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Investigation of the Effect of SCAMPER Technique on Eighth Grade Students' Academic Achievement, Environmental Attitudes and Science Learning Motivations

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The SCAMPER technique, one of the creative thinking technique, focuses on developing creative and innovative solutions by systematically reviewing possible changes that can be made on a situation or problem. In this study, the effect of SCAMPER technique on eighth grade students' academic achievement, environmental attitudes and motivation to learn science in the unit "Sustainable Life and Material Cycles (SLMC)" was examined. This study, which was conducted with 59 eighth grade students studying in a public secondary school in the Eastern Anatolia Region in the 2022-2023 academic year, was designed according to a pretest (PrT)-posttest (PsT) control group experimental design. The data of the study were collected through the "Sustainable Living and Material Cycles Academic Achievement Test" (SLMCAT), "Environmental Attitude Scale" (EAS) and "Science Learning Motivation Scale" (SLM). The study first conducted descriptive analyses, and the results showed that the increase in EGR's SLMCAT, EAS, and SLM final test scores was significantly higher than that of CGR. MANCOVA findings also supported this result; it was revealed that the SCAMPER technique had a statistically significant and high-level effect on SLMCAT, EAS and SLM PsT scores (SLMCAT: $\eta^2 = .801$, EAS: $\eta^2 = .841$, SLM: $\eta^2 = .750$). In the CGR, no significant change was observed in the PsT scores. These result show that SCAMPER technique can create more effective learning environments in teaching abstract and complex subjects. It was also concluded that this approach has a significant potential in improving students' attitudes towards the environment and increasing their motivation towards science learning.

Introduction

Rapid advances in science and technology have revealed that learning encompasses a structure far more intricate than its cognitive, affective, and behavioural dimensions alone (Akbaş, 2024). Within this framework, contemporary educational theory defines learning as a multidimensional process shaped by levels of knowledge, skills, attitudes, and motivation

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(Besançon et al., 2015; Deveci & Aydı, 2021; MoNE, 2018). Such a holistic process requires students to investigate, question, and reconstruct knowledge while generating creative solutions to everyday problems (Baki, 2023; Çelik et al., 2024; Dini & Rini, 2024; Kalemkuş, 2021; Kim, 2013). Creativity, moreover, constitutes the principal driving force behind both individual development and societal progress and is therefore among the foremost goals of global education systems (Besançon et al., 2015; Brauer et al., 2024; Henriksen et al., 2021; MoNE, 2018; NRC, 2012). Nevertheless, the abstract and complex concepts in the middle-school science unit “Sustainable Life and Matter Cycles” may engender learning deficiencies and misconceptions, thereby hindering the development of creativity skills (Hacıoğlu, 2017; Martínez et al., 2021; Suri Köksal, 2018; Tekerci & Kılınc, 2023; Zeytinli Ünal, 2018). At this juncture, the SCAMPER (Substitute, Combine, Adapt, Modify/Enlarge/Shrink, Repurpose, Subtract, Reverse) technique—which enables existing knowledge to be re-examined from multiple perspectives—comes into play and has been shown to foster innovative thinking by enhancing academic achievement (Altıparmak & Eryılmaz-Muştu, 2021; Fahmy et al., 2017; Pitrianti et al., 2021; Ritter & Mostert, 2017), motivation (Jeong et al., 2016), critical thinking (Abdurrahman & Mahmood, 2021; Saifaldin & Al-Dabbagh, 2024), ecological literacy (Abdelsattar & Abdel Karim, 2022; Abd-Elghafour Seedek & Babtain, 2022; Ali et al., 2024; Arıcı Doğan et al., 2023; Brem & Puente-Díaz, 2021), and interdisciplinary problem-solving skills (Baş & Kaptan, 2021; Tahir & Marniati, 2020; Wu & Wu, 2020).

However, studies on the application of the SCAMPER technique in the context of conceptual difficulties experienced by students in abstract topics such as energy cycles and human-induced environmental impacts in the 8th grade curriculum are limited (Nurbaety et al., 2015; Zeytinli Ünal, 2018). This study aims to fill this gap and examines the effect of SCAMPER on conceptual understanding, creative problem solving and environmental attitudes in science education with empirical data. The study provides concrete recommendations for curriculum design and instructional strategies and emphasizes the importance of human-centered pedagogies among technology-driven educational models.

Aim and Sub-problems

This study aims to fill this gap in the literature by examining the effect of SCAMPER technique on 8th grade students' academic achievement, environmental attitudes and motivation to learn science in the unit “Sustainable Life and Material Cycles (SLMC)”. Based on previous studies emphasizing the importance of creative and student-centered learning environments (Baki, 2024; Kim & Lim, 2022), the study tests the hypothesis that SCAMPER-based activities will strengthen conceptual understanding, encourage creative solutions to environmental problems, and improve motivational outcomes. By focusing on creativity and adaptability in line with global educational priorities (MoNE, 2018; Radziszewski, 2017), this study aims to provide concrete recommendations for optimizing 21st century science pedagogy.

The problem of the research is formed by the question: 'When the variables of 8th-grade students' sustainable life and material cycles academic achievement test (SLMCAT), environmental attitude scale (EAS), and science learning motivation (SLM) PrT (Pre-Test) scores are controlled, what is the effect of the implemented SCAMPER technique on academic achievement, attitude, and motivation PsT (Post-Test) scores?'

In the research conducted in line with this basic problem, answers to the following sub-questions were also sought:



- When students' SLMCAT, EAS, and SLM PrT scores are controlled for, does the application of the SCAMPER technique exert a significant effect solely on SLMCAT PsT scores?
- When students' SLMCAT, EAS, and SLM PrT scores are controlled for, does the application of the SCAMPER technique exert a significant effect solely on the EAS level?
- When students' ETESAT, EAS, and SM PrT scores are controlled for, does the application of the SCAMPER technique exert a significant effect solely on SLM?

Method

Research Model

This investigation was conducted within a quasi-experimental framework, adopting the PrT–PsT CGR model. Experimental designs are conventionally classified as weak, quasi-experimental according to the presence of random assignment and the stringency of internal and external validity controls (Gülovalı & Odabaş, 2011). Because fully random group assignment is seldom practicable in school-based educational research, a quasi-experimental approach was selected, and students were retained in their intact classes while being allocated to EGR or CGR. Quasi-experimental designs offer considerable scientific credibility without requiring randomization, thereby enabling researchers to examine interventions in naturally occurring groups (Büyüköztürk et al., 2018; Creswell & Plano Clark, 2011; Mertens, 2024). Within this methodological family, several procedures can be followed—such as administering PrT–PsT to a single group or applying the PrT–PsT scheme across separate groups (Çepni, 2010). One variant is the PrT–PsT CGR design with randomized allocation (Cook & Wong, 2008). In this arrangement, one or more instructional interventions are delivered to the EGR over the course of the study, while both EGR and CGR complete PrT and PsT assessments. This configuration permits comparison of baseline conditions and evaluation of the intervention's impact throughout the research period. A detailed schematic representation of the model is provided in Figure 1:

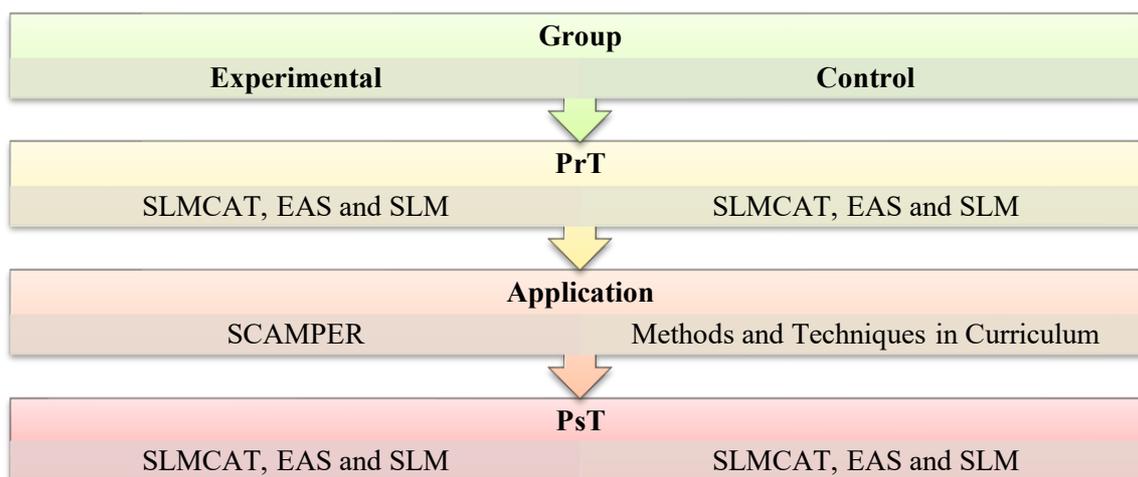


Figure 1. Research model schematic.

