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SELF-REGULATED LEARNING STRATEGIES IMPACT FOURTH-GRADE STUDENTS' POSITIVE OUTCOMES IN SCIENCE CLASS

Busra Cengiz-Istanbullu,
Gonul Sakiz

Abstract. *For long years, researchers in the field believed that the development of self-regulated learning (SRL) behaviors of students could only be initiated around middle school years. Nowadays, a growing number of research around the world attempt to challenge this belief by demonstrating that SRL behaviors and strategies can emerge in students at an earlier age than expected through proper training and eventually affect students' positive academic outcomes in the learning process. The purpose of this study was to examine the impact of the use of self-regulated learning strategies (SRLS) on fourth-grade students' academic self-efficacy, science motivation, academic worry, and achievement in a primary school science classroom. A pre-test – post-test control group quasi-experimental design was used. The participants were 39 fourth-grade students from a private primary school in Istanbul, Turkey. The SRLS (goal-setting, planning, note-taking, monitoring and self-evaluation) used in the study were explicitly taught to the students in the experimental group. The data were collected using two self-report questionnaires and an achievement test. A 2x3 Split-plot ANOVA test was used for data analyses. The results revealed that the use of SRLS significantly positively impacted students' perceived academic self-efficacy, science motivation and academic achievement; and, significantly negatively affected their academic worry. The results of the retention tests, however, showed the necessity of continuous stimulation of SRLS to obtain optimal benefits for student outcomes.*

Keywords: *academic achievement, academic self-efficacy, academic worry, science motivation, self-regulated learning strategies (SRLS)*

Busra Cengiz-Istanbullu
Doga College, Turkey
Gonul Sakiz
Marmara University, Turkey

Introduction

In today's world, the information flow in our lives is mesmerizingly fast. Therefore, catching personally relevant and necessary information from the flow and eliminating the rest, staying focused and protecting our well-being are critical issues and require the adoption of the high level of self-regulatory skills. Regardless of developmental differences, self-regulation exists at various levels and qualities to attain personal goals (Zimmerman, 2001). Self-regulation involves "self-generated emotions, thoughts and actions that one can plan and adapt to achieve the goal" (Zimmerman, 1999, p. 14).

Individuals who can efficiently self-regulate their actions participate vigorously in the learning process and use the metacognitive, motivational, and behavioral skills needed to accomplish their goals (Zimmerman, 1989). Self-regulated individuals evaluate their internally driven conscious and/or unconscious behaviors and put an effort to change their reactions to the learning process (Vohs & Baumeister, 2004). They monitor their motivation and behavior to achieve their predetermined goals (Pintrich, 2000). Facilitating learning affects self-development positively (Zimmerman, 1990a). Self-regulated learners take responsibility for their own learning, use certain strategies, examine how those strategies affect the outcomes, and, eventually, develop their own learning strategies (Gömleksiz & Bozpolat, 2012; Haddad, 2016; Zimmerman, 1990a). Zimmerman (1990a) developed a cyclical structure of SRL which includes three basic phases: forethought, performance, and self-reflection. In the forethought phase, learners determine their goals and choose the most appropriate strategies to achieve these goals; focus on the situations that motivate them during the process. In the performance phase, they apply the strategies chosen and control the process through observations. In the self-reflection phase, the learning process is completed, and the entire process is evaluated.

Being a self-regulated learner requires the adoption of appropriate self-regulatory strategies, which are the certain actions and processes individuals use to succeed (Zimmerman, 1989). The utilization of self-regulated learning strategies (SRLS) improves individuals' learning skills (Ader, 2014). Knowing the proper SRLS strategies, however, is not enough. Learners also need to believe that the strategies are beneficial and that they can competently utilize them (Cerezo et al., 2019). According to Bandura (1991) and Zimmerman

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(1990b), during the learning process, individuals go through many trial-and-error processes to determine the most appropriate strategy to use. The selection of SRLS depends on person, environment, and behaviors. Students who believe in themselves and their abilities, are more likely to use their strategic knowledge in appropriate situations, so they set their goals and make appropriate plans.

There are a wide range of SRLS such as self-evaluation, transformation, goal-setting and planning, structuring the environment, gathering information, taking notes and monitoring, repeating and memorizing, and seeking help (Zimmerman & Martinez-Pons, 1986). In the present study, four major SRLS were examined: goal-setting, planning, note-taking, monitoring and self-evaluation. These strategies are embedded in the forethought, performance, and self-reflection phases. Limiting the use of diverse strategies with youngsters may help sustain their motivation even under the condition of failed attempts toward successful outcomes (Cerezo et al., 2019).

Goal-setting and planning involve guessing the results of certain actions and making action plans using determined goals and achieving the desired results (Bandura, 1999). Individuals motivated to achieve their goals try more intensely to reach their goals by guiding their behaviors (Bandura, 1998). Students set various goals for themselves to succeed in the learning period. The subgoals used in the goal-setting stage are like the control points to reach the major goal (Zimmerman & Cleary, 2009). Research conducted in the field with the participation of students from different developmental levels shows that the goal-setting strategy positively affects students' learning outcomes (Martin & Elliot, 2016; Öztürk & Çakıroğlu, 2021; Yusuff, 2018).

