

Impact of a Mnemonic Strategy on Learning Science Concepts for Middle School Students With Specific Learning Disabilities

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The purpose of this experimental study was to examine the effectiveness of the keyword strategy, one of the mnemonic strategies, in learning science concepts for middle school students with specific learning disabilities (SLD) in Türkiye. The participants were 27 middle school students between the 5th and 8th grades receiving supplemental instruction in special education and rehabilitation centers. In addition to the existing supplemental instruction in the centers, the students in the experimental group received science concept instruction based on the keyword strategy. This implementation was carried out once a week for three weeks for each student. The students in the control group followed the regular supplemental instruction in their centers. Data was collected using the science concept measurement tool and the social validity form prepared by the researchers. The data was analyzed via the analysis of variance (ANOVA) test. The results indicated a significant improvement in science concept scores for students in the experimental group from pretest to posttest, and this improvement was retained in the scores of the follow-up test conducted six weeks after the implementation. The social validity findings showed that these students generally expressed positive opinions about the science concept instruction based on the keyword strategy. For future research, studies should compare the performance of typically developing students and students with SLD who receive instruction based on the mnemonic strategies.

Keywords: **specific learning disabilities, science education, mnemonic strategies, keyword strategy, middle school students, Türkiye**

Introduction

Students with specific learning disabilities (SLD) are frequently encountered among students who receive inclusive education in general education settings (Gal et al., 2010). It is acknowledged that students with SLD have difficulties in acquiring basic academic skills, although they have normal or above-normal intellectual skills (Melekoğlu, 2020). One of the basic academic courses that students with SLD in primary school must attend is science. Science education given in this period enables students to make sense of the world and their environment, use the materials around

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them, solve problems, get to know their bodies, and learn more about basic subjects such as good nutrition (Isik-Oner & Akcay, 2021). Studies indicate that students with SLD perform poorly in science classes (Brigham et al., 2011; Kaldenberg et al., 2015). One of the possible reasons for this is that the concepts in science courses are generally abstract and require predominantly cognitive performance (Brigham et al., 2011). Mnemonic strategies are known as memory-supporting strategies and aid in coding by creating associations that do not exist naturally (Gore, 2010; Scruggs & Mastropieri, 1990; Selcuk, 2018). Various scholars have classified mnemonic strategies in different ways. According to Thompson (1987), mnemonic strategies are divided into five groups: linguistics, spatial, visual, physical response, and verbal. However, Baddeley (1999) classified mnemonics into visual and verbal strategies. Among the strategies created using visual symbols, the most frequently used (keyword strategy) was first developed by Atkinson (1975). It consists of an acoustic bond established between words and the steps of supporting this bond with visuals (Atkinson, 1975; Mastropieri et al., 2000). Levin (1988) further simplified the steps of the strategy and grouped them under three headings: "Saving," "Associating," and "Retrieval." In the first stage, a word that is similar to the target word in pronunciation is determined; this word is the keyword. In the second stage, the association stage, the target word is associated with the keyword via verbal repetition. In addition, an image representing the keyword can be drawn by the student or used on hand. In the last stage, the keyword and image are remembered when the target word is heard, and thus, the meaning of the target word is found (Levin, 1988). For example, the "orange" keyword was determined for teaching the concept of origin, which is the center of the coordinate plane, and the "origin–orange" association was created by adding an orange image to the origin. In the retrieval stage, which is the last stage, the students are asked what the target word means, and they are asked to reach the meaning of the target word by first remembering the keyword and then the related image from the moment they hear the target word (Siegel, 2017).

The keyword strategy, like other mnemonic strategies, facilitates learning by making concepts that are difficult to remember more concrete (Lubin & Polloway, 2016). The inclusion of both images and keywords that students already know in the strategy facilitates learning. Previous research findings indicate that these strategies, which are included in the teaching process, increase the students' motivation and thus increase their learning performance (Dunn & Miller, 2016; Scruggs & Mastropieri, 1989). In addition, these strategies not only increase learning performance but also support the students' creativity (Cioca & Nerisanu, 2020). For example, the creation of associations that do not exist naturally in the keyword strategy and the use of interesting visuals can help attract students' attention and develop their creativity.

