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The Effects of SCAMPER Technique Activities in the 8th Grade Simple Machines Unit on Students' Academic Achievement, Motivation and Attitude towards Science Lessons*

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Abstract: This study examines the effects of the SCAMPER technique-based educational activities in the simple machines unit of a science lesson on students' academic achievement, motivation and attitude. The study examines the effects of the simple machines unit activities in the science lesson through a paired quasi-experimental design, which is one of the quantitative research methods. The sample group of the research consists of 33 eighth-grade students studying in a middle school in the Ortaköy district of the Aksaray province in 2018–2019. The research uses simple random sampling method. The experimental group was given SCAMPER-based activities in the simple machines unit for 4 hours a week with a total of 16 hours, and lessons were conducted with the control group in line with the curriculum. To collect data within the framework of the research, the 'attitude scale towards science lesson', scale for 'students' motivation towards science learning' and 'simple machines unit achievement test' were used. As a result, when compared to the control group, there was a significant difference in the academic achievement and motivation of the experimental group who performed SCAMPER-based activities in the simple machines unit of the science lesson. There was no significant difference between the attitude scores of the experimental and control group as a result of the study.

Keywords: *Academic achievement, attitude, creative thinking, motivation, SCAMPER, science education.*

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Introduction

Science and technology are in the process of rapid change and development in the 21st century's space age. In addition to keeping up with this age, to be a part of the development and to create a strong future, there is a need for individuals who are scientific thinkers, can come up with creative solutions and are innovative, critical, logical and reflective. From the earliest stages / phases of human history to today's information age, the needs of societies have guided and shaped education. To raise individuals who respond to problems with high-order thinking skills, educational programmes continuously change and prepare students for the conditions of the future. It is a necessity to be scientifically literate to be able to adapt to the rapidly changing world, explain certain basic scientific concepts, ideas and phenomena, utilise / make use of technological developments in daily life by following the changes, better analyse nature and society and have the ability to solve complex problems. Science courses are the key to this. One of the important goals of science education is to raise individuals with high-order thinking skills, who explore, question and design original products, to transfer what they have learned to new situations and to think differently (Ministry of Education [MoE], 2017). The realisation of these goals can only be achieved through creative science teaching. Creativity can form the basis for the development of useful products by gaining functionality with science education. To achieve these goals, creativity is a sought after characteristic in individuals. Güneş and Karaşah (2016) defined creativity as finding new and permanent solutions by the recognising the problems in life and stated that creative teaching is in harmony with science education. Creative teaching can form a basis for the development of useful products as it gains functionality through science education.

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Wayne (2006) explains creative teaching in two different ways. The first of these is 'teaching in a creative way' and the second is 'teaching with the aim of creativity'. According to these explanations, teaching in a creative way happens when teachers display creative approaches to make learning more interesting, attractive and intriguing. Education with the aim of creativity is teaching in a way that students have creative thoughts and behaviours. When students actively participate in the learning process, they can learn by doing, experiencing, observing and applying. This is possible with creative learning environments rather than teacher-centred teaching methods such as lectures and note-taking. In a study, Özerbaş (2011) investigated the effect of a learning environment designed in accordance with the creative thinking method on the permanence of student academic success and achievement. In its conclusion, the study observed that the academic success of the experimental group's students who studied in the creative thinking learning environment was better than the control group students who studied in the teacher-centred learning environment.

Success, which refers to the results of tests that include the expressions of information developed in lessons and specified with a quantitative score, indicates 'academic achievement'. However, success is not only limited to the cognitive dimensions of knowledge. The behavioural changes in the psychomotor and affective development of the student are also the elements of success (Ahmann & Glock, 1971). The affective domain includes emotional elements such as love, fear, hate, interest, attitude and motivation (Demirel, 2011). It is important to include students' emotions, feelings, attitudes and motivations in the learning process including these elements in teaching increases success (Bolin et al., 2005; Combs, 1982; Çermik & Fenli-Aktan, 2020; Erden & Akman, 2001). Motivation is one of the most important power sources of students' behaviour in school that determines the direction, intensity, determination and speed in achieving the desired goal in educational settings. Learning motivation is when the learner finds learning activities meaningful and valuable, and benefits from them. There are internal and external factors that affect learning motivation. Internal factors are related to the emotional and physical states of the individual such as attitude towards learning and achievement, interests, attention level and personal characteristics (Akbaba, 2006). According to Kind et al. (2007), attitude expresses an individual's feelings towards an object within the framework of their knowledge and beliefs about that object. Attitude towards science includes values, beliefs and feelings about science, science lessons at school and the effects of science on society (Osborne et al., 2003). Through the determination of students' attitudes in the teaching process, and their attitudes at a certain time, it is possible to determine their future behaviours and their attitudes about the current conditions, their attitudes can be changed or they can be made to form new attitudes. Thus, the behaviours of individuals could be determined and described scientifically. This provides the opportunity to be informed about their behaviours and to be guided (Baysan & Tekarslan, 1998; Öner, 1997). Therefore, it is important to determine the motivation and attitudes of the students to direct them correctly. In addition, the determination of whether the method used in the lesson creates new attitudes in students is relevant for reusing the applied method or the interpretation of further behaviours of the individual.

In the lessons prepared according to the constructivist theory, the students are expected to participate in the lesson effectively, access the information themselves and use the information they reach by associating it with other information. Consequently, the constructivist approach defines the individual as conscious, researching, creative students who know what, how and why to learn (Jonassen et al., 1999; Hançer, 2007). According to the science curriculum, the important elements of the learning process are the development of exploration, questioning, argumentation and product design skills (MoE, 2017). Also, in the science curriculum; it is expected that students are provided with opportunities that enable them to express and communicate in writing; verbally and visually, and to develop creative thinking skills (MoE, 2017).