Planning requires the consideration of time, environmental factors and expected behavior in relation to the given task (Ader, 2014; Zimmerman & Cleary, 2009). Students determine the appropriate strategy to use during planning. If the predetermined strategy is not suitable for achieving the purpose, students may change it with a more suitable one in the process (Lavasani et al., 2011). Research shows that using the planning strategy in the course of learning activities is positively related to students' advanced learning outcomes (Lavasani et al., 2011; Öztürk & Çakıroğlu, 2021; Wong et al., 2021).

Note-taking and monitoring strategies involve recording the actions and keeping track of the learning process. When note-taking and monitoring are not used, individuals must rely on their memory to explain their achievement or failure, and memory may mislead individuals (Schunk & Zimmerman, 2003). The process of monitoring is very effective in setting realistic goals and evaluating the progress in the process of achieving the predetermined goals (Bandura, 1991). Without monitoring, individuals can be less certain about how well they learn. Monitoring allows them to see their progress during learning and increases their academic self-efficacy (Schunk & Ertmer, 2000). Research shows that using the self-monitoring strategy during learning period positively affects students' academic performance (Arslantas & Kurnaz, 2017; Guo, 2022; Hsu, 2020).

Self-evaluation involves a regular and systematic comparison of goals and obtained outcomes (Sakız & Yetkin-Özdemir, 2014). Individuals shape their motivation and behavior by evaluating the positive and negative results received through the actions (Bandura, 1999). In the learning process, students are in a continuous assessment process and choose the most appropriate and easiest strategy to use. According to Zimmerman (2000), there are four criteria used in the self-evaluation process. These include learning, previous performance, normative comparison, and in-team function. For example, a score obtained from an achievement test, progress made compared to previous performance, performance level in comparison to others and efficiency in completing a given responsibility in teamwork can be considered as self-evaluative actions. Studies demonstrate that the use of the self-evaluation strategy in the learning process results in higher academic outcomes in students from different developmental periods (Dignath et al., 2008; Lavasani et al., 2011; Raković et al., 2022).

Research Problem

Self-regulated learning strategies (SRLS) can be acquired easily when strategy instruction is placed in education (Dignath et al., 2008; Guo, 2022; Weinstein et al., 2011). Self-regulated learning strategies (SRLS), have long been examined in relation to a wide range of variables including academic achievement (Broadbent & Poon, 2015; Cerezo et al., 2019; De La Fuente et al., 2020; Öztürk & Çakıroğlu, 2021; Vettori et al., 2020), motivation (Schraw et al., 2006; Pintrich & De Groot, 1990; Pravesti et al., 2020; Uka & Uka, 2020), metacognitive skills (Bahri & Corebima, 2015; Schraw et al., 2006; Senler & Vural-Sungur, 2014), problem-solving skills (Ahghar, 2012; ElAdl & Polpol, 2020) and gender (Kara-Ertürk & Gönen, 2015; Shoval et al., 2021). The overall results of the related studies show that the use of SRLS contributes positively to academic achievement, motivation, metacognitive skills, learning and problem-solving skills. Nevertheless, the research on SRLS commonly involved students in middle school (Chen &

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Cleary, 2009; Cheng, 2011; Daniela, 2015; Uka & Uka, 2020), high school (ElAdl & Polpol, 2020; Kartalcı & Demircioğlu, 2018; Sun & Wang, 2020; Vettori et al., 2020; Zimmerman & Kitsantas, 1997) or university settings (Aizpurua et al., 2018; Anthonysamy et al., 2020; De La Fuente et al., 2020; Hsu, 2020; Öztürk & Çakıroğlu, 2021; Sahin et al., 2020).

Because SRL skills and strategy development have quite a long time been perceived as requiring high-level thinking skills, and pre-school and primary school students would be insufficient in this regard, the relevant research with young age groups remained highly limited (Veenman & Spaans, 2005; Zimmerman 1990). Contrary to common expectations, developing SRL skills in young children is crucially important (Salisch et al., 2015). Therefore, the contemporary research studies in the field endeavor to confront the common thought related to the emergence period of SRL behaviors in students and attempt to provide evidence supporting that students can develop SRL skills and strategies at an earlier age than expected through the implementation of proper training programs (Lenes et al., 2020; Pas et al., 2021; Perry & VandeKamp, 2000). Kangas et al. (2015) discussed the importance of self-regulation in early childhood education and demonstrated the specific SRLS used by students. Dignath et al. (2008) revealed that instructional programs for SRL at the primary school level are highly effective in the learning process and, hence, primary school students can acquire self-regulated behaviors quite efficiently. They also emphasized that older students may possess some strategies difficult to change due to their previous experiences affecting their current state of knowledge, and, hence, younger students may be more open to acquiring new strategies because their existing ones are limited. In this process, students should be guided by teachers on how to benefit most effectively from the strategies during learning (Broadbent & Poon, 2015). If teachers inform students about how and when to use strategies and practice these procedures in class, the outcomes may potentially be more favorable for students (Weinstein et al., 2011). Designing the classroom instruction in such a way that would promote students' learning and practice of SRLS may strengthen the projected positive academic outcomes for students (Soltani & Askarizadeh, 2021).

