



SCAMSSCRESH: An Integrated SCAMPER–SSCS Learning Model for Enhancing Students' Critical and Creative Thinking Skills

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Abstract

Critical and creative thinking are essential for science problem solving, yet unstructured brainstorming may lead students to cognitive fixation and reliance on familiar solutions. This study developed and evaluated SCAMSSCRESH, a learning model that integrates SCAMPER-based structured brainstorming into the Search, Solve, Create, and Share (SSCS) framework. Using an adapted Borg and Gall research and development approach, the study examined the model's feasibility, practicality, and effectiveness in junior high school science learning. SCAMSSCRESH comprises four stages: Search-SCAMPER, Solve-SCAMPER, Create, and Share, supported by a social system, reaction principles, and instructional resources. Expert evaluation demonstrated high content validity across the model and its supporting materials, while field testing indicated that the model was sufficiently practical for classroom implementation. Comparative testing further showed that students learning through SCAMSSCRESH achieved substantially greater improvements in critical and creative thinking than those receiving conventional instruction, with particularly strong gains in critical thinking. These findings suggest that embedding structured SCAMPER prompts within SSCS can provide systematic cognitive scaffolding for generating, evaluating, and communicating alternative solutions. The study contributes an empirically validated problem-solving model that integrates divergent and convergent thinking processes to support higher-order thinking in science learning.

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INTRODUCTION

In preparation for the challenges of the 21st Century, international educational assessment programs like PISA and TIMSS have motivated global educational reforms that emphasize higher-order thinking skills rather than mere subject-matter knowledge. Some of the skills that students must have to face the 21st Century and become highly qualified human resources are critical thinking skills (Chusni et al., 2020; Enciso et al., 2017) and creative thinking skills (Brown, 2015; Nakano & Wechsler, 2018; Ritter & Mostert, 2017; Supena et al., 2021). Critical thinking prepares students to think across disciplines through cognitive activities by focusing on decisions about what to believe or do (Sudiarta, 2007). Students also need critical thinking skills to solve problems in their daily lives (Ariani, 2020). Meanwhile, students also need creative thinking skills to modify knowledge, reuse it, or create new ideas and innovations and find potential solutions to problems (Kiraga, 2023; Kutlu & Gökdere, 2015; Rahardjanto et al., 2019). Critical and creative thinking skills are discussed together because both are complementary cognitive processes that play a vital role in solving complex problems. Creative thinking skills encourage students to think divergently (generating a variety of

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innovative solutions), while critical thinking skills aim to carefully evaluate and select the most logical and practical ideas (convergent thinking) (Thornhill-Miller et al., 2023; Vincent-Lancrin et al., 2019).

However, evidence suggests that students' higher-order thinking skills remain underdeveloped. Hafni and Sari's study (2021) found that students were insufficiently trained to analyze problems before evaluating and drawing conclusions, while Nuryanti et al., (2018) reported a low level of critical thinking among junior high school students, with an average achievement of only 40.46%. This concern is also reflected globally, where 73% of students assessed in PISA 2022 failed to reach proficiency Levels 5 and 6 (OECD, 2024). Several factors contribute to these limitations, including teachers' limited competence in designing HOTS-oriented strategies and assessments, dense curricula that prioritize content coverage, and teacher-centered instruction that relies heavily on memorization (Nelson & Crow, 2014; Saavedra & Opfer Anna, 2012). Such instruction can restrict students' opportunities to explore ideas independently, engage in active problem-solving, and develop critical and creative thinking (Alam, 2023; Bisri et al., 2025; Falah et al., 2018; Ghafar, 2023; Ghaleb, 2024). Therefore, structured learning models that shift learning toward student-centered problem solving while providing appropriate scaffolding are needed to support these skills.

One problem-solving-based model that addresses these needs is the Search, Solve, Create, and Share (SSCS) model (Pizzini et al., 1989). Previous studies have demonstrated that SSCS can improve students' critical thinking skills by engaging them in systematic problem identification, solution development, creation, and sharing (Diani et al., 2019; Jusman, 2021; Milama et al., 2017; Tiyaswati et al., 2021; Ulya, 2011). Through these stages, students actively explore problems, discuss possible solutions, and communicate their reasoning. However, the conventional SSCS model has a potential limitation in its brainstorming component. Although brainstorming can encourage students to generate ideas, unstructured group brainstorming may keep students anchored to existing examples or familiar solutions, limiting the variety and novelty of their ideas (Kohn & Smith, 2011). This tendency is related to the Einstellung effect, in which individuals rely on familiar and previously successful problem-solving methods rather than considering alternative approaches (Bilalić et al., 2008; Luchins, 1942).

Educational research shows that providing examples or general solutions at the start of instruction can further reinforce students' fixation on existing ideas, reducing the diversity and innovativeness of their responses (Vasconcelos & Crilly, 2016). However, previous research has not addressed this potential cognitive fixation within the brainstorming stages of SSCS. Thus, although SSCS has demonstrated value for analytical and critical thinking, its unstructured idea-generation process may limit its potential to develop creative thinking (Ritter & Mostert, 2017).