It has been observed that creative intelligence is inherent in every individual, but creative thinking skills can be dulled or developed with the family's influence or education received at school (Karataş & Özcan, 2010). Through the usage of appropriate curricula, individuals can both develop their creative thinking skills and be successful (Erdoğdu, 2006; Tican, 2019). Demirci (2007) emphasised the necessity of using techniques that support creativity in lessons by preparing teaching environments in schools where students feel free and arrive at original ideas to develop creativity. Moreover, he suggested that in the programmes where creativity is targeted in science teaching, the evaluation of the process should be given more importance than the product. This situation shows that students' different opinions should be supported, they can express their opinions easily, they can develop opposite arguments, they can discuss their claims with justifications, and that an evaluation should be made based on the process rather than memorizing the knowledge. Student success can only come out as a cognitive process. With the transfer of creative learning environments to classes, learning environments that will allow students to develop their affective and psychomotor skills as well as their academic success will be created. Therefore, it has become a necessity to create creative classroom environments where the teacher is a guide and will develop creative thinking skills, and use innovative methods and techniques apart from traditional teaching methods (Bardak & Karamustafaoğlu, 2016).

The SCAMPER technique, also referred to as directed brainstorming; is one of the creative thinking techniques proposed by Alex Osborne in 1953 and developed by Bob Eberle. This technique, which consists of different steps and has open-ended questions at each step, enables students to think in a versatile way. It is a technique in which students can both develop their creativity and creative thinking skills and have fun as they progress through the steps (Yağcı, 2012).

SCAMPER, which means to scurry, rush, jump, is an acrostic formed by combining the initials of seven words:

S: Substitute

C: Combine

A: Adapt

M: Modify, Minify, Magnify

P: Put to other uses

E: Eliminate

R: Reverse

Michalko (2000) expressed the basic philosophy of the SCAMPER technique as 'Every idea is born from another existing idea' (As cited in Yıldız, 2003). The SCAMPER technique enables individuals to imagine, think about and design original products of an item (Yağcı, 2012).

Instead of restricting thoughts, this technique prevents the constant dwelling on certain ideas by developing different perspectives with various questions and producing alternative thoughts. It helps individuals go beyond their mental patterns, change or combine their thoughts. While applying the SCAMPER technique, there is directed brainstorming regarding the selected object. This technique, unlike brainstorming, includes certain steps. When implementing the SCAMPER technique, an item is first selected and this selected item can be changed, developed, divided into parts or combined with other objects as the steps progress. Questions can be asked to students at every step to reveal different ideas. With these questions, students can be made to think about the aspects they cannot think of (Yiğitalp, 2014). With the questions posed in the SCAMPER technique, a subject or object is requested to be changed or developed (Glenn, 1997). With the idea that the SCAMPER technique is effective in developing creative thinking, it is recommended to use this technique both as a teaching technique and as a creative thinking technique in support of creative thinking (Yıldız & İsrael, 2002; İslim, 2009; Poon et al., 2014).

Majid et al. (2013) investigated the effects of using the Internet and SCAMPER technique on creative writing. Of the 60 students, aged 10 and 11, those who used the Internet showed an improvement in their creative writing in terms of fluency and meticulousness, while SCAMPER users' creative language and attitude scores significantly improved. Jelena et al. (2014), while examining the effect of the SCAMPER technique on knowledge, self-confidence and motivation of students between the ages of 14–17, observed that students' knowledge, motivation and self-confidence increased. Moreover, the students participating in the study stated that they learned the basics of creativity and their creative thinking skills developed with the education they received. Poon et al. (2014) present creative thinking design and applications in a three-hour SCAMPER workshop with middle school students, for practitioners to design their short creativity programmes. The workshop includes various components such as a stimulating environment to facilitate creative thinking, opportunities for exploration and presentation, psychological safety, content knowledge and creative thinking skills. As a result of the study, the feedback of the students shows their satisfaction with the workshop and that they enjoy the creativity-enhancing workshop components.

Gladding and Henderson (2000) used the SCAMPER model to encourage creativity by explaining the different thinking factors that are part of the creative process due to the nature and importance of creativity in family counselling. They introduced the SCAMPER creativity model to clinicians or startup therapists as a practical way that shortens lengthy procedures, and that remind families of aspects of working creatively as well as being creative.

The study by Çeliker and Harman (2015), tried to reveal the effect of the SCAMPER technique on increasing the awareness of third-grade science students about the collection and use of solid wastes. According to the results of the research, science students identified schools and visual media as the main source of information on the collection and use of solid wastes. After the applications of the SCAMPER technique, the students stated that they would recycle all solid wastes except organic wastes and, if any, they would dispose of each type of waste in different recycling containers.

İslim (2009) conducted a research on the effect of the information and communication technologies course taught with the SCAMPER technique on students' creative problem-solving skills and academic achievement. As a result of the study, it was concluded that there was a significant difference in favour of the experimental group in the students' creative problem-solving scores and academic achievement. In his study, Yiğitalp (2014) examined the effect of SCAMPER-based education on the problem-solving skills of children with five-year-olds attending a pre-school education institution, and concluded that the technique increased their problem-solving skills. Karataş and Tonga (2016) examined the opinions of information technology teacher candidates on the use of the SCAMPER technique in their education and training processes. The study observed that the pre-service teachers generally did not have previous knowledge about the SCAMPER technique. As a result of the study, the prospective teachers expressed positive opinions about using this technique when they started their careers. Pre-service teachers think that this technique can improve students' creative thinking skills and generate new ideas. There are also opinions that this

technique is not suitable for every subject. Kocatepe (2017) conducted a research on the effect of the SCAMPER technique on the academic success in a middle school 6th grade science lesson on the reproduction, growth and development in plants and animals. As a result of the study, a significant difference was found between the post-test scores of the experimental and control groups. According to the results of the study, the increase observed in the achievement scores of the children in the experimental group is due to the teachings with the SCAMPER technique.