Research Focus

In the current study, the use of SRLS was examined in relation to four critical outcomes for student success in primary schools. These include academic self-efficacy, science motivation, academic worry, and academic achievement. Academic self-efficacy can be defined as individuals' beliefs in what and to what extent they can achieve in the learning process (Bandura, 1999). Learning environments should be organized to boost students' academic self-efficacy (Sakız, 2013). Increased self-efficacy fosters higher persistence and endurance toward difficulties and leads to higher levels of achievement (Schunk & Meece, 2006). It also encourages a positive attitude towards lessons linking to higher achievement (Huang, 2016; Roick & Ringeisen, 2017). Research shows that using SRLS enhances students' self-efficacy through increased knowledge (Cerezo et al., 2019). If SRL training is provided at an early age, children's participation skills, self-esteem and self-efficacy are improved notably (Kangas et al., 2015).

Motivation can be perceived as the powerful force driving the person to achieve a certain goal (Çavaş-Huyugüzel & Çavaş, 2014). Highly motivated students have much higher energy to succeed in the learning process (Maison et al., 2019). Negative attitudes gained at an early age are difficult to change, so developing motivation in young children and achieving success as a result of motivation, positively affect an individual's life (Patrick et al., 2008). Research supports that the use of SRL in science class positively affects students' science motivation and achievement (Maison et al., 2019).

Worry can be defined as a cognitive process in which a person rethinks the negative consequences of an existing condition and focuses on the part of the potential consequences that threatens the person (Vasey et al., 1994). Worry begins in pre-school and can diversify through a lifetime (Vasey et al., 1994). Students' thinking of failure related to the science course causes academic worry (Kağıtçı & Kurbanoğlu, 2013; Kurbanoğlu & Nefes, 2016). A high level of worry also negatively affects students' problem-solving skills (Parkinson & Creswell, 2011). The use of SRLS helps manage high levels of worry (Weinstein et al., 2011). For individuals who use SRLS effectively in the learning process and are aware of their potential, the level of academic worry decreases, and learners develop a positive attitude toward lessons (El-Adl & Alkharusi, 2020; Mesurado et al., 2018).

Research Purpose

From early childhood to adulthood, self-regulation of behaviors is possible and highly beneficial for achieving independent learning. Although research shows that the instruction and the use of self-regulated learning strate-


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gies in the early years of schooling is crucially important for youngsters (Dignath et al., 2008; Kangas et al., 2015), there has not been much experimental research concerning this developmental level. The purpose of this study was to examine the impact of using SRLS on fourth-grade students' academic self-efficacy, science motivation, academic worry, and achievement in a primary school science classroom. Hypothetically, it was expected that students who were trained to use SRLS in the learning process would demonstrate higher self-efficacy beliefs and science motivation, lower academic worry and greater academic achievement compared to those who have not received any training on the use of SRLS.

Within the scope of this study, the science course was specifically chosen. The common purpose of science teaching globally is to raise individuals who can solve problems, produce, manage, and control their own learning; have critical thinking, are determined, have high communication skills, empathic ability and contribute to society (MEB, 2018). All these expected qualifications require holding high self-regulatory skills. Besides, as a worldwide endeavor, advancement in science achievement at all developmental levels is highly prioritized. In international TIMSS (Trends in Mathematics Science Study) exams which include the assessment of fourth-grade students' science proficiency levels across countries, Turkey was ranked as 36th among 50 countries in 2011, 35th of 47 in 2015 and 19th among 58 countries in 2019 (MEB, 2020) in science achievement. Even though there is an increase in the rankings over time, the students' level of advanced proficiency in science was 4% in TIMSS 2015 and 12% in TIMSS 2019, and, hence, the desired outcomes have not been achieved so far. Therefore, more research in the field is needed to enquire about the potential ways to improve students' science proficiency in Turkey at all grade levels. The present study would hopefully contribute to meeting this strong need.

Research Methodology

General Background

In this study, a pre-test – post-test control group quasi-experimental design was used. In most educational research, a random assignment of participants is not achievable due to concerns related to disturbing existing educational conditions (Creswell, 2009). In this quasi-experimental research, students were not assigned to the groups randomly. The equivalency in groups, however, was assured through pre-tests and acquiring similar learning conditions. The study was carried out in the fall term of the academic year 2017-2018. All permissions were obtained from the Istanbul Provincial Directorate of National Education. The rules stated in *the Higher Education Institutions Scientific Research and Publication Ethics Directive* were followed during the execution of the study.