In the true experimental design with PrT–PsT CGR, in which the participants are divided into two groups as EGR and CGR, PrT and PsT are applied to both groups, while the application

that constitutes the independent variable of the research is carried out only in the EGR (Creswell & Creswell, 2017). In the study, while the subject of SLMC was taught with the SCAMPER technique with the EGR, the lesson was taught with the methods and techniques in the science curriculum with the CGR, and no other application that could affect the dependent variables was performed. In the research process, intra- and inter-group comparisons were made based on the data obtained from the PrT and PsT.

Working Group

The study group consisted of 59 eighth grade students studying in two different branches in a public school in the Eastern Anatolia Region in the 2022-2023 academic year. In order to select equivalent classes in terms of academic achievement among five different eighth grade classes in the school where the study was conducted, the year-end grade point averages of all classes in the science course for the 2021-2022 academic year were examined from the e-school platform, and as a result of this process, it was determined that the year-end grade point averages of the science course of the classes were 61.89 for class 8A, 65.37 for class 8B, 81.34 for class 8C, 75.67 for class 8D, and 83.25 for class 8E, respectively. Considering their grade point averages, 8C (81.34) and 8E (83.25) classes with close academic performances were selected as the study group. In line with the random assignment criteria among the selected branches, 8C branch was determined as the EGR and 8E branch was determined as the CGR by lot method. Information about the gender distribution of the students in the EGR and CGR'ss is given in Table 1.

Table 1. Demographic characteristics of the study group

Group	Male		Female		Total	
	n	%	n	%	n	%
EGR	18	54,5	15	45,5	33	100,0
CGR	12	46,2	14	53,8	26	100,0
Total	30	50,8	29	49,2	59	100,0

EGR: Experimental group, CGR: Control group

Table 1 shows that 54.5% of the students in the EGR were male and 45.5% were female; 46.2% of the students in the CGR were male and 53.8% were female; and 50.8% of the students in the study group were male and 49.2% were female. An a priori power analysis conducted in G*Power 3.1 for an ANCOVA model with two groups and one covariate ($\alpha = .05$, power = .80, effect size $f = 0.60$) indicated that a minimum of 54 participants (27 per group) was required. This threshold is consistent with the large effect sizes reported in previous SCAMPER studies (Altıparmak & Eryılmaz-Muştu, 2021; Dehham et al., 2020; Gholami et al., 2023; Islim & Karatas, 2016; Kocatepe et al., 2019). The present study surpassed this criterion, enrolling 59 students (EGR = 30; CGR = 29). Furthermore, a post-hoc power analysis based on the observed partial η^2 values ($\eta^2_p = .70-.77$; $f \approx 1.8$) yielded a power of 1.00, confirming the adequacy of the sample size (Figure 2).

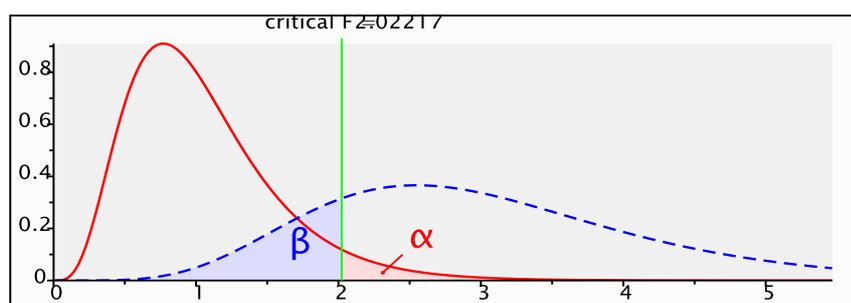


Figure 2. A-priori Power Analysis

Data Collection Tools

In the study, three distinct measurement tools were employed: the (SLMCAT) to assess students’ academic performance in the SLMC unit, the (EAS) to evaluate their environmental attitudes, and the (SLMT) to measure their motivation toward learning science.

Sustainable Life and Material Cycles Academic Achievement Test (SLMCAT)

Within the scope of the research, a 20-item multiple-choice achievement test was prepared to determine students’ academic success in the subjects of food chains and energy flow, energy transformations, matter cycles, environmental issues, and sustainable development. The test, designed on the basis of Bloom’s Taxonomy, includes five questions for each content area. To ensure content validity, the learning outcomes in the Science Curriculum were first examined, after which questions from the High School Entrance Examination (*LGS*), scholarship examinations, and the *EBA* platform were reviewed to create a preliminary draft. *EBA* (Education Information Network) is Türkiye’s national K–12 digital learning portal operated by the Ministry of National Education; it hosts curriculum-aligned, quality-assured materials (e.g., videos, interactive resources, and extensive question banks) and was widely used for distance education alongside TRT *EBA* TV during the COVID-19 period. This draft was examined by two academics specialising in science education and two experienced science teachers working in public schools. No negative issues were reported as a result of the review. For the validity and reliability analyses of the developed achievement test, a pilot application was carried out with the participation of 127 students, and item difficulty and item discrimination indices were calculated based on the data obtained (Hasançebi et al., 2020). The interpretation criteria for these indices are presented in Table 2.

Table 2. Item difficulty and discrimination index evaluation criteria (Kan, 2014; Kilmen, 2017)

Item difficulty index	Evaluation	Item discrimination index	Evaluation
0.00-0.19	Very difficult	0.40 and over	Very good level of discrimination
0.20-0.39	Difficult	0.30-0.39	Good level of discrimination
0.40-0.59	Medium	0.20-0.29	Needs to be developed and improved
0.60-.079	Easy	0.19 and below	Very low level of discrimination. Fails the test.
0.80-1.00	Very easy		

The values obtained as a result of the analysis of the item difficulty index are given in Table 3.

Table 3. Item difficulty index values and comments for achievement test items

Items	Item Difficulty (pj)	Comment	Items	Item Difficulty (pj)	Comment
1	0,71	Easy	11	0,46	Medium
2	0,53	Medium	12	0,48	Medium
3	0,51	Medium	13	0,40	Medium
4	0,43	Medium	14	0,43	Medium
5	0,58	Medium	15	0,39	Difficult
6	0,56	Medium	16	0,46	Medium
7	0,41	Medium	17	0,44	Medium
8	0,56	Medium	18	0,28	Difficult
9	0,58	Medium	19	0,28	Difficult
10	0,46	Medium	20	0,42	Medium

Considering the values in Table 3, it is seen that the difficulty indices of the items in the achievement test were distributed between 0.28 and 0.71 as a result of the pilot application. As a result of the analysis of the data, it was seen that 80% of the items in the test had three different difficulty levels: 80% medium, 15% difficult and 5% easy. In the statistical analysis, the overall difficulty level of the test was calculated as 0.47. This value shows that the test as a whole has a moderate difficulty profile.