One approach to address this limitation is SCAMPER, a structured, guided brainstorming technique that uses a series of questions to stimulate alternative ideas and perspectives. The acronym represents Substitute, Combine, Adapt, Modify, Put to Other Uses, Eliminate, and Rearrange/Reverse (Eberle, 1972). By directing students to examine a problem from multiple perspectives, SCAMPER can support fluency, flexibility, originality, and elaboration while reducing fixation on familiar solutions (Altıparmak & Eryilmaz-Muştu, 2021; Serrat, 2017b). Previous research has also reported that SCAMPER can promote idea novelty and creative problem solving compared with conventional brainstorming (Duran-Novoa et al., 2019).

To address this gap, this study developed the SCAMSSCRESH learning model by integrating the structured SCAMPER brainstorming technique into the SSCS framework. The model modifies the SSCS brainstorming component by providing systematic guiding questions that help students explore problems from multiple perspectives, address the limitations of unstructured idea generation, and support both critical and creative thinking. Accordingly, this study addressed four research questions:

1. What are the characteristics of the SCAMSSCRESH learning model prototype for developing students' critical and creative thinking skills?
2. What is the feasibility of the SCAMSSCRESH learning model?
3. What is the practicality of the SCAMSSCRESH learning model?
4. How effective is the SCAMSSCRESH learning model in developing students' critical and creative thinking skills?

METHOD

This study is development research that aims to develop a learning product in the form of the SCAMSSCRESH learning model. Development research was chosen for this study because it involves developing, validating, and testing the SCAMSSCRESH learning model as a tool for developing critical and creative thinking skills in science education. The development process was adapted from Borg & Gall's (1983) R&D approach, which includes ten steps. In this study, the ten steps of development were modified into three major steps, including: (1) preliminary stage; (2) development stage; and (3) pilot testing stage with revisions and dissemination. Figure 1 illustrates the three major stages of the modified Borg and Gall development process.

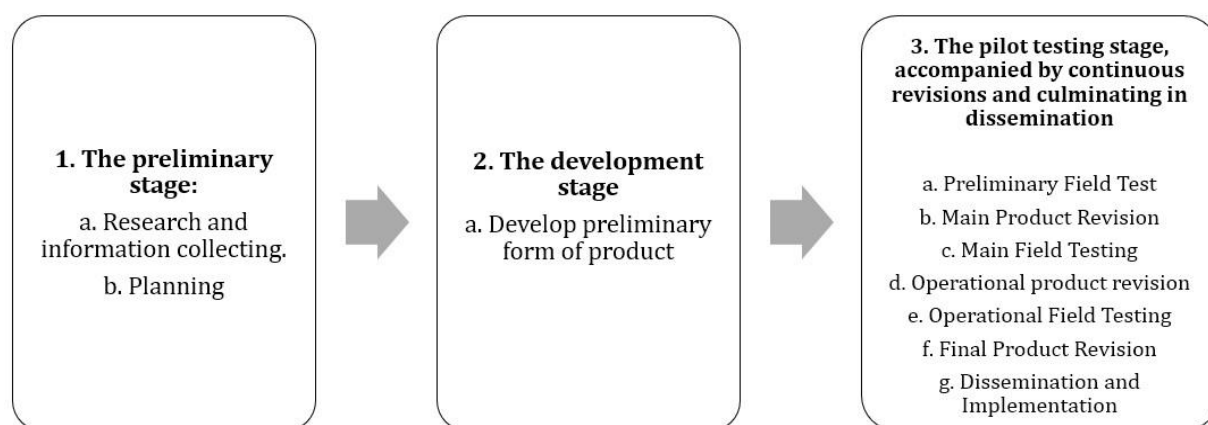


Figure 1. The Development Stages (Borg & Gall, 1983).

Research Subjects

The participants were eighth-grade students at SMP Negeri 1 Banyudono, Boyolali. The school was selected because it implements the Merdeka Curriculum, and preliminary observations indicated that students' critical and creative thinking skills in science learning were still low. The limited field trial involved 32 eighth-grade students from a non-sample class, aged 13–14 years, with relatively heterogeneous initial abilities. The operational field trial involved students from two eighth-grade classes selected using cluster random sampling. Initially, 59 students participated in the operational field test: 28 in the experimental class and 31 in the control class. Because students were absent during the creative-thinking posttest, this analysis included 54 participants: 28 in the experimental class and 26 in the control class. Students in both classes completed tests measuring critical and creative thinking skills and a questionnaire concerning their responses to the SCAMSSCRESH learning model.