Participants

The participants of this study were 39 fourth-grade students (n_{exp} = 20 and n_{cont} = 19) from two classrooms in a private primary school located in the European side of Istanbul, Turkey. The average class size in private schools in Istanbul is around 20, which was also the case in this study. The convenient sampling method using easily accessible samples was chosen in this study. Both genders were almost equally represented in the groups. Overall, 49% of the participants were female and the average age was 9.15 with a standard deviation of .49. The participants were widely from middle-class families. Of all the parents, 10% held secondary or lower education, 28% held high school degrees and 62% held undergraduate or graduate education degrees. During the study, students' natural classroom environments were not changed. Before the implementation, students were informed about the study, the voluntary nature of their participation and their freedom to leave at any time, and the confidentiality of their responses to the scale items.

Measures

Science and Technology Course Self-Efficacy Scale. Students' self-efficacy toward science courses was measured using *Science and Technology Course Self-Efficacy Scale* developed by Tatar et al. (2009). This scale included 27 items (15 positive and 12 negative items). All items were measured with a 5-point Likert type scale ranging from 1 (completely disagree) and 5 (completely agree). The sample items were as follows: "I am not very sure that, I can understand difficult scientific and technologic concepts" and "I can accomplish science and technology projects successfully." The internal consistency reliability was calculated as .80.

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The Motivation for Science Learning Scale. Student motivation toward science learning was measured using *The Motivation for Science Learning Scale* developed by Tuan et al. (2005) and adapted to Turkish by Yılmaz and Cavaş (2007). The 5-point Likert type scale consisted of 33 items, ranging from 1 (completely disagree) to 5 (completely agree). The sample items were as follows: "When I come across science concepts that I don't understand, I still make an effort to understand them" and "when learning new science concepts, I make an effort to understand them." The internal consistency reliability estimate for this scale was .87.

Science and Technology Lesson Worry Scale. Science and Technology Lesson Worry Scale developed by Kağıtçı and Kurbanoğlu (2013) was used to determine students' level of worry for the science course. The 5-point Likert type scale consisted of 18 items, ranging from 1 (completely disagree) to 5 (completely agree). The sample items were as follows: "Even thinking about attending the science course makes me worried" and "watching the teacher solving a science problem at the board makes me worried". The internal consistency reliability estimate for this scale was .85.

Science Achievement Test. Science Achievement Test developed by Üçüncü (2019) was used to determine the achievement levels of students in the Introduction to Matter Unit. The test included 20 multiple choice questions consisting of four options. The correct answers were scored as 1 and the wrong answers as 0. The internal consistency reliability estimate for this test was calculated as .72.

Procedure

The total duration of the study, including the pre- and post-test implementations, was 10 weeks. The experimental part of the study took place over three-hour class periods for eight weeks in the science unit of Introduction to Matter. The retention test was applied four weeks after the post-test. In the control group, only pre-, post- and retention tests were applied. Considering students' developmental levels and the length of the scales, each scale was applied during a 40-minute class period. The scale applications were carried out during the free activity times in school without disrupting students' regular course flow.

The SRLS used in the experimental group (goal-setting and planning, note-taking and monitoring and self-evaluation) were explained during the activities. For each strategy instruction, two weeks were allocated. During the strategy instruction of goal-setting and planning, first, a sample goal-setting map was handed out to the students and the concept of goals as well as close and distant goals were discussed all together and detailed explanations and several examples were provided by the teacher. The students were then asked to create close, distant, and sub-goals for the Introduction to Matter Unit with the guidance of their teacher. In addition, the stories with heroes that students can identify themselves with involving goal-setting and planning strategies were read by the teacher and the stories were deepened with related videos and pictures. Finally, goal-setting maps were developed by the students for each subject.

The students were informed about the nature of note-taking and monitoring strategies. They were explained that the more they became aware of their actions and their results in the learning process, the fewer mistakes they would make and the more involved they would become in their learning. The students were provided with a self-monitoring form and explanations on how to use it during the course. Using the form, they took notes and made markings to check their active participation in the course every 10 minutes during a 40-minute lesson. 10-minute periods were reminded by the teacher.

During self-evaluation strategy training, the students were informed about its characteristics and benefits for learning. The related stories were shared, and discussions were carried out for use of this strategy during the learning process. At the end of the lesson, the students were requested to fill in a self-evaluation form in which they assessed what and how they did in the lesson. They provided information on what they learned, how they felt, which steps they followed when they did not understand something, how they reacted when they made mistakes and how they used the allocated time and so on.

All essential steps for ensuring the validity and the reliability of the study were properly performed throughout the research. Following the development of the SRL tasks, Lawshe (1975) test was conducted for the purpose of acquiring content validity. The draft document was sent to 10 specialists. The following six measurement criteria were submitted to them for evaluation: purpose, students' prior knowledge, appropriateness of the allocated time

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for each application, classroom organization, teacher-student roles, and difficulty level of each task. The specialists coded each task for each criterion as suitable, not suitable, or needs revision. Using the formula, the Content Validity Ratio (CVR) was calculated and found to be .96, which meets the validity criteria for 10 experts (> .80, Ayre & Scally, 2014). Using all other comments and suggestions, the final version of the SRL tasks was developed. All scales used in the present study were selected from those with adequate and substantial information regarding the validity and the reliability procedures.