In order to determine the psychometric properties of the test in more detail, the discrimination indices of the items were also calculated and the values obtained are given in Table 4:

Table 4. Discrimination index values and comments for the items in the achievement test

Items	L.G.C.N	U.G.C. N	Item (r _{ix})	Disc.	Disc. Level	Items	L.G.C.N	U.G.C. N	Item (r _{ix})	Disc.	Disc. Level
1	43	47	0,44		V.G.	11	17	42	0,52		V.G.
2	24	43	0,31		G.	12	24	37	0,51		V.G.
3	31	34	0,41		V.G.	13	18	33	0,40		V.G.
4	24	30	0,35		G.	14	15	39	0,56		V.G.
5	26	48	0,49		V.G.	15	23	26	0,24		CbI
6	39	32	0,35		G.	16	24	34	0,43		V.G.
7	9	43	0,53		V.G.	17	13	43	0,53		V.G.
8	35	36	0,41		V.G.	18	16	20	0,40		V.G.
9	29	45	0,27		CbI	19	5	31	0,44		V.G.
10	30	28	0,25		CbI	20	16	37	0,41		V.G.

I.N.: Item number, L.G.C.N.: Lower group correct number, U.G.C.N.: Upper group correct number; V.G.: Very good, G.: Good CbI: Can be improved

When Table 4 is examined, it is seen that the discrimination indices of the items in the achievement test vary between 0.25 and 0.53. As a result of the statistical analysis, it was determined that 70% of the items in the test were very good, 15% were good and 15% were good but could be improved, and the overall discrimination level of the achievement test was very good ($r = 0.41$). The KR-20 formula was used to determine the reliability level of the achievement test. This formula, which allows the test to be analyzed holistically, is accepted as a valid method for determining the internal consistency of scales evaluated with binary scoring (1-0) (Ntumi et al., 2023; Chinda et al., 2023). Considering the methodological advantages of the method, KR-20 formula was used to determine the consistency level of the achievement test. The findings obtained as a result of the evaluations are given in Table 5.

Table 5. KR-20 index values and comments for achievement test items

Items	Scale if Deleted	Mean Item	Scale Variance Item Deleted	KR-20 if Deleted	Items	Scale if Deleted	Mean Item	Scale Variance Item Deleted	KR-20 if Deleted
1	8.63		19.35	0.804	11	8.89		18.60	0.796
2	8.83		19.40	0.807	12	8.88		18.80	0.799
3	8.85		19.00	0.802	13	8.96		18.95	0.801
4	8.93		19.80	0.812	14	8.93		18.40	0.793
5	8.77		18.60	0.796	15	8.97		20.23	0.816
6	8.80		19.57	0.809	16	8.90		18.95	0.801
7	8.95		18.25	0.791	17	8.92		18.23	0.791
8	8.80		19.52	0.808	18	9.07		19.59	0.807
9	8.77		19.57	0.809	19	9.07		18.94	0.798
10	8.90		19.97	0.814	20	8.94		19.49	0.808

When Table 5 is examined, it is seen that the KR-20 value of the measurement tool is 0.811. This finding shows that the test has high internal consistency.

Environmental Attitude Scale

In this study, the “Environmental Attitude Scale” developed by Uzun et al. (2019), comprising 40 five-point Likert-type items, was employed to measure students’ environmental attitudes. While the original study reported an internal consistency coefficient of $\alpha = .94$, the present research obtained $\alpha = .88$, indicating that the instrument’s reliability remains at a high level.

Science Motivation Questionnaire II

In this study, “Science Motivation Questionnaire II” developed by Glynn et al. (2011) and adapted into Turkish by Işın et al. (2020) was used to measure students' motivation levels towards science learning. In order to evaluate the psychometric properties of the scale, exploratory and confirmatory factor analyses were applied to test the construct validity, and reliability was analyzed with Cronbach's alpha internal consistency coefficient. Cronbach's alpha value, which was calculated as 0.83 in the main study, was calculated as 0.78 in this study. The questionnaire, which was prepared in a five-point Likert-type structure, includes a total of 22 items.

Experimental Process

During the research process, the unit “Sustainable Life and the Material Cycle” was taught using two different approaches: SCAMPER-based activities in the EGR and curriculum-recommended methods in the CGR.

Protocol for Ensuring Independence of Observations. Sessions for EGR and CGR were conducted on separate days with at least a 48-hour interval (see Schedule A1). Each 80-minute session—10 min introduction, 55 min treatment, 15 min assessment—was supervised by the principal investigator plus two independent observers. Students were assigned random seating (1.5 m spacing), digital devices were collected at entry, and completed instruments were returned in closed envelopes. These measures eliminated inter-dependence among observations, thereby satisfying the independence assumption required for MANCOVA. The step-by-step experimental procedure is outlined below (Figure 3).



Figure 3. Experimental flowchart

Data Analysis

This study was designed to examine the effect of SCAMPER technique-based activities on eighth grade students' academic achievement, environmental attitudes and motivation to learn science in the unit SLMC. Within the scope of the study, the data obtained from the SLMCAT (achievement), EAS (attitude) and SLM (motivation) scales of the students were evaluated with multidimensional analyses in line with the sub-problems of the research.

The quantitative data obtained in the study were evaluated with descriptive and inferential statistical methods. In the descriptive analysis phase, central tendency (mean, mode, median) and distribution criteria (standard deviation, range, minimum-maximum values) were calculated for the PrT and PsT scores of the groups; whether the data showed normal distribution was examined with skewness and kurtosis coefficients.

To test the combined impact of the SCAMPER intervention on achievement (SLMCAT), attitude (EAS), and motivation (SLM), a Multivariate Analysis of Covariance (MANCOVA) was first conducted, using the corresponding pre-test (PrT) scores as covariates. MANCOVA

was preferred because the three dependent variables are theoretically related and empirically correlated, and the procedure controls the family-wise Type-I error rate while accounting for intercorrelations among outcomes. When the omnibus Wilks' Lambda indicated a significant multivariate effect, separate univariate ANCOVAs (with Bonferroni adjustment) were performed for each dependent variable to locate the source of the multivariate difference. Partial eta-squared ($\eta^2_{p^2}$) values were reported to quantify effect sizes.

In statistical evaluations, the significance level was set as $p < 0.05$ and the effect size calculations were used to interpret the effect of the SCAMPER technique on the independent variables. MANCOVA results revealed the overall effect of the SCAMPER technique by taking into account the intra- and inter-group variances, while ANCOVA findings revealed the specific contribution of the applied technique on each dependent variable.

The study compared the baseline levels of the groups in terms of dependent variables with descriptive statistics and revealed the effect of SCAMPER-based activities on dependent variables with quantitative data through inferential techniques.

Findings

Descriptive Statistics

The PrT and PsT scores of the EGR and CGRs were obtained using the SLMCAT, EAS, and SLM measurement instruments. In evaluating the data collected from these instruments, descriptive statistical analyses (mean, standard deviation, skewness, kurtosis, minimum, maximum, and range) were computed, and the resulting values are presented in Table 6.

Table 6. Descriptive statistics of the groups' PrT and PsT scores of the measurement tools

Group	Measurement Tool	Test type	n	Mean	ss	Skewness	ss	Kurtosis	ss	Min	Max	Shapiro F	Wilk df	sig
EGR	SLMCAT	PrT	33	55,60	11,43	,592	,409	,678	,798	35,00	85,00	,930	33	,350
		PsT	33	74,84	10,78	-,396	,409	,186	,798	50,00	95,00	,947	33	,111
	EAS	PrT	33	2,94	0,20	-,608	,409	,659	,798	2,40	3,34	,973	33	,565
		PsT	33	3,66	0,35	-,466	,409	,158	,798	2,77	4,33	,968	33	,434
	SLM	PrT	33	3,09	0,23	,175	,409	-,822	,798	2,68	3,56	,976	33	,667
		PsT	33	4,17	0,48	,133	,409	-,951	,798	3,32	5,00	,961	33	,275
CGR	SLMCAT	PrT	26	54,61	11,57	,983	,456	2,055	,887	40,0	90,0	,907	26	,053
		PsT	26	57,31	11,51	,704	,456	1,187	,887	40,0	90,0	,933	26	,092
	EAS	PrT	26	3,01	0,16	-,778	,456	,579	,887	2,63	3,31	,925	26	,060
		PsT	26	2,70	0,27	,836	,456	,749	,887	2,22	3,33	,926	26	,063
	SLM	PrT	26	3,08	0,24	-,126	,456	-,992	,887	2,64	3,52	,963	26	,450
		PsT	26	3,23	0,20	,199	,456	-,890	,887	2,92	3,64	,954	26	,281