The studies in the field regarding the SCAMPER technique, also known as directed brainstorming, show that even though this technique is used in pre-school lessons such as Turkish, Information Technologies and Painting, it is not used enough in science lessons. In addition to improving creativity, SCAMPER, which is used as a teaching technique, is thought to be an effective method that can be used in science curriculum exercises as it provides the opportunity for the practice to be in line with the requirements and can be applied in science lessons. The simple machines unit of the science lesson intends for students to gain knowledge and skills about the simple machines that they encounter in daily life, make original designs using the knowledge and skills they attain and gain innovative and creative thinking skills (MoE, 2017). The SCAMPER technique aims to develop innovative and creative thinking behaviours of individuals and a creative thinking technique that provides the opportunity to create original products by guiding various questions that support different and original thoughts to achieve this goal. For this reason, researchers consider that it is effective in attaining the targeted behaviours in simple machines unit in science course.

It is believed that the use of this technique as a teaching technique in science lessons, in line with the goals of the science curriculum, will contribute to the development of children's creative skills as well as positively affect the academic achievement, attitude and motivation towards science.

Purpose of the Research

This study determines the effect of the SCAMPER technique activities on academic achievement in and attitude towards science and motivation in the simple machines unit of 8th grade students.

Research Questions

Within the scope of the problem statement, answers to the following research questions were sought.

1. What is the effect of the SCAMPER technique activities in the simple machines unit of the 8th grade middle school science lesson on the academic success of the experimental group students?

2. What is the effect of the SCAMPER technique activities in the simple machines unit of the 8th grade middle school science lesson on the attitudes of the experimental group students towards science lessons?

3. What is the effect of the SCAMPER technique activities in the simple machines unit of the 8th grade middle school science lesson on the motivation of experimental group students towards science lessons?

Methodology

Research Model

This study used a paired quasi-experimental design, which is a quantitative research method. It examined the effect that applying the SCAMPER technique to the simple machines subject in the science course had on the academic achievement, attitude and motivation scores of the students. In this design, wherein the random method was not used, the prepared groups were matched over certain variables, and individuals were randomly assigned to the matched groups (Büyüköztürk et al., 2008). The study used a pre- and post-test matched control group design.

Study Group

The study group of this study comprised 33 students (15 girls and 18 boys) who were studying in 8th grade in a state school in the Ortaköy district of the Aksaray province in 2018–2019. In the study, simple random sampling was used as the selection method of the study group. One of the two 8th grade classes in the school was randomly selected as the experimental and the other as the control group. In this sampling method, each selected sample is equally likely to be selected, that is, although the possibility of the selection of all individuals is equal and by chance, the choice of one person does not affect other individuals (Büyüköztürk et al., 2008).

Data Collection Tools

In this study, the simple machines unit achievement test (SMUAT), which consists of 19 questions developed by Özkan and Eryılmaz-Muştu (2018), was used as a data collection tool to measure the academic achievements of the students in the science lesson. Simple Machines' unit. The researchers calculated reliability coefficient (KR-20) of the achievement test as 0.88; for this research it was calculated as 0.81. This study used the attitude scale towards science lesson (ASTSL) developed by Geban et al. (1994) to determine students' attitudes towards science. The scale consists of 15 items, 11 positive and 4 negative. The reliability coefficient of the one-dimensional scale was calculated by the

researchers as 0.83, and for this study as 0.84. In this study, to determine the students 'motivation for science, the scale for students' motivation towards learning science (SMTSL) developed by Tuan et al. (2005) was used. Originally in English, the scale was adapted to Turkish by Yılmaz and Huyugüzel-Çavaş in 2007 after having performed validity and reliability studies. The scale that consists of 33 items includes 6 factors in total: self-efficacy, active learning strategies, science learning value, performance goal, achievement goal and learning environment stimulation. The Cronbach's alpha coefficient of the scale was calculated as 0.87 by the researchers, and 0.881 for this study. The self-efficacy factor, which is the first factor of the scale, has 7 items and the reliability coefficient of this factor was calculated as.738. The active learning strategies factor, the second factor of the scale, consists of 7 items and its reliability coefficient was.854. The third factor of the scale, the science learning value factor, is 5 items, and its reliability coefficient was .731. The fourth sub-dimension of the scale, the performance goal sub-dimension, has 3 items, and the reliability coefficient of this factor was .601. The fifth sub-dimension of the scale, achievement goal, consists of 5 items and its reliability coefficient was .787. The sixth sub-dimension of the scale, the learning environment stimulation, has 6 items and its reliability coefficient calculates to .700.

Implementation

In the research process, to measure the readiness level of the students in the experimental and control groups, SMUAT, ASTSL and SMTSL scale were separately applied to the groups. First, the experimental group was introduced to the SCAMPER creative thinking technique, purpose, importance and steps of the technique. Then, the subjects of levers, inclined plane, pulleys and spinning wheels in the simple machines unit of the science lesson were explained to both the control and experimental groups. During this process, activities related to the SCAMPER technique were carried out with the experimental group for 4 weeks, 4 hours a week, for a total of 16 hours. Each week a topic was presented, at the end of the week SCAMPER-based activities were conducted, the activity form was distributed to the students and they were asked to fill it in. Lessons were conducted with the control group in line with the science curriculum. At the end of the application, to examine the effect of the technique, the research was completed by applying the achievement test and attitude and motivation scales as post-tests to the experimental and control groups.