Data Analysis

Before the experimentation, the equivalency of the groups was tested using t-test analyses. As shown in Table 1, the students in both groups were found equal in terms of examined variables [academic self-efficacy (t_{37} = -.62, p = .80), science motivation (t_{37} = 1.94, p = .48), academic worry (t_{37} = 1.86, p = .07), and academic achievement (t_{37} = -.82, p = .60)].

Table 1
The Comparison of the Pre-test Scores of Two Groups in Relation to Academic Self-Efficacy, Science Motivation, Academic Worry and Academic Achievement Variables

Groups	Dependent Variables	N	$\bar{x}$	SD	t	df	p
Experimental Gr.	Academic Self-Efficacy	20	3.08	.25	-.62	37	.80
Control Gr.		19	3.14	.26			
Experimental Gr.	Science Motivation	20	3.42	.29	1.94	37	.48
Control Gr.		19	3.23	.32			
Experimental Gr.	Academic Worry	20	2.37	.40	1.86	37	.07
Control Gr.		19	1.98	.82			
Experimental Gr.	Academic Achievement	20	.49	.14	-.82	37	.60
Control Gr.		19	.53	.30			

Following the intervention, the preliminary descriptive analyses were conducted. For further analyses, the Split-plot ANOVA tests were applied to enable comparing and contrasting between and within groups simultaneously. Split-plot ANOVA (mixed design) is a technique used to compare averages in repeated measurements (Chartier & Cousineau, 2011). The data were intermittent and continuous, normally distributed and the variances showed a homogeneous distribution. Using Cohen's (1988) criteria, effect sizes (η_p^2) were also calculated for each test and the cut-point values of .01, .06 and .14 were interpreted as small, medium, and large effects, respectively. The significance level for all statistical analyses was determined as .05. Bonferroni adjustment was used for multiple comparisons.

Research Results

The Preliminary Results

The descriptive analyses of the pre-, post- and retention test scores of both groups in relation to given variables are provided in Table 2. The preliminary results revealed that the experimental group students' levels of academic self-efficacy, science motivation and academic achievement were likely to increase at the post-test compared to the pre-test, and then, slightly decrease at the retention test compared to the post-test. Students' academic worry levels in the same group tended to gradually decline over time.

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Table 2
Descriptive Analyses of Groups in Relation to Academic Self-Efficacy, Science Motivation, Academic Worry and Academic Achievement Levels at Pre-, Post- and Retention Tests

Groups	Dependent Variables	N	Pre-test		Post-test		Retention test	
			$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Experimental Gr.	Academic Self-efficacy	20	3.08	.25	3.31	.21	3.13	.28
Control Gr.		19	3.14	.26	3.09	.19	2.76	.58
Experimental Gr.	Science Motivation	20	3.42	.29	3.52	.36	3.48	.48
Control Gr.		19	3.23	.32	3.21	.24	2.99	.73
Experimental Gr.	Academic Worry	20	2.37	.40	2.04	.57	1.57	.74
Control Gr.		19	1.98	.82	1.73	.71	1.85	.92
Experimental Gr.	Academic Achievement	20	.49	.14	.82	.11	.73	.11
Control Gr.		19	.53	.19	.70	.11	.62	.19

As shown in Table 2, the control group students' levels of academic self-efficacy and science motivation were seemingly demonstrating a slight but continuous fall throughout all testing periods. Students' levels of academic worry in the control group were inclined to decrease at the post-test but then slightly increase. In terms of academic achievement outcomes, similar to the experimental group, an increase in the post-test scores was followed by a minor decrease in the retention test scores.

Split-Plot ANOVA Results

Following the descriptive analyses, a 2x3 Split-plot ANOVA test was performed. The results are provided in Table 3 and illustrated in Figure 1. In terms of academic self-efficacy, there was a statistically significant difference between groups with a high effect size, in favor of the experimental group [$F(1,37) = 6.46$, $p = .02$, $\eta_p^2 = .15$]. The main effect of time was significant and the effect size was high [$F(2,74) = 7.32$, $p = .001$, $\eta_p^2 = .17$]. The post hoc analyses showed that the difference in time variable was caused by the difference between post- and retention test scores ($p = .003$). The group and time interaction effect was significant with a medium effect size [$F(2,74) = 4.98$, $p = .009$, $\eta_p^2 = .12$]. The post hoc analyses showed that while there was no significant difference between groups at pre-test ($p = .54$), they differed significantly at post- and retention test periods ($p = .003$ and $p = .02$, respectively), in favor of the experimental group. In the experimental group, a significant difference was only detected between pre- and post-test scores ($p = .003$). In the control group, however, significant differences were observed in two time points, between pre-and retention test scores and post- and retention test scores ($p = .007$ and $p = .008$, respectively). The graphical representation is provided in Figure 1a.