When Table 6 is examined, it is observed that the experimental group (EGR) showed an increase of 19.24 points between the SLMCAT pre-test mean ($\bar{X} = 55.60$) and post-test mean ($\bar{X} = 74.84$), whereas the control group (CGR) exhibited an increase of 2.70 points between its pre-test ($\bar{X} = 54.61$) and post-test ($\bar{X} = 57.31$) means. A similar pattern emerges for environmental attitudes: the EGR post-test mean for EAS ($\bar{X} = 3.66$) rose by 0.72 compared with its pre-test mean ($\bar{X} = 2.94$), while the CGR post-test mean ($\bar{X} = 2.70$) declined by 0.31 relative to its pre-test mean ($\bar{X} = 3.01$). Finally, the science-learning motivation (SLM) post-test mean of the EGR ($\bar{X} = 4.17$) increased by 1.08 points over its pre-test mean ($\bar{X} = 3.09$); the CGR's corresponding rise was only 0.15 points (post-test $\bar{X} = 3.08$; pre-test $\bar{X} = 2.93$).

Considering the magnitude of these descriptive gains, the SCAMPER technique appears to exert a markedly stronger influence on students' academic achievement, environmental attitudes, and science-learning motivation within the "Sustainable Living and Matter Cycles" unit than the instructional approach used with the control group.

To verify multivariate normality, Shapiro–Wilk tests were performed at the class level for each dependent variable; all p-values exceeded .05, and the Q–Q plots displayed linear patterns. In addition, the skewness and kurtosis coefficients for the SLMCAT, EAS, and SLM post-test scores fell within the –1.5 to +1.5 range, a commonly accepted threshold indicating a normal distribution (Tabachnick & Fidell, 2013). Alternative heuristic cut-offs reported in the literature— –1 to +1 (Büyüköztürk et al., 2018) and –2 to +2 (George & Mallery, 2003)—likewise support these findings. Taken together, all indicators confirm that the data satisfy the normality assumption required for parametric analyses.

Inferential Statistics

Determination of Co-Variables

Within the scope of the study, the PRT of SLMCAT, EAS and SLM tests were considered both as independent variables and covariates. The independent variables PRT scores and PsT scores were correlated. Correlation analysis was applied to determine the direction and strength of the linear relationship between these variables. The results of the analysis revealed statistically significant positive correlations between SLMCATPr and SLMCATPs, EASPr and EASPs, and SLMPPr and SLMPs. In the literature, it is stated that the fact that an independent variable shows a significant relationship with one or more dependent variables is a sufficient criterion for using this variable as a covariate (Tabachnick & Fidell, 2013). The significance test results of the correlations between variables are presented in Table 7.

Table 7. Correlation analysis findings on the relationship between the scores of PrT and PsT variables

Variables	SLMCATPr	SLMCATPs	EASPr	EASPs	SLMPPr	SLMPs
SLMCATPr	1	,906**	,080	,086	-,126	-,147
SLMCATPs	,906**	1	,031	,025	-,061	-,091
EASPr	,080	,031	1	,975**	,298	,306
EASPs	,086	,025	,975**	1	,284	,294
SLMPPr	-,126	-,061	,298	,284	1	,993**
SLMPs	-,147	-0,91	,306	,294	,993**	1

When the data in Table 7 are analyzed, significant statistical relationships were found between SLMCATPr and SLMCATPs ($r = 0.906$, $p < 0.05$), EASPr and EASPs ($r = 0.975$, $p < 0.05$) and SLMPPr and SLMPs ($r = 0.993$, $p < 0.05$). In line with these results, the relevant variables were considered as control variables in MANCOVA and subsequent ANCOVA analyses. In addition, scatter plots showing the relationships between the variables are presented in Figure 2.

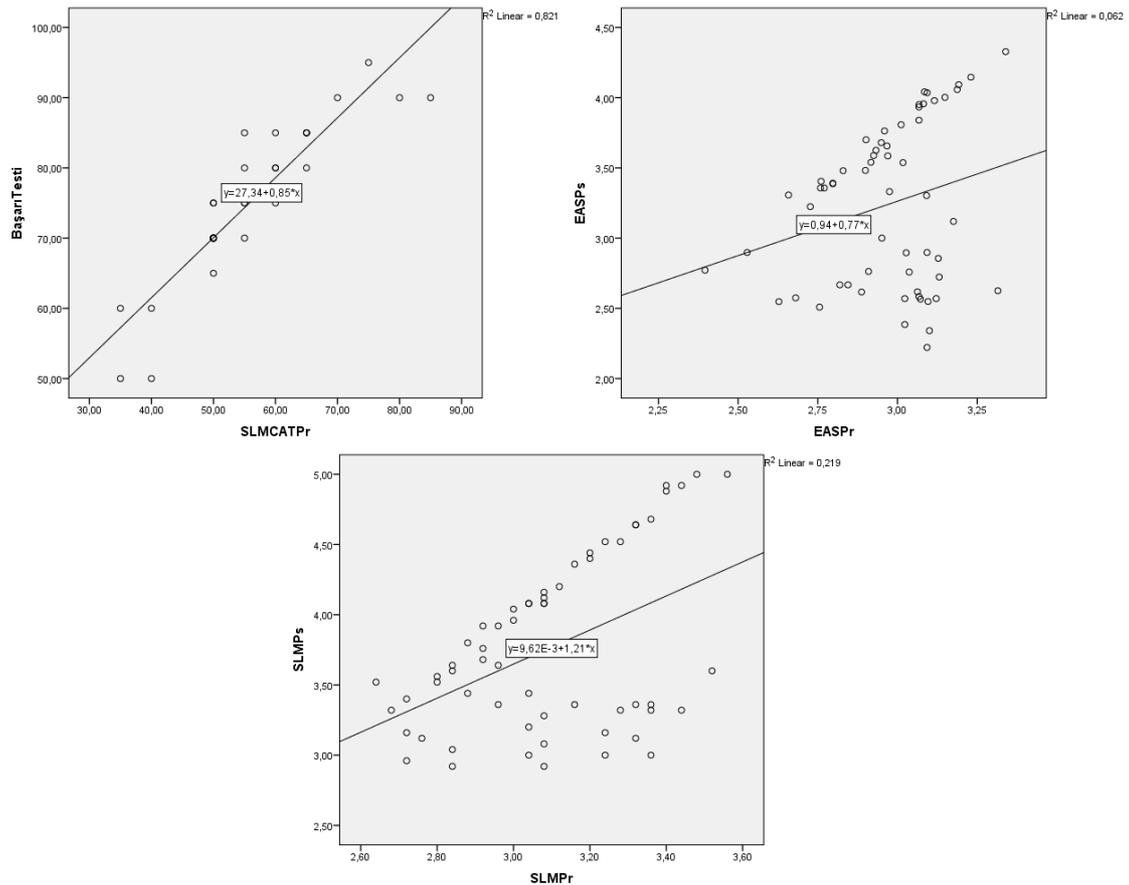


Figure 4. Scatter plots revealing the correlation structure of PrT and PsT scores evaluated within the scope of dependent variables

When the scatter plots in Figure 4 are analyzed, it is seen that there is a linear relationship between the dependent variables and the covariates.

Assumptions of MANCOVA Analysis

Within the scope of the study, the five basic assumptions of MANCOVA analysis (normality, regression homogeneity, covariance equality (Box's Test), multicollinearity and independence of observations) were examined separately (Cooley & Lohnes, 1971). The descriptive results in Table 6 show that the skewness and kurtosis values are consistent with a normal distribution.