In the seven steps of the activity form, distributed after the simple machine type learned in the simple machines unit in the research, such questions arise:

1. What else could you use instead of this setup that would have the same function?
2. What other objects could you combine with this object to make it more useful?
3. How can you take advantage of the materials you previously threw away to make this object?
4. If changes were to be made in the weight, durability and size of this object to make it more functional, what kind of alterations are possible?
5. What is necessary and what is not required for this object?
6. For what other purpose can you use this object?
7. If you designed this object, what kind of design would you do?'

These steps aim to encourage students to think creatively, revealing their creative ideas, as well as understanding each subject and improving by applying these ideas to other situations.

Data Analysis

The data obtained from the achievement test and attitude and motivation scale used in the study were quantitatively analysed using the SPSS 22 package software.

Firstly, it was examined whether the data obtained from the achievement test and attitude and motivation scales showed normal distribution. Normally distributed data were analysed through parametric tests, and data that were not normally distributed used non-parametric tests. The normal distribution results of the research data are given in Table 1.

Table 1. Normal distribution t-chart of achievement test and attitude and motivation

Pre- and Post-test Score	Group	Shapiro-Wilk Statistics	df	p
Pre-test	Control	.916	17	.128
Success Scores	Experiment	.729	16	.000
Post-test	Control	.913	17	.113
Success Scores	Experiment	.870	16	.027
Pre-test	Control	.952	17	.496
Attitude Scores	Experiment	.905	16	.097
Post-test	Control	.949	17	.447
Attitude Scores	Experiment	.931	16	.254
Pre-test	Control	.962	17	.663
Motivation Scores	Experiment	.952	16	.528
Post-test	Control	.925	17	.181
Motivation Scores	Experiment	.902	16	.085

When Table 1 is examined, as the total scores of the simple machines achievement test of the science course did not show a normal distribution ($p < .05$), they were analysed through performing the non-parametric Mann–Whitney U-test. The motivation and attitude scores towards science were normally distributed ($p > .05$). For this reason, to determine whether there was a significant difference between the experimental and control groups, the scores were analysed with independent samples t-tests, which are parametric tests.

Findings

Findings of the Pre-test Data of the Study

In this section, the findings related to the analysis of the data obtained from the students' SMUAT, ASTSL and SMTSL scales were included.

Findings obtained from the pre-test data of the simple machines unit achievement test

The experimental and control groups' Mann–Whitney U-test results from the pre-implementation of the SMUAT scores are shown in Table 2.

Table 2. Pre-test U-test results of students' motivation towards science learning scores according to groups.

Group	N	Mean Rank	Rank Sum	U	p
Experiment	16	20.03	320.50	87.50	.076
Control	17	14.15	240.50		

In Table 2, according to the results of the Mann–Whitney U-test conducted before the experimental study, no significant difference was found in the pre-test scores of the simple machines unite achievement tests between the students who participated in the study programme that used the SCAMPER technique (experimental group) and the students who did not use the technique (control group) ($U = 87.50$; $p < .05$). Based on this situation, it can be said that the success level of both groups is equal.

Findings obtained from the attitude scale towards science lesson pre-test data

The experimental and control groups' t-test results of the pre-test scores of the ASTSL done before the application are shown in Table 3.

Table 3. Test results of attitude scale towards science lesson pre-test scores according to groups.

Group	N	$\bar{X}$	SD	df	t	p
Experiment	16	60.25	11.01	31	−.368	.715
Control	17	58.76	12.11			

When Table 3 was examined, it was observed that there was no significant difference between the distribution of students' attitudes towards the science lesson according to the experimental and control groups ($t(31) = -.368$; $p > .05$).

Findings obtained from the scale for students' motivation towards science learning pre-test data

The t-test results of the scale for SMTSL pre-test scores according to the experimental and control groups are shown in Table 4.

Table 4. T-test results of the students' motivation towards science learning scale pre-test scores according to the groups.

Group	N	$\bar{X}$	SD	df	t	p
Experiment	16	128.56	14.47	31	−.294	.771
Control	17	130.41	20.85			

When Table 4 was examined, it was observed that there was no significant difference between the distribution of students' motivation scale scores for science according to the experimental and control groups (t (31) = - was; p> .05).

When the pre-test findings of the research data were examined, the absence of a significant difference between the achievement test and attitude and motivation scale scores indicated that the readiness levels of the experimental and control group are equal.

Findings of the Simple Machines Unit Achievement Test

Table 5 presents the paired sample t-test results of the findings obtained from the in-group pre-test and post-test scores of the control group students' academic achievement test.

Table 5. The results obtained from the in-group pre- and post-test academic achievement scores of the control group students

Control Group	N	$\bar{X}$	SD	df	t	p	η^2
Pre-test	17	5.17	2.60	16	-7.038	.000	.75
Final test	17	12.64	3.80				

When the pre-test and post-test scores of the academic achievement test are examined, the study observes a statistically significant difference in the mean scores of the control group students ($t = -7.03$; $p < .05$). The mean scores of the control group students from the academic achievement test show a significant increase in the post-test ($\bar{X} = 17.18$) compared to the pre-test ($\bar{X} = 6.31$). This finding shows that the academic achievement increased in the group in which the SCAMPER technique was not applied and this increase had a significant effect ($\eta^2 = .75$). The effect size shows how much the independent variable explains the total variance in the dependent variable and varies between .00 and 1.00. According to its value, the effect size values at the levels of .01, .06 and .14 are interpreted as 'small', 'medium' and 'large' effects, respectively (Büyüköztürk, 2011).