Studies using mnemonic strategies in the literature have revealed that these strategies are effective (Boon et al., 2019; Lubin & Polloway, 2016). For example, Lubin and Polloway (2016) examined nine studies on mnemonic strategies that could be used in science and social sciences instruction for students with SLD. Among the reviewed studies, King-Sears et al. (1992), Scruggs et al. (1985), and Scruggs et al. (1987) focused on the impact of mnemonic strategies on the science learning of students with SLD. Their findings indicate that mnemonic strategies are effective in teaching science and social sciences, and they suggested the dissemination of mnemonic strategies

in teaching students with SLD. Although effective strategies such as mnemonic strategies for the science education of students with SLD have been investigated in the international literature, there is a limited number of studies on this subject in Türkiye (Er Nas et al., 2019). Furthermore, Karaer and Melekoglu (2020) examined intervention studies published between 2008 and 2017 related to science education for students with SLD. Their findings showed that these studies are usually found in the international literature, with no such intervention study in Türkiye. Moreover, when the recent literature is further examined, few experimental studies have been conducted using the keyword strategy in special education (Consiglio, 2018; Fontana et al., 2007; Irish, 2002; Kleinheksel, 2005; Siegel, 2017; Terrill et al., 2004). Among these recent studies, only a limited number focus on the use of keyword strategy in science education (Karaer & Melekoglu, 2020; Kleinheksel, 2005). Therefore, there is a strong need to investigate the impact of the keyword strategy in teaching science to students with SLD in Türkiye. This is so that researchers can expect a dissemination of the use of mnemonic strategies in science education for students with SLD in the Turkish education system. In addition, teachers' awareness of mnemonic strategies and their ability to implement these strategies may contribute to strengthening their students' memory (Selcuk, 2018). Accordingly, this study aimed to examine the effectiveness of the keyword strategy, one of the mnemonic strategies, in learning science concepts for middle school students with SLD in Türkiye. In line with this purpose, answers to the following questions were sought:

1. Is there a statistically significant difference in the science concept scores of students in the experimental and control groups from pretest to posttest?
2. Are there statistically significant differences in the science concept scores of students in the experimental group among the pretest, posttest, and follow-up test?
3. What are the opinions of the students in the experimental group about the keyword strategy?

Method

Experimental Design

The research used a quasi-experimental design with a pretest-posttest control group. There are two groups—the control and the experimental group—and the pretest and posttest data is collected from both groups (Mills & Gay, 2016). While the dependent variable of the study is the success level of the participants (their score from the science concept measurement tool), the independent variable is the instruction based on the keyword strategy.

Participants

The participants were 27 middle school students with SLD between the 5th and 8th grades receiving supplemental instruction in special education and rehabilitation centers in Türkiye. Among the participants, 20 students were boys, and seven students were girls. The ages of the students ranged from 10 to 13. The Anadolu-Sak Intelligence Scale (ASIS) scores of the students varied between 70 and

107, and the scores showed that the intelligence level of all the students was within the normal range. The participating students were randomly assigned to the experimental and control groups, and each group consisted of 14 participants. During the study, 13 students remained in the experimental group because one student left the study. The research group was determined using criterion sampling. Middle school students diagnosed with SLD who had four or fewer correct scores from the science concept measurement tool were included in the study group. Levene's test was used to determine whether the students differed in terms of age, ASIS, and science concept measurement tool score. According to the Levene's test results, the experimental and control group students' ages ($F = 0.135$, $p > .05$), ASIS scores ($F = 0.219$, $p > .05$), and science concept measurement tool scores ($F = 0.565$, $p > .05$) were not significantly different.

Data Collection Instruments

At the beginning of the research process, the science concept determination form was prepared to determine the concepts taught throughout the process, and this form was prepared after the concepts were determined. To be used in the pretest, posttest, and follow-up test, the science concept measurement tool prepared by the researchers was included. A social validity form was prepared to collect social validity data.