In terms of science motivation levels, there was a statistically significant difference between groups with a high effect size, in favor of the experimental group [$F(1,37) = 9.72$, $p = .004$, $\eta_p^2 = .21$]. The post hoc analyses showed that an obtained significant difference between groups was caused by the differences at post- and retention test periods ($p = .004$ and $p = .02$, respectively). The main effect of time was not detected [$F(2,74) = 1.42$, $p = .25$]. The group and time interaction effect was not significant as well [$F(2,74) = 1.72$, $p = .19$]. The graphical representation is given in Figure 1b.

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Table 3
Split-plot ANOVA Results for the Effects of the Independent Variables (Group and Time) on the Dependent Variables

Dependent Variables	Source of Variance	*SS*	*df*	*MS*	*F*	*p*	η_p^2
	Between Groups						
Academic Self-efficacy	Intercept	1117.26	1	1117.26	7902.05	< .001	.99
	Group	.91	1	.91	6.46	.02	.15
	Error	5.23	37	.14			
	Within Groups						
	Time	1.29	2	.65	7.32	.001	.17
	Group*Time	.88	2	.44	4.98	.009	.12
	Error	6.54	74	.09			
	Between Groups						
Science Motivation	Intercept	1281.00	1	1281.00	3885.91	< .001	.99
	Group	3.20	1	3.20	9.72	.004	.21
	Error	12.19	37	.33			
	Within Groups						
	Time	.35	2	.18	1.42	.25	.04
	Group*Time	.43	2	.21	1.72	.19	.04
	Error	9.17	74	.12			
	Between Groups						
Academic Worry	Intercept	434.01	1	434.01	518.52	< .001	.93
	Group	.56	1	.56	.67	.42	.02
	Error	30.97	37	.84			
	Within Groups						
	Time	4.31	2	2.16	6.25	.003	.15
	Group*Time	2.58	2	1.29	3.75	.03	.09
	Error	25.51	74	.35			
	Between Groups						
Academic Achievement	Intercept	50.13	1	50.13	1198.37	< .001	.97
	Group	.11	1	.11	2.70	.11	.07
	Error	1.54	37	.04			
	Within Groups						
	Time	1.26	2	.63	49.99	< .001	.58
	Group*Time	.17	2	.08	6.62	.002	.15
	Error	.93	74	.01			

Academic worry levels of the students in both groups showed no statistically significant difference [$F(1,37) = .67$, $p = .42$]. On the other hand, as presented in Table 3, a main effect of time variable was detected with a high effect size [$F(2,74) = 6.25$, $p = .003$, $\eta_p^2 = .15$]. The post hoc analyses showed that the difference in time variable was caused by the difference between pre- and retention test scores ($p = .002$). The interaction effect between group and time was also significant with a medium effect size [$F(2,74) = 3.75$, $p = .03$, $\eta_p^2 = .09$]. The post hoc analyses revealed that the obtained difference was caused by the variations in scores between pre- and retention tests in the experimental group ($p < .001$). The academic worry levels of the students in the experimental group showed

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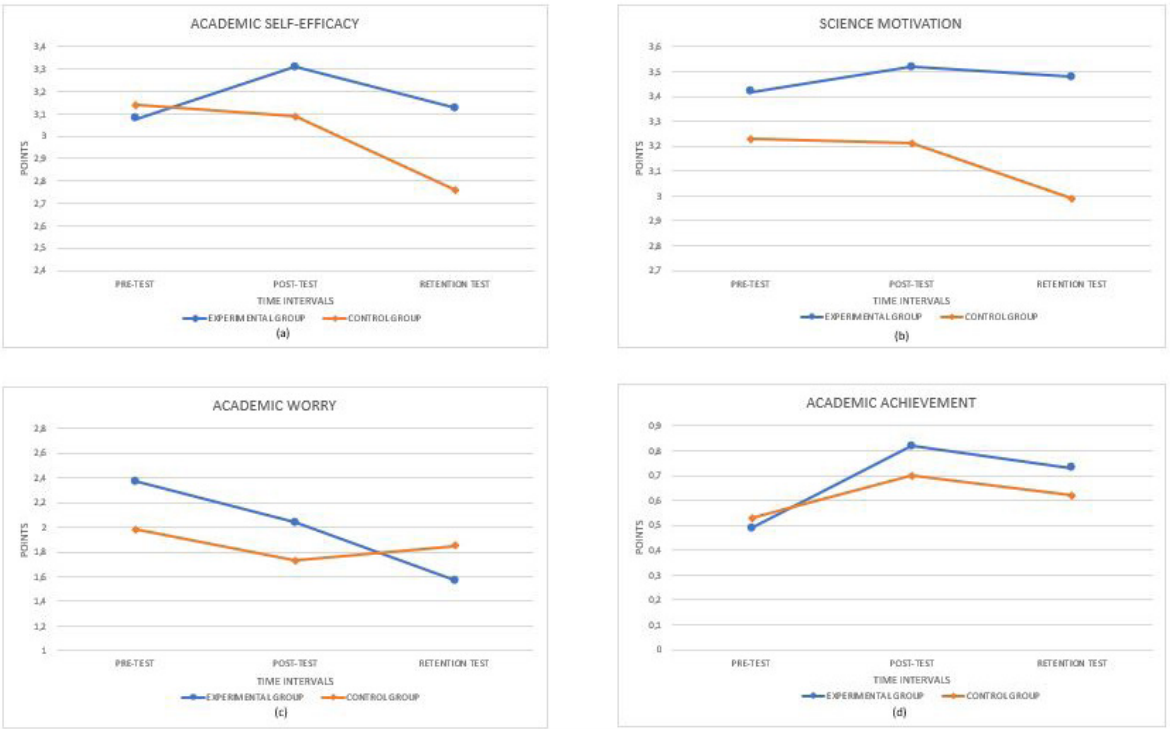
a continuous fall throughout the testing periods. In the control group, however, a moderate decrease in students' academic worry scores in the post-test was followed by a slight increase in the retention test, indicating no noticeable change overall. The graphical representation is provided in Figure 1c.