Table 6 presents the results of the Wilcoxon Signed Ranks test of the findings obtained from the in-group pre-test and post-test scores of the experimental group students' academic achievement test.

Table 6. The results obtained from the in-group pre- and post-test academic achievement scores of the experimental group students

Experimental group	Post-test /Pre-test	n	Mean Rank	Rank Sum	z	p	η^2
Academic success	Negative Sequence	0	.00	.00	−3.550	.000	.45
	Positive Sequence	16	8.85	136.00			
	Equal	0					

When the pre-test and post-test scores of the academic achievement test are examined, a statistically significant difference is observed in the mean scores of the experimental group students ($z = -3.550$; $p < .05$). Considering the mean rank and rank sum of the scores, it can be said that the difference observed in the experimental group is in favour of the positive sequence, which is the post-test success score. This finding shows that science lessons conducted with the SCAMPER technique have a great effect ($\eta^2 = .45$) in increasing the academic success of students.

Compared to the pre-test scores, a statistically significant increase was observed in the post-test scores of the academic achievement test of both the experimental group students who participated in SCAMPER-based activities in the science course and the control group students who did not participate in the activities. To evaluate the difference of SCAMPER-based activities in academic achievement, an analysis of the score difference between groups was conducted.

The Mann–Whitney U-test results of the post-test scores obtained from SMUAT of the control group who did not participate in SCAMPER-based activities and experimental group students who participated in these activities in the science course are given in Table 7.

Table 7. Post-test U-test results of simple machines unit achievement scores according to groups.

Group	N	Mean Rank	Rank Sum	U	z	p	η^2
Experiment	16	23.19	371.00	37.00	−3.598	.000	.29
Control	17	11.18	190.00				

When Table 7 was examined, after a four-week experimental study period, there was a significant difference between the post-test scores of the students who participated in the study with the SCAMPER technique (experimental group) and scores of the students who did not use such a technique and whose lessons were carried out in line with the current curriculum (control group) (U = 37.00; p < .05). Looking at the mean ranks, it is seen that the students participating in the SCAMPER programme (experimental group) have higher scores in the achievement tests than the students who did not participate in the programme (control group). The calculated effect size (η^2) value is η^2 = .29. Accordingly, it is possible to state that 29% of the variance observed in the academic achievement test scores of students is due to SCAMPER activities. This finding shows that performing SCAMPER-based activities in the unit of simple machines in science lesson is effective in increasing academic success.

Findings of the Attitude Scale towards Science Lesson

Table 8 shows the change in the attitude scores of the control group students towards the in-group science lesson.

Table 8. The results obtained from control group students' in-group pre-test and post-test attitude scores towards the science lesson

Control Group	N	$\bar{X}$	SD	df	t	p
Pre-test	17	58.76	12.11	16	-.494	.628
Final test	17	60.29	10.26			

Table 8 shows that there is no statistically significant difference in the attitude of students in the control group towards the science lesson within the group mean scores (t = -494; p > .05). There was an increase in the attitude score of the control group students towards science lesson in the post-test ($\bar{X}$ =60.29) compared to the pre-test ($\bar{X}$ =58.76), but this increase was not statistically significant.

Table 9 presents the results of the Wilcoxon Signed Ranks test of the findings obtained from the pre-test and post-test scores in which the attitudes of the experimental group students towards science lesson were examined.

Table 9. The results obtained from the experimental group students' in-group pre-test and post-test attitude scores towards the science lesson

Experimental group	N	$\bar{X}$	SD	df	t	p
Pre-test	16	60.25	11.01	15	−1.061	.306
Final test	16	63.93	7.92			

Table 9 shows that there is no statistically significant difference in the attitudes of the experimental group students towards the science lesson within the group mean scores (t = -.1.061; p > .05). There was an increase in the attitude score of the experimental group students towards science lesson in the post-test ($\bar{X}$ =63.93) compared to the pre-test ($\bar{X}$ =60.25) but this increase was not statistically significant.

There was no statistically significant difference in the attitude scale pre-test and post-test scores of the experimental group students who participated in the SCAMPER-based activities in the science course and the control group students who did not participate in the activities. To examine the effect of SCAMPER activities on students' attitudes towards the science lesson and to evaluate the difference between experimental and control groups, an analysis of the difference of scores between the groups was conducted. The distribution results of the post-test scores of ASTSL, which were separately administered to both groups after SCAMPER activities, are given in Table 10.

Table 10. Attitude scale towards science lesson post-test scores according to the groups' t-test results

Group	N	$\bar{X}$	SD	df	t	p
Experiment	16	63.93	7.92	31	−1.13	.265
Control	17	60.29	10.26			

When Table 10 was examined, it was determined that there is no significant difference between the distribution of students' attitudes towards the science lesson according to the experimental and control groups after SCAMPER-based activities (t (31) = 1.13; p > .05). Findings of the Scale for Students' Motivation towards Science Learning

Table 11 presents the change in the scores of the control group students on the motivation scale for in-group science learning.

Table 11. The results obtained from the control group students' motivation towards science learning in-group pre-test and post-test scores

Control Group	N	$\overline{X}$	SD	df	t	p
Pre-test	17	130.41	20.85	16	.262	.796
Post-test	17	131.53	16.80			

Table 11 shows that there is no statistically significant difference in the motivation group students' mean scores for science education (t =.262; p > .05). The mean scores of the control group students for learning science increased in the post-test ($\overline{X}$ =131.53) compared to the pre-test mean scores ($\overline{X}$ =130.41), but this increase was not statistically significant.