Anadolu-Sak Intelligence Scale (ASIS)

The ASIS is an individually administered intelligence scale that objectively measures general intelligence and the main components that constitute this intelligence. While the individual implementation of the scale for children aged 4–12 years takes 25–45 minutes, its scoring takes three minutes. Consisting of seven sub-tests, the ASIS provides eight different profiles of performance. Within the analyses made, the internal consistency reliability coefficient of the ASIS is a median of .91 for the sub-tests and a median of .97 for the components' scores. These values indicate a perfect level of internal consistency. The sub-test and component scores' reliability coefficients were found to be .81 minimum and .99 maximum. Especially since the reliability coefficients of general IQ, verbal IQ, and visual IQ are .99, .99, and .97, respectively, this indicates that diagnoses based on these scores may also be reliable. Within the test–retest reliability study of the ASIS, an increase in standard deviation of .3 occurred in the General Intelligence Index (GIQ), .25 in the Verbal Ability Index (VAI), .3 in the Nonverbal Ability Index/Visual Ability Index (NVAI), and about .3 in the Memory Capacity Index (MCI). However, these increases are quite low. Since the ASIS is a new test for children and it is difficult to remember the items of many sub-tests, these may be the two most important causes of diminishing the effect of learning (Sak et al., 2016).

Science Concept Determination Form

The science concept determination form has been prepared to determine the most common science concepts within the framework of four main subject areas in the science education program of Türkiye. The form was delivered to volunteer classroom teachers and science teachers. A pool was created from the science concepts

in the form, which was delivered to 32 volunteer teachers, and the concepts that could be adapted to the keyword strategy were determined. The science concepts of "sphere," "continent," "ocean," "sun," "planet," "substance," "waste," "gas," "force," and "pulling force" were determined to be taught, and the included science concepts were classified into four main subject areas. In addition, primary school science book samples were examined, and science concepts in the books were included.

Science Concept Definition Form

The science concept definition form was prepared to define the determined science concepts. For these definitions, primary school science books were examined, and the definitions were created by considering the opinions of an expert with a doctorate in science. Then the science concept definitions were listed in a form. The forms were distributed to 35 volunteer classroom teachers, and their opinions were received on the appropriateness of the science concept definitions, along with their suggestions. The definitions were finalized in line with these opinions.

Science Concept Measurement Tool

After the science concepts and their definitions were clarified, the science concept measurement tool was created by the researchers to administer all the pretest–posttest and follow-up tests. The definitions of the science concepts were included in a questionnaire, and a form consisting of 10 short-answer questions was prepared. While the maximum score that can be obtained from these questions is 10, the minimum score that can be obtained is 0. A pilot study was conducted by administering this measurement tool to 20 students who showed typical development, and it was observed that the questions measured the target concepts.

Social Validity Form

The social validity form was created by the researchers to determine the students' views on the strategy. While the form was being prepared, opinions were received from two experts with doctorate degrees in special education. The form includes 12 questions consisting of three answer options ("yes," "no," "undecided"). In addition, there are two open-ended questions regarding the study.

Data Collection Process

All the implementations were provided in the Turkish language and carried out one-on-one with each student in the students' centers.

Pilot Implementation Process

A session was held with a middle school student (6th grade) with SLD to collect information about whether she knew the meanings of the keywords, whether she could associate the keywords and target science concepts, her views on the visuals, the order of instruction of the target concepts, and the session durations. At the end of the session, necessary arrangements were made, and the teaching plans were finalized. After the arrangements, the science concept keywords in Turkish were clarified (globe–oar [küre–kürek], continent–weft [kıta–atkı], ocean–dolphin [okyanus-yunus], substance–street [madde–cadde], gas–soda [gaz–gazoz], waste–

thrower [atık–atıcı], force–tub [kuvvet–küvet], pulling force–drawer [çekme kuvveti–çekmece], planet–traveler [gezegen–gezgin], and sun–fire [güneş–ateş]). The visuals used for each science concept were prepared by a designer. Figure 1 shows a sample image prepared for the science concept "planet," and in Figure 2, a sample image is prepared for the science concept "ocean."