Figure 1
Graphical Representations of the Effects of the Independent Variables on the Dependent Variables



Note: Independent Variables - Group: experimental vs. control; Time: 1- pre-test (time 1), 2- post-test (time 2), 3- retention test (time 3)
Dependent Variables - (a) academic self-efficacy, (b) science motivation, (c) academic worry, (d) academic achievement

As presented in Table 3 and illustrated in Figure 1d, academic achievement levels of the students in both groups showed no statistically significant difference [$F(1,37) = 2.70$, $p = .11$]. On the other hand, in terms of time variable, a statistically significant difference with a high effect size was detected [$F(2,74) = 49.99$, $p < .001$, $\eta_p^2 = .58$]. The post hoc analyses revealed that students' academic achievement levels differed significantly at all three time points ($p < .001$). The group and time interaction effect was also significant with a high effect size [$F(2,74) = 6.62$, $p = .002$, $\eta_p^2 = .15$]. Although, there was no difference in groups at pre-test ($p = .42$), differences in scores were detected at post and retention tests, in favor of the experimental group ($p = .003$ and $p = .04$). In the experimental group, significant differences were detected between pre- and post ($p < .001$), pre- and retention ($p < .001$), and post- and retention test scores of ($p = .007$). In the control group, significant differences were found between pre- and post and post- and retention test scores ($p < .001$ and $p = .02$). No statistically significant difference was found between pre- and retention test scores of the control group students, meaning that students basically had not adequately remembered what they had learned earlier ($p = .12$). Overall, academic achievement scores of the students in the experimental group showed a greater increase at all time intervals compared to those in the control group.

Discussion

The purpose of this study was to examine the impact of the use of SRLS on fourth-grade students' academic self-efficacy, science motivation, academic worry, and academic achievement outcomes in primary school science classrooms. The major interest was to see whether the effect of SRLS on student outcomes at

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the primary school level would produce similar results with the studies conducted at secondary school or higher levels. The obtained results were in the predicted directions and coherent with the existing research. The comparisons of the students' scores between the experimental and the control groups in terms of self-efficacy, science motivation, academic worry and academic achievement showed statistically significant differences in favor of the experimental group. The obtained differences between groups were consistent with the previous studies (Mesurado et al., 2018; Öztürk & Çakıroğlu, 2021; Schraw et al., 2006).

The use of SRLS in the learning process significantly positively impacted students' academic self-efficacy. This outcome was coherent with the existing research (Cerezo et al., 2019; Lavasani et al., 2011; Roick & Ringeisen, 2017; Schraw et al., 2006; Zimmerman & Kistantas, 1997). The link between the use of SRLS in the learning process and academic self-efficacy might be twofold. The present study revealed that the SRLS positively impacts academic self-efficacy. Correspondingly, higher self-efficacy may indeed trigger one's motivation to learn and practice appropriate learning strategies when needed.

In the current study, similar to the self-efficacy findings, it was found that the use of SRLS in the learning process had a positive impact on students' science motivation. This result was also in line with the relevant research in the field (Lavasani et al., 2011; Soltani & Askarizadeh, 2021; Schraw et al., 2006; Pintrich & De Groot, 1990; Pravesti et al., 2020). Motivation is a key factor triggering behavioral engagement and learning and, eventually, leading to greater academic performance in any given discipline. Therefore, searching for ways to improve students' motivation in learning environments attracts researchers' attention in the field. The present study provided supporting evidence that one way to improve students' motivation in class is to expose students to SRLS in learning.

The present research showed that the use of SRLS significantly negatively impacted students' academic worry as supported by previous research (Mesurado et al., 2018; Morosanova & Fomina, 2017). Worry and other related negative emotions set a big barrier to students' learning and academic performance. Students' emotions are affected by many variables in learning contexts. In recent years, motivation research has focused more on academic emotions (Linnenbrink-Garcia & Pekrun, 2016; Reeve, 2018). The practice of proper SRLS may successfully inhibit the arousal of negative emotions in classroom environments, as it was the case for worry outcomes in the current study.