Table 12 presents the results of the Wilcoxon Signed Ranks test of the findings obtained from the in-group pre-test and post-test scores in which the experimental group SMTSL science was examined.

Table 12. The results obtained from the experimental group students' motivation towards science learning in-group pre-test and post-test scores

Control Group	N	$\overline{X}$	SD	df	t	p	η^2
Pre-test	16	128.56	14.47	15	3.495	.003	.43
Post-test	16	140.00	11.34				

Table 12 shows that there is a statistically significant difference in the motivation of the experimental group students towards learning science in the mean scores within the group (t = 3.495; p < .05). The motivation score of the experimental group students for learning science increased in the post-test ($\overline{X}$ =140.003) compared to the pre-test ($\overline{X}$ =128.56) and this increase was statistically significant. The effect size was calculated as η^2 = 43. Accordingly, it can be stated that 43% of the variance observed in students' motivation scores for science is due to SCAMPER activities. It was seen that SCAMPER activities had a great effect on the change in the motivation of the experimental group students towards in-group science learning.

While a great change was observed in the motivation scores of the experimental group students participating in the SCAMPER activities in the science lesson, there was no statistically significant difference in the motivation pre-test and post-test scores of the control group students who did not participate in the application. In order to examine the effect of SCAMPER applications on students' motivation to learn science and to evaluate the difference between experimental and control groups, the study conducted an analysis of the difference in scores between groups.

The distribution results of the post-test scores of the scale for SMTSL after the application are given in Table 13.

Table 13. T-test results of the scale for students' motivation scale towards science learning post-test scores according to the group.

Group	N	$\overline{X}$	SD	df	t	p
Experiment	16	140.00	11.34	31	−1.68	.102
Control	17	131.52	16.80			

When Table 13 was examined, it was found that there was no significant difference between the distribution of scores for the scale for SMTSL according to the experimental and control groups (t (31) = 1.68; p > .05).

Findings related to the sub-dimensions of the students' motivation towards science learning scale

No significant difference was found between the students' motivation scores for science education before and after the application. For this reason, sub-dimensions of the scale for SMTSL were to evaluate the in-group examined effectiveness of the application. Considering the sample, non-parametric tests were used to examine the sub-dimensions of the scale for SMTSL. As there was no significant difference between the groups' scale for SMTSL results in the study, the sub-dimensions of the motivation scale were separately analysed from the in-group pre- and post-test scores in the control and experimental groups.

Control group's pre- and post-test results of the sub-dimensions of the scale for students' motivation towards science learning

The results from the Wilcoxon signed-rank test applied to the findings obtained from the in-group pre- and post-test scores from the sub-dimensions of the scale for SMTSL of the control group students are shown in Table 14

Table 14. Data results of the test scores of the sub-dimensions of the students' motivation towards science learning scale before and after the application of the control group.

Motivation Scale Sub-Dimensions	Post- and Pre-test	n	Mean Rank	Rank Sum	z	p
Self-Efficacy	Negative Sequence	9	6.50	58.50	.912	.362
	Positive Sequence	4	8.13	32.50		
	Equal	4				
Active Learning Strategies	Negative Sequence	8	6.00	48.00	.283	.777
	Positive Sequence	6	9.50	57.00		
	Equal	3				
Science Learning Value	Negative Sequence	5	5.80	29.00	.787	.431
	Positive Sequence	7	7.00	49.00		
	Equal	5				
Performance Goal	Negative Sequence	5	7.40	37.00	.597	.551
	Positive Sequence	8	6.75	54.00		
	Equal	4				
Achievement Goal	Negative Sequence	5	6.50	32.50	.518	.605
	Positive Sequence	7	6.50	45.50		
	Equal	5				
Learning Environment Stimulation	Negative Sequence	7	6.79	47.50	.140	.888
	Positive Sequence	6	7.25	43.50		
	Equal	4				

When Table 14 was examined, no significant difference was observed between the scores of the students in the control group obtained both in the pre- and the post-test sub-dimensions of the SMTSL scale ($p > .05$).

Experimental group's pre- and post-test results for sub-dimensions of the scale for students' motivation towards science learning

Table 15 shows the results of the Wilcoxon Signed Ranks test regarding whether the scores obtained from the sub-dimensions of the scale for students' motivation toward science learning significantly differ before and after the application of the SCAMPER-based activities in the science lesson of the students in the experimental group.

Table 15. Data results of the test scores of the sub-dimensions of the students' motivation towards science learning scale before and after the application of the experimental group.

Motivation Scale Bottom Sizes	Post- and Pre-test	n	Mean Rank	Rank Sum	z	p	η^2
Self-Efficacy	Negative Sequence	9	8.56	77.00	.467	.641	.012
	Positive Sequence	7	8.43	59.00			
	Equal	0					
Active Learning Strategies	Negative Sequence	3	8.17	24.50	2.25	.024	.24
	Positive Sequence	13	8.58	111.50			
	Equal	0					
Science Learning Value	Negative Sequence	1	10.00	10.00	3.01	.003	.36
	Positive Sequence	15	8.40	126.00			
	Equal	0					
Performance Goal	Negative Sequence	6	7.83	47.00	.634	.526	.024
	Positive Sequence	6	5.17	31.00			
	Equal	4					

Table 15. Continued

Motivation Scale Bottom Sizes	Post- and Pre-test	n	Mean Rank	Rank Sum	z	p	ŋ ²
Achievement Goal	Negative	3	5.67	17.00	2.00	.045	.20
	Sequence	10	7.40	74.00			
	Positive Sequence	3					
	Equal						
Learning Environment Stimulation	Negative	2	2.25	10.50	2.82	.005	.33
	Sequence	13	8.42	109.50			
	Positive Sequence	1					
	Equal						