Figure 1. **Planet-traveler image**

Figure 2. **Ocean-dolphin image**

Implementation of the Science Concept Measurement Tool for Typically Developing Students

For the implementation of the prepared science concept measurement tool, 20 students in two public primary schools were reached. The students attended the 4th grade of primary school, and the interviews reveal that they have not been diagnosed with any disability. The science concept measurement tool was administered to each student in the school guidance unit. Necessary preparations were made before the

implementation, and the students were informed about the study. The first researcher read the questions in the measurement tool herself, and the students were asked to answer the questions from the calendar as the measurement tool was placed in front of them. The answers were recorded (written down) by the first researcher, and after all the questions were read and answered, the students were given two stickers of their choice. The percentage of questions answered correctly was 69%, and the students with typical development answered seven out of the 10 questions correctly. In summary, primary school students with typical development have learned most of the targeted science concepts.

Implementation of Pretest

The results of the science concept measurement tool administered to form the study group were accepted as the pretest results, and the process administered to the students with typical development was followed. First, the calendar with the questions, the science concept measurement tool form, and stickers were prepared, and information about the administration was given. The first researcher read the questions in the science concept measurement tool, and the students were asked to follow the questions on the calendar. The answers were recorded (written) by the first researcher, and after all the questions were read and answered, the students were given two stickers of their choice. No information was given about the answers, and one month after the pretest data was collected, the science teaching plan prepared using the keyword strategy began implementation, with 13 students in the experimental group.

Implementation Process using Keyword Strategy

The science teaching plan, which was prepared using the keyword strategy, was implemented one day a week, along with one session for three weeks. The necessary permissions were obtained before the implementation, and all the implementations were conducted one-on-one with each student in their centers. All three sessions were held similarly, and the only difference was the reinforcements given at the end of the session. The sessions were completed in seven weeks. Three concepts were taught in the first two sessions and four in the last session. All the sessions were carried out using the modeling strategy.

Each session consists of five steps. The first step is the introductory step, wherein the researcher states the names of the concepts to be learned in this session (globe–oar [küre–kürek], continent–weft [kıta–atkı], ocean–dolphin [okyanus–yunus]) and explains their reinforcement. Then when the student is ready, the process begins. The second step is the introduction to the strategy. In this step, the researcher states the name of the strategy (keyword strategy) and talks about what the strategy is used for ("When someone asks us what these concepts mean, we may have a hard time remembering what these concepts mean. So we will use a strategy where we can easily remember what these concepts mean"). Then the researcher introduces strategy-specific materials (keywords–images). The third step is the introduction of the concept. In this step, the card with the definition of the concept is taken out, and the researcher reads the definition out loud, followed by the student. A connection is then established by stating the concept–keyword pair on the card. Immediately after,

the previously prepared image is placed on the table and is explained by the researcher and then the student (the latter is given the necessary clues). In the fourth step, the student is active. The student first tries to remember the keyword when recalling the definition of the learned concept and then tries to remember what happened in the image. Where necessary, the researcher provides clues and allows the student to repeat the strategy steps. The last step is the summarization step, wherein the researcher repeats the strategy steps and ends the process by giving reinforcement to the student.

Implementation of the Posttest

After the implementation of the science teaching plans prepared using the keyword strategy, the posttest was applied. It was carried out similarly to the pretest. The posttest data of the students in the control group was collected within one week after the implementation process was completed using the keyword strategy.

Implementation of the Follow-Up Test

The data was collected six weeks after the completion of the implementation process using the keyword strategy. The follow-up, collected in a manner similar to that of the pretest and posttest, was taken only from the students in the experimental group.

Social Validity Data Collection

The prepared social validity form was distributed to the experimental group students to determine their views on the implementation process using the keyword strategy, and the students were asked to fill out the form. Then the students were thanked for their participation. A sample session was held with the students in the control group to see how the implementation process was carried out using the keyword strategy.