In order to assess the assumption of equality in terms of the slopes of the regression curves of the groups, MRC analyses were performed separately on all dependent variables (SLMCATPs, EASPs and SLMPs). In this process, the covariates (SLMCATPr, EASPr and SLMPPr) were added to the first block (Block 1), the group variable (GR) was added to the second block (Block 2) and the newly created interaction values (GR*SLMCATPr*EASPr*SLMPPr) were added to the third block (Block 3) and regression analyses were performed using the enter method. Then, it was evaluated whether the change in the resulting R² value was significant for each dependent variable separately. For this assumption to be met, the p-value is expected to be above 0.05, i.e. statistically insignificant. Table 8 presents the findings regarding the assumption of homogeneity of regression lines in line with the outputs of the MRC analysis.

Table 8. Findings on dependent variables in MRC Regression homogeneity analysis

Dependent	Model	Change Statistics				
		R ² change	F change	df1	df2	Sig. F change
SLMCATPs	Block 1	,586	26,001	3	55	,000
	Block 2	,331	216,693	1	54	,000
	Block 3	,002	1,463	1	53	,232
EASPs	Block 1	,067	1,326	3	55	,275
	Block 2	,784	285,675	1	54	,000
	Block 3	,001	0,390	1	53	,535
SLMPs	Block 1	,238	5,736	3	55	,002
	Block 2	,571	162,034	1	54	,000
	Block 3	,014	4,180	1	53	,046

Considering the data in Table 8, it is seen that the interactions of group and independent variables with covariates ($F(1, 53) = 1,463$; $p = ,232$ for SLMCATPs, and $F(1, 53) = ,390$; $p = ,535$ for EASPs) do not have a statistically significant effect on these two dependent variables ($p > ,05$). These findings indicate that the model examined meets the assumption of homogeneity of regression lines. However, this assumption was not met for the dependent variable SLMPs.

In order to evaluate the homogeneity assumption of the covariance matrices of the dependent variables, Box's M test was applied and the values obtained as a result of the analysis are shown in Table 9.

Table 9. Box's M test findings for the equality assumption of covariance matrices of dependent variables

Box's M	F	df1	df2	p
19,714	3,093	6	20192,442	,005*

Box's M = 19,714; $F(6, 20 192,442) = 3,093$; $p = ,005$, thus the equality of covariance matrices assumption was violated. To address this, multivariate results were reported using a robust MANCOVA that focuses on Pillai's Trace and incorporates a 1 000-sample bootstrap correction.

Levene's test was conducted to evaluate the assumption of homogeneity of error variances for the scores of the dependent variables (SLMCATPs, EASPs and SLMPs) and the findings are given in Table 10.

Table 10. Levene's Test results for assessing the equality of error variances

Dependent variable	F	df1	df2	p
SLMCATPs	,076	1	57	,783
EASPs	2,707	1	57	,105
SLMPs	16,588	1	57	,000

As shown in Table 10, the p-values for SLMCATPs ($p = ,783$) and EASPs ($p = ,105$) exceed ,05, indicating homogeneous error variances. In contrast, the p-value for SLMPs ($p < ,001$) demonstrates a violation of the homogeneity assumption. Consequently, group differences for SLMPs were tested using a bootstrap-adjusted Welch ANCOVA (Table 11)

Table 11. Welch test for covariate-adjusted SLMPs residuals

Test	F	df1	df2	p
Welch	156.228	1	40.098	,000
Brown-Forsythe	156.228	1	40.098	,000



The Welch test ($F(1, 40,10) = 156,23; p < ,001$) indicates a large and statistically significant difference between groups in motivation scores after controlling for the covariate (SLMPr), confirming that variance heterogeneity did not obscure the substantive group effect.

Another important assumption of MANCOVA analysis is the absence of multicollinearity among the covariates. In this framework, the correlation values of the relevant variables with each other are expected to remain below 0.8. In order to test the validity of this assumption, Pearson correlation analysis was applied and the results obtained are presented in Table 12.

Table 12. Correlation analysis results for covariates

Common variables	SLMCATPr	EASPr	SLMPr
SLMCATPr	1	-,109	-,021
EASPr		1	,257
SLMPr			

As shown in Table 12, the highest absolute correlation coefficient is $r = .257$ (between EASPr and SLMPr). Because all values are well below the .80 threshold, multicollinearity is not a concern, and this MANCOVA assumption is satisfied.

The last assumption considered in MANCOVA analysis is the independence of observation. This assumption was secured by the researcher's supervision and control mechanism. The necessary care was taken to ensure that the study groups did not experience exam or grade anxiety throughout the process, and the feedback given to the students was provided under the supervision of the researcher at every stage. In addition, conducting the implementations independently of each other contributed to the fulfillment of this condition.

Results of MANCOVA Analysis

Within the scope of this study, pre-test scores and teaching method (SCAMPER) were determined as independent variables and post-test scores were determined as dependent variables. The pretest scores were defined as covariates. In order to determine whether the effect of SCAMPER technique on PsT scores was statistically significant or not, first MANCOVA and then ANCOVA analyses were applied. The findings obtained as a result of the analysis are given in Table 13.

Table 13. Findings related to MANCOVA analysis

Independent variables	Wilks' Lambda	F	df1	df2	p	Eta square (η^2)	Observed power
Intercept	,934	1,233	3	52	,307	,066	,311
SLMCATPr	,137	109,208	3	52	,000	,863	1,000
EASPr	,479	18,859	3	52	,000	,521	1,000
SLMPr	,471	19,487	3	52	,000	,529	1,000
Teaching Method	,091	174,014	3	52	,000	,909	1,000

Table 13 shows that the SCAMPER technique explains approximately 90.9% of the total variance in the dependent variables. In addition, the fact that the observed power value (1.00) exceeds the generally accepted threshold value ($>.80$) reveals that this method is an effective option in practice.

In line with the main problem of the study, the hypothesis “H0: SCAMPER technique has no effect on academic achievement, attitude and motivation PsT (Post Test) scores of 8th grade students when the variables of sustainable life and matter cycles academic achievement test (SLMCAT), environmental attitude scale (EAS) and science learning motivation (SLM) PrT

(Pre Test) scores are controlled” was established and the accuracy of the hypothesis was evaluated in line with the findings of MANCOVA analysis. When the analysis findings in Table 13 are examined, it is seen that the hypothesis was rejected in terms of the educational method variable ($\lambda = ,091$; $p = ,000$). It was determined that the educational method (SCAMPER technique) was significantly effective on the averages of SLMCATPs, EASPs and SLMPs, which were the dependent variables of the study.

In order to evaluate the effect of SCAMPER technique on each of the dependent variables (SLMCATPs, EASPs and SLMPs), it was evaluated with analysis of covariance (ANCOVA). The findings obtained as a result of the analysis are given in Table 14.

Table 14. Findings obtained as a result of ANCOVA analysis

Source	Dependent Variable	Type III Sum of Squares	df	Mean square	F	Sig.	Partial Eta Square	Observed Power
Corrected model	SLMCATPs	10560,649	4	2640,162	150,148	,000	,918	1,000
	EASPs	16,411	4	4,103	77,561	,000	,852	1,000
	SLMPs	17,573	4	4,393	57,405	,000	,810	1,000
Intercept	SLMCATPs	41,278	1	41,278	2,347	,131	,042	,325
	EASPs	,050	1	,050	,939	,337	,017	,158
	SLMPs	,011	1	,011	,144	,706	,003	,066
SLMCATPr	SLMCATPs	5934,036	1	5934,036	337,474	,000	,862	1,000
	EASPs	,022	1	,022	,421	,519	,008	,098
	SLMPs	,057	1	,057	,746	,392	,014	,136
EASPr	SLMCATPs	17,426	1	17,426	,991	,324	,018	,165
	EASPs	2,774	1	2,774	52,434	,000	,493	1,000
	SLMPs	,001	1	,001	,012	,914	,000	,051
SLMPPr	SLMCATPs	28,447	1	28,447	1,618	,209	,029	,239
	EASPs	,001	1	,001	,013	,909	,000	,051
	SLMPs	4,196	1	4,196	54,830	,000	,504	1,000
Teaching Method	SLMCATPs	3810,259	1	3810,259	216,693	,000	,801	1,000
	EASPs	15,111	1	15,111	285,675	,000	,841	1,000
	SLMPs	12,401	1	12,401	162,034	,000	,750	1,000
Error	SLMCATPs	949,520	54	17,584				
	EASPs	2,856	54	,053				
	SLMPs	4,133	54	,077				
Total	SLMCATPs	277300,000	59					
	EASPs	638,638	59					
	SLMPs	855,824	59					
Corrected Total	SLMCATPs	11510,169	58					
	EASPs	19,267	58					
	SLMPs	21,706	58					