Table 15 examined the scale for motivation towards science learning sub-dimensions scores before and after the application for those students who participated in SCAMPER-based activities. In this table, there seems to be a significant difference between the scores students received in the dimensions of active learning strategies, science learning value, achievement goals and learning environment stimulation ($p < .05$). When the effect sizes of the sub-dimensions of the motivation scale were examined, they were calculated as $ŋ^2 = .24$ for the active learning sub-dimension, $ŋ^2 = .36$ for the science learning value sub-dimension, $ŋ^2 = .20$ for the achievement goal sub-dimension and $ŋ^2 = .33$ for the learning environment stimulation sub-dimension. Considering the score differences of the mean rank and rank sum, the difference observed in the motivation scale sub-dimensions is in favour of the positive sequences, that is, the post-test scores. According to these results, the study determined that science lessons organised with SCAMPER-based activities have a significant effect on increasing the motivation of children towards science learning.

Discussion

One of the most important elements of an educational approach that puts the learner in the centre, provides the opportunity for active participation, values original thoughts and evaluates the process, not the result, like the meaningful learning theory and the constructivist learning theory, is different learning and teaching techniques. Creative thinking techniques can also be one of these techniques, depending on the purpose of use in learning environments. This study used the creative thinking technique of SCAMPER as a learning technique. SCAMPER is a method of brainstorming. The student brainstorms by being guided through various questions about a specified object at each step. As the steps progress, the selected object or elements change, develop, divide into parts, get used for different purposes, and combine with different objects. This ensures that new ideas emerge at each step and the student is able to think through emphasising the points that will not come to mind. Thus, as Wayne (2006) states, creative teaching occurs. This study carried out creative teaching by applying activities based on the SCAMPER (Directed brainstorming) technique in the simple machines unit of the science lesson. It aimed to examine the reflections of this creative teaching on students' academic achievement, attitudes, and motivations towards science. As a result of the study, it was seen that SCAMPER-based activities, which were used as a teaching technique, increased students' academic achievement and motivation towards science lessons, but there was no change in students' attitudes towards science. Academic success is measured by the quantification of open-ended or test-form questions that include the achievements of students related to a topic or concept. Therefore, the SCAMPER technique enabled students to increase their reflection time on each object or item and to approach them from different angles. This versatile thinking may have helped the students to reach the goals easily by facilitating their understanding, and thus it can be interpreted as an increase in their academic success. This situation is in line with the study of Kocatepe (2017), who uses SCAMPER as a teaching method. Kocatepe (2017) conducted a research on the effect of the SCAMPER technique used in the subject of the reproduction, growth and development of plants and animals in the 6th grade middle school science lesson on academic success. After the study, it was concluded that the increase observed in the success scores of the children in the experimental group was due to teaching with the SCAMPER technique.

In his study, İslim (2009) investigated the change in students' creative problem-solving skills and academic achievement using the SCAMPER technique in the information and communication technologies course. As a result, he concluded that SCAMPER leads to a positive increase in both creative problem-solving skills and academic achievement of students. Kocatepe (2017) conducted a research on the effects of the SCAMPER technique on academic achievement in a middle school 6th grade science lesson on reproduction, growth and development of plants and animals, and concluded that the increase observed in the achievement scores of the children in the experimental group after the study was because of teaching with the SCAMPER technique. As a result of many studies (Aksoy, 2005; Özerbaş, 2011; Sayan, 2010) on the effect of creative thinking-based teaching practices on academic achievement, it has been concluded that the training provided academic achievements. In science teaching, students are not taught how to acquire knowledge instead they construct knowledge themselves using their imaginations (Comia, 2006). During the application process, it was observed by the researcher that the students unlimitedly used their imaginations and actively participated in the lesson. With the effect of this active participation, SCAMPER applications may have enabled

students to develop various ideas using their imagination, combine these ideas with objects in daily life, make connections between the concepts they have learned, understand the subject better, and increase their academic success by solving the questions in the achievement test.

As a result of the research, it is possible to observe that there is no change in the students' attitude scores towards science and the teaching technique has no effect. Attitudes are psychological occurrences that involve affective behaviours. Attitudes cannot be directly observed as they form over time and do not easily change. They affect people's perception, decision, love, hate, preferences and behaviours. They control behaviour and cause bias during decision making (Aşkar, 1986; Eagly & Chaiken, 2007; Morgan, 1995; Ülgen, 1997). It is accepted that attitude consists of cognitive, affective and behavioural dimensions and directs behaviour (Anderson, 1988; Ekici, 2002). The development of the affective dimension takes longer than the cognitive one (Kocayusuf, 2013). In the research conducted, the reason why students' attitudes do not change at the end of teachings focused on creative thinking through the SCAMPER technique may be because the application is short-term and covers one unit. It takes a long time to change attitudes that were formed over an extensive period. When studies on student attitudes are examined, it is seen that the attitudes resist change (Blosser, 1984; Shrigley et al., 1988).

As a result of the study, it was seen that SCAMPER, which was used as a teaching technique, increased students' motivation towards science lessons. In this respect, the study is in harmony with many studies in the literature. Hoang (2007) conducted a research on the effect of creative learning activities on the increase of students' goal setting, motivation and interest in science learning. According to the results, many students stated that they found science boring, troublesome and rigorous, but creative thinking activities increased their motivation towards science. Candar (2009) investigated the effect of science and technology lessons supported by creative thinking techniques on students' academic achievement, motivation towards science and attitude towards science and creativity. As a result of many studies on the motivational effect of creative thinking-based teaching practices (Cheng, 2001; Özaltay, 2020; Wu & Wu, 2020), it was concluded that the trainings applied increased motivation positively. Jelena et al. (2014) examined the effect of the SCAMPER technique on students' knowledge, self-confidence and motivation towards creativity. As a result of the research, it was concluded that the SCAMPER technique increased the self-confidence and motivation in creativity of most of the students. It can be said that the SCAMPER technique is important for students to maintain their attention, and increase their motivation for success and the value of science learning. Simultaneously, SCAMPER-based activities are thought to increase motivation as they encourage students to explore different learning environments.