Analysis of Data

Mixed-model ANOVA was used to examine whether there is a significant difference between the pretest and posttest mean scores of the students who were taught using the keyword strategy and those who were not. To use this analysis, two basic assumptions must be met: normal distributions and homogeneous variances. To test the normality of the measurement distributions, Kolmogorov–Smirnov and Shapiro–Wilk analyses as well as Z score calculations can be performed (Taspinar, 2017). In cases where the number of participants is less than 50, the result obtained by dividing the skewness and kurtosis values with their standard errors is between −1.96 and +1.96, which indicates that the distribution is normal (Field, 2013). If it is between −1.96 and +1.96, the skewness or kurtosis value is included in 95% of the total values (Kim, 2013). Table 1 shows the skewness and kurtosis values, standard errors, and Z scores of the experimental and control groups.

Table 1. ***Experimental and Control Group Pretest-Posttest-Follow-up Skewness and Kurtosis Values and Z Scores***

Groups	Test		Values	Standard Error	Z scores
Experimental	Pretest	Skewness	-.218	.616	.3538
		Kurtosis	-1.568	1.191	1.3165
	Posttest	Skewness	-.126	.616	.2045
		Kurtosis	-1.637	1.191	1.3744
	Follow-up	Skewness	-.543	.616	.8814
		Kurtosis	-.980	1.191	.8228
Control	Pretest	Skewness	.443	.597	.7420
		Kurtosis	-1.037	1.154	.8986
	Posttest	Skewness	.417	.597	.6984
		Kurtosis	.077	1.154	.0667

As shown in Table 1, the Z score values are in the desired range. Thus, in this case, the pretest and posttest measurement distributions of the experimental and control groups are normally distributed. Levene's test was used to determine the homogeneity of variances, which is another of the two basic assumptions. According to the Levene's test results, the variances provide the homogeneity assumption when the significance scores are greater than .05. The variances were homogeneous according to the pretest ($F = .340$, $p > .05$) and posttest ($F = 1.064$, $p > .05$) measurements of the experimental and control groups.

In line with the research purpose, one-way ANOVA was used to examine whether there were significant differences among the science concept measure tool pretest, posttest, and follow-up mean scores of the students who were taught using the keyword strategy. One-way ANOVA is used when there are more than two measurements obtained from the same group (Taspinar, 2017). The number and percentages of students for each item in the social validity form (created to determine the views of the students who were taught using the keyword strategy about this strategy) were calculated. To determine whether the teaching sessions were carried out as planned, the recordings of these sessions were monitored by a researcher who is an expert in the field of special education, and the treatment fidelity was found to be 100% by dividing the observed practitioner behavior by the planned practitioner behavior and multiplying the result by 100.

Results

To examine the effect of the keyword strategy on the learning of primary school science concepts for middle school students with SLD, the analysis results were applied to determine whether there is a significant difference between the pretest and posttest mean scores of the students who were taught using the keyword strategy and those who were not.

Table 2. ***Descriptive Analysis Findings on Pretest-Posttest Scores of Experimental and Control Groups***

Groups	N	Pre-test		Post-test	
		$\bar{x}$	SD	$\bar{x}$	SD
Experimental	13	2.38	1.44	7.61	1.98
Control	14	1.50	1.34	2.35	1.78

According to the descriptive analysis findings in Table 2, the pretest mean of the experimental group was 2.38, while that of the control group was 1.50. The posttest averages of the groups show that the experimental group's was 7.61, while the control group's was 2.35. While the pretest averages of the groups are similar, their posttest averages are different. A mixed-model ANOVA test was performed to examine whether this difference was statistically significant. The test findings are given in Table 3.

Table 3. ***Mixed Model ANOVA Findings on Pretest-Posttest Scores of Experimental and Control Groups***

Variance Source	SoS	SD	MS	F	p	η2
Between Groups						
Group (Experimental-Control)	127.180	1	127.180	26.751	.000*	.517
Error	118.857	25	4.754			
Within Groups						
Measurement (Pretest-Posttest)	124.915	1	124.915	173.387	.000*	.874
Group*Measurement	64.470	1	64.470	89.488	.000*	.782
Error	18.011	25	.720			