One of the most critical findings in the present study was related to academic achievement. The results of the current study provide evidence that the adoption of SRLS in the learning process significantly advances students' achievement outcomes. Apparently, almost all students lose or fail to remember some information they acquired throughout the learning process, but its magnitude matters the most. Essentially, it is important that students should not arrive at where they have already started when learning new information, as it was almost the case for the control group students in the present study. In the experimental group, however, students' academic achievement scores in the retention test differed significantly positively from the pre-test, even though a slight fall in scores over time was detected. The use of SRLS stimulates students' active engagement in their own learning process. The positive connection between SRLS and academic achievement put forth in the relevant studies worldwide as well (Cerezo et al., 2019; Cheng, 2011; Lenes et al., 2020; Núñez et al., 2022; Öztürk & Çakıroğlu, 2021; Vettori et al., 2020). Using SRLS in science lessons supports the enrichment of students' self-regulatory skills (Velayutham et al., 2011) and results in higher academic success. Moreover, in the current study, increased self-efficacy and motivation and decreased worry outcomes, emerged as a result of the use of SRLS, potentially stimulated students' academic performance as well.

The overall results showed that students' self-efficacy and academic performance decreased slightly four weeks after the implementation of the treatment, showing the importance of continuous exposure to strategies to preserve positive outcomes (Vassallo, 2011; Weinstein et al., 2011). Nevertheless, students' levels of worry continued to drop over time, suggesting that the effect of SRLS instruction had a seemingly more lasting effect on worry outcomes. More studies are needed to understand the psychological nature of these differences.

Conclusions and Implications

Students' self-regulated learning behaviors and strategies, antecedents and consequences of these processes, and related mechanisms affecting learning have long been studied in diverse contexts, predominantly starting from middle schools. Using an experimental design, the presented research showed that the use

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of SRLS had a positive impact on students' academic self-efficacy, science motivation, academic worry, and academic achievement outcomes in a fourth-grade science classroom. The obtained results supported the notion that the use of SRLS, starting at an earlier age than predicted, may hold a high potential to contribute to students' motivation and learning. As a concerning issue for parents and teachers worldwide, many students struggle with acquiring proficiency in science and math in schools. SRLS training in educational contexts may help students overcome their struggles in these highly critical disciplines, which play central roles most of the time in reaching career goals.

This study provided evidence that strategy instruction essentially works and results in positive academic outcomes for students in primary school classrooms. That being the case, primary school teachers need to use SRLS more often in their classrooms and spread the knowledge about the value of the use of SRLS in the learning process. Teachers should also provide guidance for students on their individual and collaborative attempts at strategy use. In order for teachers to acquire sufficient knowledge and to design effective implications of SRLS during the learning process, they need proper training as well. Developing pre- and in-service teacher training programs promoting the use of SRLS would certainly contribute to students' life-long productiveness, achievement, and well-being.

Based on the design and the outcomes of the current research, several suggestions might be provided for future research. The present research was carried out in one private school with the participation of a limited number of students within a single discipline. Therefore, findings may not be generalizable to students in different contexts. This limitation leads to the need for more research in primary schools with the inclusion of diverse disciplines. The SRLS used in this study was limited to several strategies which were goal-setting, planning, note-taking, monitoring, and self-evaluation. The use of a wide range of SRLS may enhance the obtained outcomes. It is expected that a gradual increase in the number of SRLS that are explicitly instructed, modelled, and practiced in classroom settings would support students' positive motivational, emotional, behavioral and academic learning outcomes. In the current study, the experimental period was limited to eight weeks, restraining acquiring adequate information on the potential long-term effects of strategy instruction. Therefore, more longitudinal studies focusing on diverse cognitive, affective, and behavioral variables would contribute to the relevant literature. Moreover, in future studies, gathering diverse data using mixed methods, including qualitative data, may help researchers better understand the nature of the relations among given variables and the specific roles that each strategy plays on student outcomes. The use of SRLS involves an ongoing process outside the school. Given that, the potential effect of parental involvement in this process is also highly important, requiring attention from researchers in the field. Obviously, research factors, will continue to grow in the future. The obtained outcomes of the current study will hopefully stimulate more research on students' self-regulated learning behaviors and strategies in primary school contexts.

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Declaration of Interest

Authors declare no competing interest.

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Busra Cengiz-Istanbullu MA, Primary School Teacher, Istanbul, Turkey.
E-mail: bsrcngz34@gmail.com
ORCID: https://orcid.org/0000-0002-6680-6141

Gonul Sakiz
(Corresponding author) PhD, Associate Professor, Department of Elementary Education, Ataturk Faculty of Education, Marmara University, 34722 Istanbul, Turkey.
E-mail: gonul.sakiz@marmara.edu.tr
ORCID: https://orcid.org/0000-0002-7095-9554

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