For the first sub-problem of the study, the hypothesis “H1: When students' SLMCAT, EAS and SLM PrT scores are controlled, SCAMPER technique implementation has no significant effect only on SLMCAT PsT scores” was formed. When the ANCOVA analysis data in Table 14 are examined, it is seen that the hypothesis was rejected in terms of the teaching method (TM) variable ($F(1, 54) = 216.693$; $p = 0.000$). Considering the effect size value, the partial eta square was calculated as .801. This result reveals that the SCAMPER technique accounts for 80.1% of the change in SLMCATPs scores. According to Cohen (1988), the effect size determined as a result of the analysis shows that the effect of the SCAMPER technique on SLMCATPs scores is strong.

For the second sub-problem of the study, the hypothesis “H2: When students' SLMCAT, EAS and SLM PrT scores are controlled, SCAMPER technique implementation has no significant

effect only on EAS PsT scores” was formulated. When the data related to the ANCOVA analysis in Table 14 are examined, it is seen that the hypothesis was rejected in terms of the teaching method (TM) variable ($F(1, 54) = 285.675$; $p = 0.000$). Considering the effect size value, the partial eta square was calculated as .841. This result reveals that 84.1% of the change in EASPs scores is due to the SCAMPER technique. The effect size determined as a result of the analysis shows that the effect of the SCAMPER technique on EASPs scores is strong.

For the third sub-problem of the study, the hypothesis “H3: When students' SLMCAT, EAS and SLM PST scores are controlled, SCAMPER technique implementation has no significant effect only on SLM PST scores” was formulated. When the data regarding the ANCOVA analysis in Table 14 are examined, it is seen that the hypothesis was rejected in terms of the teaching method (TM) variable ($F(1, 54) = 162.034$; $p = 0.000$). Considering the effect size value, the partial eta square was calculated as .750. This result reveals that 75.0% of the change in EASPs scores is due to the SCAMPER technique. The effect size determined as a result of the analysis shows that the effect of SCAMPER technique on SLMPs scores is strong.

Discussion and Conclusion

Technological developments have transformed the processes of access to, production and dissemination of information and have reshaped education and training systems. In particular, competencies such as critical thinking, creativity, collaboration, problem solving and learning to learn, which are included within the scope of 21st century skills, have become a necessity for individuals and societies to adapt to the transformation process (Dilekçi & Karatay, 2023; Grey & Morris, 2022). These skills, which enable individuals to question and restructure information during the learning process, also support individuals to establish interdisciplinary connections related to topics and concepts and to produce creative solutions to daily life problems. In this study, the effect of SCAMPER technique on academic achievement, environmental attitudes and motivation to learn science in the unit “Sustainable Life and Material Cycles” was examined.

In the study, it was determined that the increase in the PsT scores of the EGR students was realized at a higher level compared to the CGR and the effect size for this increase was at a high level ($\eta^2 = 0.801$). This shows that the technique increases academic achievement by restructuring the subject and concepts and establishing interdisciplinary connections by adapting the problem to different situations. This finding is in line with the findings of many studies in the literature. Altıparmak and Eryılmaz-Muştu (2021) determined in their study that the academic achievement of the EGR students in the subject of “Simple Machines” taught with SCAMPER activities increased more than the CGR students taught with traditional methods and this increase was statistically significant. Pitrianti et al. (2021) and Mandasari et al. (2020) also determined that the SCAMPER technique increased the academic achievement of students in their studies with primary school students and that the effect values related to this increase were at a high level. In another study conducted in Iraq, it was found that SCAMPER also supported English language learning. In this context, it can be said that the SCAMPER technique increases academic achievement by enabling the restructuring of topics and concepts and multidimensional understanding with interdisciplinary connections. Arıcı Doğan et al. (2023) reported that SCAMPER-based environmental education increased children's recycling awareness, while Bozdemir and Önal (2024) reported that SCAMPER strengthened environmental awareness. Tharwa (2019) found that SCAMPER positively

affected university students' attitudes towards translation, indicating that the technique can support affective outcomes in different contexts. However, Altıparmak and Eryılmaz-Muştu (2021) found that there was no significant difference between groups in attitude scores towards science course. This difference suggests that attitudes may be affected by long-term interventions or multidimensional learning environments. At the same time, it is thought that measuring attitudes towards a specific subject (environment, recycling, sustainable living) or general attitude towards science knowledge (Altıparmak & Eryılmaz-Muştu, 2021) is also effective in the emergence of this difference. The fact that SCAMPER significantly increased motivation to learn science is consistent with many studies in the literature. Altıparmak and Eryılmaz-Muştu (2021) reported that motivation scores increased in the EGR compared to the CGR; Baş and Kaptan (2021) stated that SCAMPER simultaneously supports motivation and creativity in art education. Jeong et al. (2016) emphasized that SCAMPER increased motivation in food and beverage education; Wu and Wu (2020) emphasized that integration with project-based learning increased engineering students' willingness to participate. These studies show that the interactive and student-centered structure of SCAMPER makes the learning process more enjoyable and meaningful. However, Recepkethüda (2024) stated that the increase in motivation did not occur at the expected level due to adaptation problems in some students. Özyaprak (2015) stated that motivation requires continuity and one-time applications may be insufficient. This situation reveals that the effect of SCAMPER on motivation is shaped by factors such as students' learning styles, interests and duration of implementation.

While the findings of the study confirm the potential of SCAMPER to support both cognitive and affective gains, they show consistency with some studies in the literature and differences with others. Kocatepe et al. (2019) and Mandasari et al. (2020) supported the positive effect of SCAMPER on academic achievement, while Saifaldin and Al-Dabbagh (2024) found that Scamper-based education improved critical thinking. Similarly, Boonpracha (2023) found that it increased creative idea generation in product design, and Figueira et al. (2018) found that it increased inquiry skills. However, the inconsistencies observed in affective outcomes such as attitude and motivation may be related to contextual and individual factors rather than the structure of the measurement instruments. While Tharwa (2019) and Arıcı Doğan et al. (2023) focused on concrete themes (translation, recycling), this study focused on a broader concept such as “sustainable living”. Moreover, the fact that SCAMPER is effective in different age groups (preschool, primary school, university) proves the flexibility of the techniques, while studies such as Özyaprak (2015) and Recepkethüda (2024) point to the critical role of implementation time and student readiness.

The study concluded that the SCAMPER technique can be used as a versatile tool in science education. However, in order to maximize effectiveness, implementation processes should be adapted according to student needs, measurement tools should be compatible with the content, and long-term interventions should be planned. In future studies, conducting multidisciplinary research comparing the effects of SCAMPER in different disciplines (arts, engineering, language education) and examining the components of the techniques in depth through integrated analysis of qualitative and quantitative data may provide more differentiated results. In addition, focusing on the pedagogical integration of SCAMPER in teacher trainings may contribute to the dissemination of in-class applications.