Note. *p <.05; SoS= Sum of Squares; MS= Mean Square

As shown in Table 3, a significant difference was found between the mean scores of the experimental and control groups, regardless of the test ($F_{(1, 25)} = 26.751$; $p < .05$; $\eta 2 = .517$). Accordingly, the experimental group ($\bar{x} = 5.00$) was more successful, with an average greater than that of the control group ($\bar{x} = 1.92$). The effect size was found to be $\eta 2 = .517$. Based on this value, being in a different group has a more significant effect (.517 > .14). In addition, there is a significant difference in the comparison of the pretest and posttest mean scores regardless of the groups ($F_{(1.25)} = 173.387$; $p < .05$; $\eta 2 = .874$). When the averages were examined, the posttest mean score ($\bar{x}$= 4.88) was found to be higher than the pretest mean score ($\bar{x} = 1.92$). The effect size (.874 > .14) can be considered high. Given the joint effect of the measurement and the group, there was a significant difference between the means ($F_{(1.25)} = 89.488$; $p < .05$; $\eta 2 = .782$). In the experimental group, the pretest mean score

was 2.38, and it increased to 7.61 in the posttest, showing a higher increase compared to the control group. Thus, the effect is significant (.782 > .14).

The results of the analysis were applied to examine whether there are significant differences among the concept measurement tool pretest, posttest, and follow-up test score averages six weeks after the posttest of the students who were taught using the keyword strategy.

Table 4. ***Descriptive Analysis Findings on the Experimental Group Pretest-Posttest-Follow-up Scores***

Groups	N	Pretest		Posttest		Follow-up	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Experimental	13	2.38	1.44	7.61	1.98	7.00	1.63

According to the descriptive analysis findings in Table 4, the experimental group's pretest average was 2.38, its posttest average was 7.61, and its follow-up test average was 7.00. There is a notable increase after the pretest and a slight decrease after the posttest. One can also see that the highest mean is in the posttest. One-way ANOVA was performed to examine whether this difference was statistically significant. The findings are given in Table 5.

Table 5. ***One-Way ANOVA Findings on Experimental Group Pretest-Posttest-Follow-up Scores***

Source	SoS	SD	MS	F	p	Significant Difference	η2
Groups (Experimental)	80.667	12	6.722				
Measurement	212.513	2	106.256	108.576	.000*	1-2 1-3	.90
Error	23.487	24	.979				

Note. *p <0,05; SoS= Sum of Squares; MS= Mean Square 1= pretest; 2= posttest; 3= follow-up

Table 5 shows a significant difference between the pretest–posttest and pretest–follow-up test measurements ($F_{(2,24)}$ = 108.576, p < .05). No significant difference was found between the posttest and the follow-up test.

The 12 items in the social validity form prepared to determine the students' views about the strategy (whose science teaching plans, prepared using the keyword strategy, were applied) were answered by choosing one of the following options: "yes," "no," and "undecided." Each option was evaluated on an item basis, and the percentages were calculated by determining the number of students who preferred the options. The students' views on the strategy are given in Table 6.

Table 6. ***Students' Views on Strategy***

Items	Yes		Undecided		No	
	f	%	f	%	f	%
1- I think that the science concepts I learned are important for the science course	13	100	0	0	0	0
2- Keywords were like the science concepts that I would learn as pronunciation.	13	100	0	0	0	0
3- Keywords were easy to remember.	9	69.23	4	30.77	0	0
4- I liked the visuals used in the strategy.	12	92.31	1	7.69	0	0
5- It was easy to remember the visuals used in the strategy.	9	69.23	4	30.77	0	0
6- Strategy supported me to learn the definition of science concepts.	12	92.31	1	7.69	0	0
7- It was fun to learn the keyword strategy.	13	100	0	0	0	0
8- I plan to use the strategy for other lessons as well.	11	84.62	1	7.69	1	7.69
9- I would like to participate in another study that will be carried out using the same strategy.	11	84.62	1	7.69	1	7.69
10- I think I learned all 10 concepts as well.	8	61.54	4	30.77	1	7.69
11- I think I will remember the science concepts for a long time.	4	30.77	8	61.53	1	7.69
12- At the end of the study, I started to like the science lesson more.	9	69.23	3	23.08	1	7.69

All the students marked "yes" in three items. The "I think I will remember the concepts for a long time" item was marked by four students. Eight students marked the option "undecided," while the remaining one selected the option "no." One of the open-ended questions was "What is your favorite part of the study?" In response to the question, five of the students said that they like to be taught with visuals, one likes to use keywords, two like to use both visuals and keywords, one likes visuals, keywords, and his teacher, one likes it to be fun, one likes to be given reinforcement, and two like everything in the study. The other question was "What would you like to change if you did this study?" All the students answered the question by saying that there was nothing they wanted to change.