Students' motivations for science learning are multidimensional structures that can vary depending on the individual characteristics of teachers and students, teaching methods and techniques, learning environment and curriculum (Yılmaz & Huyugüzel-Çavaş, 2007). The dimensions of motivation for learning science, developing active learning strategies and taking an active role, knowing the value of learning science and being willing to learn, working for success and the teaching technique and adhering to different learning environments such as communication between students came to the fore in the SCAMPER technique. The application of a new technique may cause students to be curious. Active learning may have triggered the success factor in students, since it is a technique in which students actively participate in the lesson. In this case, both the science learning value and students' success-oriented study provided a significant increase between the pre- and post-test scores. Also, SCAMPER activities are believed to increase motivation as they encourage students to try different learning environments.

Conclusions

This study was conducted to observe the effects of SCAMPER technique (directed brainstorming) activities in the simple machines unit of a middle school 8th grade science course on students' academic achievement and attitude and motivation towards science. In the study, to determine the readiness of the experimental and control groups, the data of the total scores obtained from the pre-tests of the achievement test and attitude and motivation scales were analysed, and no significant difference was found between the pre-test scores of the students. Accordingly, it can be said that the academic achievement levels, attitude and motivation of the students participating in the study are equal towards science. This shows that SCAMPER-based activities will yield reliable results in examining the effect of students' academic achievement, attitudes and motivations.

During the four-week period, a significant difference was found between the pre-test and post-test scores of the experimental group students who participated in the SCAMPER programme in the science course in favour of the post-test. There is a significant difference between the pre-test and post-test scores of the control group students who did not participate in the activities in the science course in favour of the post-test. This result shows that both the teaching with SCAMPER activities and the teaching applied according to the curriculum have an effect on student academic achievement. To examine the difference between the two groups, when the post-test scores of the students in the experimental group who did SCAMPER activities and the control group students who did not participate in the programme from the simple machines unit achievement test were compared, it was concluded that there was a significant difference in favour of the experimental group. Based on this result, it can be said that the reason for the increase in success in simple machines is due to the applications of the SCAMPER technique.

In order to examine the change in the attitude scores of the experimental group and control group students participating in the study, the pre-test and post-test mean scores were analysed.

Although there was an increase in the pre- and post-test mean scores of the students, there was no statistically significant difference. As a result of the t-test conducted to determine the change in attitudes towards science between the experimental and control groups after the four-week application period, no significant difference was found in the changes in the total attitude scores of the experimental and control groups. It was concluded that the SCAMPER-based activities did not cause a change in students' attitudes towards science.

To examine the change in the motivation scores of the control group students participating in the study, the pre-test and post-test mean scores were analysed. Although there was an increase in the pre- and post-test mean scores of the control group students, there was no statistically significant difference. Similarly, the difference between the experimental group students' motivation towards the science lesson scores from the pre-test and post-test were analysed. In the motivation score average of the experimental group students studying in the programme in which the SCAMPER technique was applied, there was a statistically significant difference. When the distribution results of the post-test scores of the scale for SMTSL, which was done to determine the change in students' motivation after SCAMPER-based activities, no significant difference was found between the scores of the students within to the experimental and control groups. As there was no change in student motivation in general, the sub-dimensions of the motivation scale were examined to evaluate the in-group effectiveness of the application. As a result of the data obtained from the pre- and post-test scores of the motivation scale for science learning used in the study, it was concluded that there was no significant difference between the scores of the students in the control group from the sub-dimensions of the scale. Accordingly, it can be said that the lessons conducted in the control group according to the science course curriculum did not cause a change in the motivation of students towards science learning. According to the results obtained from the total scores of the students in the experimental group in which SCAMPER technique activities were performed in the science course, it is seen from the motivation scale sub-dimensions that there is a significant difference in the dimensions of active learning strategies, science learning value, achievement goal and learning environment stimulation. When the effect size values are examined, it can be said that SCAMPER applications also have a wide effect on the scores of the motivation sub-dimensions of science. According to these results, it can be concluded that the science lesson teaching organized with SCAMPER technique activities has an important effect on increasing the motivation of children towards science.

Recommendations

This study investigated the effect of SCAMPER-based activities on creative thinking techniques in science lessons on students' academic achievement, attitudes, and motivation towards science. The creative thinking technique was used as a teaching technique in the study. In this process, activities with students were within the scope of a science topic. It is possible to apply this technique to units other than the simple machines unit to increase the academic achievement and motivation for science lessons in students. In this context, the SCAMPER technique, which is mostly used in the field of psychology, is explained in more detail and it is recommended to actively use the SCAMPER technique, which is thought to increase the interest, motivation and success of students in the science course. In addition, in the studies using the SCAMPER technique, after the product design step, if they want, students could draw the products they imagine or design them materially. It is thought that this situation will positively affect the development of students' creativity. The SCAMPER technique can be used effectively in engineering applications education and applied science units, and can be used as a technique that regulates and directs students' ideas to make unique and original designs and create new and creative products.

Limitations

This study is limited to 35 students in the 8th grade of the school of research, with four subjects (3–8) selected from the simple machines unit in which SCAMPER-based activities were applied, the science course curriculum achievements and a 4 week application period.

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