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References

- Abd-Elghafour Seedek, H.A., & Babtain, H.M. (2022). The effectiveness of the SCAMPER strategy for teaching science on conceptual comprehension among middle school students. *Egyptian Journal of Science Education*, 25(2), 156-184. <https://doi.org/10.21608/mkmt.2022.236898>
- Abdelsattar, Z.S., & Karim, M.A.S.A. (2022). Strategic effect (SCAMPER) in collection matter sciences and the thinking futuristic female students class second average. *International Journal of Health Sciences*, 6(S7), 3316–3329. <https://doi.org/10.53730/ijhs.v6nS7.12466>
- Abdurrahman, I., & Mahmood, N. (2021). The effect of SCAMPER strategy on evoking Iraqi EFL preparatory pupils' creative thinking skills. *Journal of Tikrit University for Humanities*, 28(3, 4), 1-15. <https://doi.org/10.25130/jtuh.28.3.4.2021.22>.
- Akbaş, A. (2024). Artificial intelligence and social transformation: A sociological perspective. *International Journal of Humanities and Education*, 10(22), 151-180. <https://doi.org/10.59304/ijhe.1477203>
- Ali, W., Rifai, M., & El-Din, L. (2024). The role of creative thinking using artificial intelligence applications in managing environmental crises a field study on crisis management centers at the egyptian ministry of environment. *Journal of Environmental Science*, 53(6), 1711-1733. <https://doi.org/10.21608/jes.2024.272723.1743>.
- Altıparmak, T., & Eryılmaz-Muştu, O. (2021). The effects of SCAMPER technique activities in the 8th grade simple machines unit on students' academic achievement, motivation and attitude towards science lessons. *International Journal of Educational Methodology*, 7(1), 155-170. <https://doi.org/10.12973/ijem.7.1.155>
- Arıcı Doğan, D., Diler, S.S., Aslan, M., Özaksoy, N., Neşe, T., & Tüccar, E. (2023). Production of materials from recyclable materials for children aged 48-68 month after the environmental education given with scamper technique. *Journal of New Approaches in Education*, 6(2), 20-33.
- Baki, Y. (2023). The Impact of Scamper Technique on the Development of Creative Writing and Creative Thinking Skills. *Journal of Mother Tongue Education*, 11(4), 911-935.
- Baki, Y. (2024). The effect of the SCAMPER technique on the development of writing skills. *Korkut Ata Journal of Studies in Turcology*, 14, 1251-1270. DOI: 10.51531/korkutataturkiyat.1426267
- Baş, Ş., & Kaptan, A. Y. (2021). The use of SCAMPER technique in artistic creation process. *Cumhuriyet International Journal of Education*, 10(3), 1126-1149. <https://doi.org/10.30703/cije.816188>

- Besançon, M., Fenouillet, F., Shankland, R. (2015). Influence of school environment on adolescents' creative potential, motivation and well-being. *Learning and Individual Differences*, 43, 178-184. <https://doi.org/10.1016/j.lindif.2015.08.029>
- Boonpracha, J. (2023). SCAMPER for creativity of students' creative idea creation in product design. *Thinking Skills and Creativity*, 48, 101282. <https://doi.org/10.1016/j.tsc.2023.101282>.
- Bozdemir, E., & Önal, H. (2024). Examining the effect of cartoons evaluated with the Scamper technique on the creativity of 60-72 months old children. *International Journal of Primary Education Studies*, 5(1), 25-37. <https://doi.org/10.59062/ijpes.1470150>
- Brauer, R., Ormiston, J., & Beausaert, S. (2024). Creativity-fostering teacher behaviors in higher education: a transdisciplinary systematic literature review. *Review of Educational Research*. <https://doi.org/10.3102/00346543241258226>.
- Brem, A., & Puente-Díaz, R. (2020). Creativity, innovation, sustainability: a conceptual model for future research efforts. *Sustainability*, 12(8), 1-5. <https://doi.org/10.3390/su12083139>.
- Büyüköztürk, Ş., Çakmak Kılıç, E., Akgün, E.Ö., Karadeniz, Ş., & Demirel, F. (2018). *Bilimsel araştırma yöntemleri [Scientific research methods]* (26th Edition), Ankara: Pegem Academy Publ.
- Chinda, C. I., Aroyehun, A. R., & Chinda, W. (2023). Instrument reliability determination. In N. Wonu & P. Igwe (Eds.), *Research Methods for University Scholars* (pp. 189–202). Port Harcourt, Nigeria: Katapuno-Prints.
- Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.
- Cook, T.D., & Wong, V.C. (2008). Better quasi-experimental practice. In P. Alasuutari, L. Bickman & J. Brannen (Eds.), *The SAGE handbook of social research methods* (134-166). Retrieved from <https://arunodayauniversity.ac.in/wp-content/uploads/2025/01/The-SAGE-Handbook-of-Social-Research-Methods-Sage.pdf#page=151>
- Creswell, J.W., & Plano Clark, V.L. (2011) *Designing and conducting mixed methods research*. 2nd Edition, Los Angeles: Sage Publications.
- Creswell, J.W., & Creswell, J.D. (2017) *Research design: Qualitative, quantitative, and mixed methods approaches*. 4th Edition, Newbury Park: Sage.
- Çelik, I., Gedrimiene, E., Siklander, S., & Muukkonen, H. (2024). The affordances of artificial intelligence-based tools for supporting 21st-century skills. *Australasian Journal of Educational Technology*. <https://doi.org/10.14742/ajet.9069>.
- Çepni, S. (2010). *Araştırma ve proje çalışmalarına giriş [Introduction to research and project work]*, (5th Edition), Tabzon: Erol Publ.
- Dehham, S. H., Nayif Hasan, A. A., & Farj, I. I. (2020). Analysis of the psychological effect of scamper education program and creative thinking among primary pupils. *Indian Journal of Public Health Research & Development*, 11(4), 1900–1904.
- Deveci, İ., & Aydın, M. (2021). Science teachers' opinions on to be gained life skills in the curricula. *Trakya Journal of Education*, 11(1), 164-186. <https://doi.org/10.24315/tred.693345>
- Dilekçi, A., & Karatay, H. (2023). The effects of the 21st century skills curriculum on the development of students' creative thinking skills. *Thinking Skills and Creativity*. 47, 101229. <https://doi.org/10.1016/j.tsc.2022.101229>.
- Dini, N.A.I., & Rini, E.F.S. (2024). Integration of local potential in science learning to improve 21st-century skills. *IJCER (International Journal of Chemistry Education Research)*, 8(2), 156–165. <https://doi.org/10.20885/ijcer.vol8.iss2.art9>

