciously control their learning in mathematics and their priority was good grades and scores on tests and exams. Meanwhile, in the aftermath of the implementation process, they stated that cooperative studying reduced competition among friends, hence boosting assistance seeking, they were more successful in math and they could try all sorts of methods as they targeted learning and were resolute in that sense. In addition, students also informed that they delivered homework more efficiently and consciously since they focused on learning. Consequently, one may suggest that the qualitative and quantitative findings of present study are in parallel with those in literature.

As a result, because by nature, self-regulated learning skills cannot be acquired in classroom only, educators should set the viable environment in both school and home settings and teachers should cooperate with families. In order for regular school–parent cooperation, teachers should regularly monitor students. Teachers should establish learning atmospheres enabling different ways of thinking and exchange of different ways of problem-solving among students. As grades go up, mathematics becomes a rather fearsome, even hateful subject, which drops success rates of students. Use of learning approaches such as game-based, project-based, technology-backed, etc. during math classes renders students' attitude toward math positive and positively affect their achievement. Therefore, use of various approaches in classroom environment should be encouraged. One of the most effective methods in the self-regulated learning process is doing homework. For this, students should set goals on their homework and deliver accordingly and materials to enable self-assessment should be employed. The scope of the study is limited to the topics of integers, algebraic expressions, and area delivered to elementary school grade six students in math subject and to the effects of self-regulated learning activities on these topics over achievement and motivational beliefs. Studies similar to this experimental study on mathematics can be conducted in other subjects, as well. Similar studies can be conducted at other grade levels than grade six. Qualitative studies involving families and the views of families gathered through experimental research can be carried out.

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