Conclusion, Discussion, and Recommendations

In the research conducted to examine the effectiveness of the keyword strategy, one of the mnemonic strategies, in learning science concepts among middle school students with SLD, answers were sought to three research questions determined in line with the analyses made. First, it investigated whether there was a significant difference between the pretest and posttest mean scores of the students who were taught using the keyword strategy and those who were not. There was a significant difference between the pretest and posttest mean scores of the experimental group, and the students' mean scores increased in the posttest. Accordingly, the effect of being in the group taught using the keyword strategy on learning science concepts has a high level. This result is consistent with those of previous studies (Consiglio, 2018; Fontana et al., 2007; Kleinheksel, 2005; Siegel, 2017). As a result of the same concept measurement tool applied to students with typical development, the students were able to correctly answer seven of the 10 questions asked on average. The posttest average of the students in the experimental group ($\bar{x} = 7.61$) shows that the students in this group were able to reach a similar performance level to their typically developing peers. This result matches findings in the literature, according to which students with SLD can perform similarly to their peers with typical development when effective methods and strategies are used (Pierangelo & Giuliani, 2006). Research findings examining the effectiveness of the keyword strategy in which both individuals with typical development and students with SLD participate are in line with those of research in which students with SLD participate (Baleghizadeh & Ashoori, 2010; Carney & Levin, 2000; Keskinkılıc, 2005; Köksal, 2012; Sahin & Kil, 2018). In the study, there was a difference between the pretest and posttest mean scores of the control group students who followed the program in their centers. A slight increase was observed in the mean score of the group that was not taught using the keyword strategy, from the pretest ($\bar{x} = 1.50$) to the posttest ($\bar{x} = 2.35$). This situation constitutes the limitation of the research, and more measures can be taken in other studies to control external variables.

Second, the study examined whether there were significant differences among the pretest, posttest, and follow-up test scores of the students who were taught using the keyword strategy six weeks after the posttest. There was a significant difference between the pretest–posttest and pretest–follow-up test measurements, and there was no significant difference between the posttest and follow-up test. This result is consistent with the findings of previous studies (Irish, 2002; Scruggs & Mastropieri, 1992; Siegel, 2017). Based on the posttest–follow-up test score averages, there is a decrease in the students' follow-up test score averages. This decrease is usually expected in follow-ups (Tekin-Iftar & Kircaali-Iftar, 2013) but despite this, students with SLD caught the average of students with typical development.

Finally, the students' views about the keyword strategy were examined. It was concluded that all the students found it enjoyable to learn science concepts with the keyword strategy, that the concepts they learned were important for the science lesson, and that the determined keywords were similar to the concepts they would learn given their pronunciation. These results are consistent with those of other studies in the literature (Dewitt, 2010; Fontana et al., 2007; King-Sears et al., 1992; Mastropieri et al., 1994; Siegel, 2017). In addition, most of the students said, "I think

I will remember the concepts for a long time." They marked the item as "undecided." However, when the follow-up test score averages ($\bar{x} = 7.00$) calculated six weeks after the posttest were examined, the students showed consistent success. Despite this, the reason why students think that they cannot remember the concepts they have learned for a long time is thought to be related to the general characteristics of students with SLD. The literature states that these students may experience learned helplessness given their academic failures and that they can generalize their failures to other fields (Hersh et al., 1996).

This research reveals that the keyword strategy, which is one of the memory-supporting strategies, made a positive contribution to the learning of science concepts among middle school students with SLD and that the students maintained their performance in the follow-up test and expressed positive opinions about learning with the keyword strategy. In addition, considering the results of the research, instead of learning with ready-made keywords, students can create their own keywords, definitions, and visuals via a tablet and use different mnemonic strategies together, and different studies can be planned in which students with SLD and their typically developing peers participate.

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Authors' Note

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