- Fahmy, G.A., Qoura, A.A.S, & Hassan, S.R. (2017). YUsing SCAMPER-based activities in teaching story to enhance EFL primary stage pupils' speaking skills (An exploratory study). *Journal of Research in Curriculum Instruction and Educational Technology*, 3(4), 11-33. DOI:[10.21608/jrciet.2017.24352](https://doi.org/10.21608/jrciet.2017.24352)
- Figueira, F. L., de Souza, J. A., Dandolini, G. A., de Carvalho, D. N., & Lezana, A. G. R. (2018). Técnica de geração de ideias SCAMPER: Revisão estruturada de conteúdo. *Anais Do Congresso Internacional De Conhecimento E Inovação – Ciki*, 1(1), 1-14. <https://doi.org/10.48090/ciki.v%vi%i.476>
- Gholami, A., Hoseini, T. & Jdorra, N. (2023). The effect of using the scamper method on students' academic achievement and creativity in virtual biology education. *Theory and Practice in Teachers Education*, 9(15), 48-31.
- Glynn, S. M., & Koballa, T. R., Jr. (2006). Motivation to learn in college science. In J. J. Mintzes & W. H. Leonard (Eds.), *Handbook of College Science Teaching* (pp. 25–32). Arlington, VA: National Science Teachers Association Press.
- Grey, S., & Morris, P. (2022). Capturing the spark: PISA, twenty-first century skills and the reconstruction of creativity. *Globalisation, Societies and Education*, 22, 156 - 171. <https://doi.org/10.1080/14767724.2022.2100981>.
- Gülovalı, Ç., & Odabaş, A. (2011). *TÜBA Türkçe bilim terimleri sözlüğü sosyal bilimler [TÜBA Dictionary of Turkish science terms social sciences]*, Ankara: Yeni Reform Publ.
- Hacıoğlu, Y. (2017). The effect of science, technology, engineering and mathematics (STEM) education based activities on prospective science teachers' critical and creative thinking skills. (Doctoral dissertation), Gazi University, Türkiye.
- Hasançebi, B., Terzi, Y., & Küçük, Z. (2020). Distractor analysis based on item difficulty index and item discrimination index. *Gümüşhane University Journal of the Institute of Natural Sciences*, 10(1), 224-240.
- Henriksen, D., Creely, E., Henderson, M., & Mishra, P. (2021). Creativity and technology in teaching and learning: a literature review of the uneasy space of implementation. *Educational Technology Research and Development*, 69, 2091 - 2108. <https://doi.org/10.1007/s11423-020-09912-z>.
- Islim, O. F., & Karatas, S. (2016). Using the Scamper technique in an ICT course to enhance creative problem solving skills: An experimental study. *Turkish Online Journal of Educational Technology*, 2016, 1291-1296.
- Işın, O., Akçay, H., & Kapıcı, H. O. (2020). Adaptation of the science learning motivation scale into Turkish. *Mediterranean Journal of Educational Research*, 14(31), 505–529. <https://doi.org/10.29329/mjer.2020.234.24>
- Jeong, S., Moon, J., Ha, H., & Jung, J. (2016). The influence of NCS (National Competency Standard) food and beverage practice class using the SCAMPER method on learning motivation. *Culinary Science & Hospitality Research*, 22, 19-31. <https://doi.org/10.20878/cshr.2016.22.1.003>.
- Kalemkuş, J. (2021). Investigation of science curriculum learning outcomes in terms of 21st century skills. *Anadolu Journal of Educational Sciences International*, 11(1), 63-87. DOI: 10.18039/ajesi.800552.
- Kan, A. (2014). Test development. In S. Tekindal (Ed.), *Measurement and Evaluation in Education* (4th ed., pp. 259–296). Ankara: Pegem Academy Publishing.
- Kilmen, S. (2017). Item analysis, item selection, and interpretation. In R. N. Demirtaşlı (Ed.), *Measurement and Evaluation in Education* (4th ed., pp. 327–348). Ankara: Anı Publishing.

- Kim, H. (2013). *Elementary school teachers' conception and management conditions on creativity and character education*, (Master thesis), Ewha Womans University, South Korea.
- Kim, M., & Lim, C. (2022). Exploring the types of elementary students scientific creativity according to the structural relationship between creative process and product, *Journal Of The Korean Association For Science Education*, 42(1), 33-49. <https://doi.org/10.14697/jkase.2022.42.1.33>
- Kocatepe, O., Haşiloğlu, M., & Kurt, M. (2019). Middle school 6th grade science course academic achievement of scamper technique on reproduction, growth and development in plants and animals. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, 9(2), 64-73, Doi: 10.9790/1959-0902026473.
- Mandasari, W., Hawa, S., & Yosef, Y. (2020). Penerapan metode scamper terhadap hasil belajar dan keaktifan peserta didik kelas iv sekolah dasar. *Jurnal Inovasi Sekolah Dasar*, 7(1), 66-73. <https://doi.org/10.36706/JISD.V7I1.11624>.
- Martínez, O., Fernández-Samacá, L., & Cárdenas, L. (2021). Trends and opportunities by fostering creativity in science and engineering: a systematic review. *European Journal of Engineering Education*, 46, 1117 - 1140. <https://doi.org/10.1080/03043797.2021.1974350>.
- Mertens, D.M. (2024). *Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods* (6. Baskı). Sage.
- Ministry of National Education [MoNE] (2018). *Science course curriculum*. Ankara.
- National Research Council [NRC]. (2012). *A Framework for K-12 science education: practices, crosscutting concepts, and core ideas*. The National Academic, Washington DC.
- Ntumi, S., Agbenyo, S., Tetteh, A., Ebow Yalley, C., Yeboah, A. & Gyapong Nimo D., (2023). Teacher preparedness and implementation of the national pre-tertiary education curriculum framework in Ghana. *Journal of Educational Research and Practice*, 13, 251–269. <https://doi.org/10.5590/JERAP.2023.13.1.18>
- Nurbaety, D., Rustaman, N.Y. & Sanjaya, Y. (2015). The use of drawing method for diagnosing students' misconception about plant structure in relation to photosynthesis. *Proceedings of International Seminar on Mathematics, Science, and Computer Science Education (MSCEIS 2015)*. AIP Conf. Proc. doi: 10.1063/1.4941192.
- Özyaprak, M. (2015). The effectiveness of SCAMPER technique on creative thinking skills. *Journal for the Education of Gifted Young Scientists*, 4, 31-40. <https://doi.org/10.17478/JEGYS.2016116348>.
- Pitrianti, E., Usman, N., & Hawa, S. (2020). Penggunaan metode scamper terhadap hasil belajar peserta didik kelas IV. *Jurnal Inovasi Sekolah Dasar*. 7(2), 164-171. <https://doi.org/10.36706/JISD.V7I2.13256>.
- Radziszewski, E. (2017). SCAMPER and creative problem solving in political science: Insights from classroom observation, *Journal of Political Science Education*, 13(3), 308-316. <https://doi.org/10.1080/15512169.2017.1334562>
- Recepkehüda, R. (2024). *Examining the impact of SCAMPER technique-based activities on creative thinking and academic success*. (Master Thesis), Bartın University, Türkiye.
- Ritter, S.M., & Mostert, N.M. (2016). Enhancement of creative thinking skills using a cognitive-based creativity training. *Journal of Cognitive Enhancement*, 1, 243 - 253. <https://doi.org/10.1007/s41465-016-0002-3>
- Saifaldin, S., & Al-Dabbagh, A. (2024). The effect of an educational program based on the strategy of generating ideas (SCAMPER) in the teaching of history on developing critical thinking skills among gifted students in the center of Erbil

- Governorate. *Journal of University of Raparin*, 11(5), 692-713. [https://doi.org/10.26750/vol\(11\).no\(5\).paper28](https://doi.org/10.26750/vol(11).no(5).paper28).
- Suri Köksal, İ. (2018). The effect of science education supported by drawings on 8th grade students academic achievement and their understanding of visual materials was investigated. (Master Tezi), Marmara University, Türkiye.
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston, MA: Pearson.
- Tahir, T., & Marniati, M. (2020). Penerapan metode SCAMPER dalam mengembangkan kemampuan pemecahan masalah ditinjau dari motivasi mahasiswa pendidikan matematika universitas sembilanbelas november kolaka. *Jurnal Silogisme: Kajian Ilmu Matematika dan Pembelajarannya*, 4, 43-48. <https://doi.org/10.24269/silogisme.v4i2.2072>.
- Tekerci, H., & Kılınc, M. (2023). Components of learning: examination of pre-school teacher candidates' habits of mind. *Journal of Ahmet Kelesoglu Education Faculty*, 5(2), 343-358. <https://doi.org/10.38151/akef.2023.58>
- Tharwa, F. (2019). Using the SCAMPER model to develop translation skills for major students in the faculty of education, Majmaah University, Saudi Arabia. *Arab World English Journal for Translation and Literary Studies*, 3(2), 91-113. <https://doi.org/10.24093/awejtls/vol3no2.9>.
- Uzun, N., Gilbertson, K. L., Keles, O. & Ratinen, İ. (2019). Environmental attitude scale for secondary school, high school and undergraduate students: Validity and reliability study. *Journal of Education in Science Environment and Health*, 5(1), 79-90. <https://doi.org/10.21891/jeseh.491259>
- Wu, T., & Wu, Y. (2020). Applying project-based learning and SCAMPER teaching strategies in engineering education to explore the influence of creativity on cognition, personal motivation, and personality traits. *Thinking Skills and Creativity*, 35, 100631. <https://doi.org/10.1016/j.tsc.2020.100631>.
- Zeytinli Ünal, M. (2018). Teaching 8th grades "Living things and energy relations" unit with using models. (Master Thesis). Karadeniz Technical University, Türkiye.