Research Instruments

The data collection instruments consisted of an expert validation form for assessing the feasibility of the SCAMSSCRESH learning model and its supporting products, essay tests for measuring students' critical and creative thinking skills, an observation sheet for assessing the implementation of instruction, and a student response questionnaire concerning the implementation of the SCAMSSCRESH learning model. The expert validation form consisted of 30 items rated on a 1–4 Likert scale, ranging from Very Poor to Very Good. The critical and creative thinking tests were administered as essay tests and scored using analytical rubrics on a 0–4 scale. The critical thinking test consisted of seven essay questions based on the indicators of interpretation, analysis, inference, explanation, evaluation, and self-regulation, with a maximum score of 28. The creative thinking test used a 0–4 rubric, with a maximum score of 24. The instructional implementation instrument consisted of 20 observation items rated on a 1–4 scale, with 1 indicating Not Implemented and 4 indicating Implemented Very Well. A student response questionnaire also assessed students' responses to the implementation of the SCAMSSCRESH learning model. Before implementation, learning experts validated the research instruments using Aiken's V analysis.

Research Design

The preliminary stage involved identifying research problems and gathering information through literature review, classroom observations, and interviews with junior high school science teachers and students. The literature review focused on the limitations of SSCS and unstructured brainstorming and the potential of structured or guided brainstorming.

The development stage involved developing the initial SCAMSSCRESH learning model and its supporting instructional materials. The prototype included the theoretical rationale, learning syntax, social system, teacher roles and responsibilities, support system, and instructional and accompanying impacts. Supporting materials consisted of teaching modules aligned with the Merdeka Curriculum, student worksheets (LKPD), and assessment instruments for critical and creative thinking skills. Learning experts evaluated the prototype and instructional materials through focus group discussions (FGDs), and the resulting feedback informed revisions.

The pilot and dissemination stages consisted of limited and operational field testing. The limited pilot employed a one-group pretest–posttest design, and the resulting empirical data and feedback were used to refine the model. The revised model was subsequently tested in an operational field test involving an experimental class using the SCAMSSCRESH model and a control class receiving conventional instruction. The dissemination stage was conducted through publication in a scientific journal.

Data Analysis

The feasibility and validity of the SCAMSSCRESH learning model, its supporting instructional materials, and the critical and creative thinking skills instruments were assessed using Aiken's *V* based on evaluations by five experts. The Aiken's *V* values were interpreted as very low ($0.00 < V \leq 0.20$), low ($0.20 < V \leq 0.40$), moderate ($0.40 < V \leq 0.60$), high ($0.60 < V \leq 0.80$), and very high ($0.80 < V \leq 1.00$) (Aiken, 1980; Aiken, 1985).

Product readability was assessed through student questionnaires concerning the worksheets and teaching-material handouts. The mean score for each assessment aspect was calculated using the formula proposed by Widoyoko (2007). The resulting scores were interpreted according to Widoyoko (2017) as very poor ($1.00 \leq X \leq 1.75$), poor ($1.75 < X \leq 2.50$), good ($2.50 < X \leq 3.25$), and very good ($3.25 < X \leq 4.00$). The developed learning materials were considered practical when the average score reached at least the "good" category. The practicality of the SCAMSSCRESH learning model and its instructional materials was additionally assessed using percentage scores, categorized as very practical (85.01%–100.00%), quite practical (70.01%–85.00%), less practical (50.01%–70.00%), and not practical (1.00%–50.00%).

For the limited pilot test, we compared pretest and posttest scores because we measured the same participants. We used a paired-samples *t*-test when the differences between pretest and posttest scores were normally distributed, and the Wilcoxon Signed-Rank test when the normality assumption was not met. We set statistical significance at $p \leq 0.05$.

For the operational field test, students' improvement in critical and creative thinking skills was measured using normalized gain (N-Gain) calculated from pretest and posttest scores. N-Gain values were categorized as high ($0.70 \leq g \leq 1.00$), medium ($0.30 \leq g < 0.70$), and low ($0.00 \leq g < 0.30$). The Shapiro–Wilk test assessed normality, and Levene's test assessed homogeneity of variance. When the assumptions of normality and homogeneity were met, an independent-samples *t*-test compared N-Gain scores between the experimental and control groups. When the assumptions were not met, the Mann–Whitney *U* test was applied. Statistical analyses were conducted using SPSS Statistics, with statistical significance determined at $p \leq 0.05$.

Effect sizes were also calculated to determine the magnitude of the observed differences. Cohen's *d* was used where appropriate, with values of 0.20, 0.50, and 0.80 representing small, medium, and large effects, respectively. For the Mann–Whitney *U* test, the correlation coefficient (*r*) was calculated, with values of approximately 0.10, 0.30, and 0.50 or higher interpreted as small, medium, and large effects, respectively (Calin-Jageman & Cumming, 2019; Cumming, 2013, 2014).

RESULTS AND DISCUSSIONS

The SCAMSSCRESH Learning Model is one model that should be anticipated based on the requirements for 21st Century Science Learning. The SCAMSSCRESH Learning Model was created by combining the SSCS model and SCAMPER. The SCAMSSCRESH Learning Model is based on constructivist learning theory. The SCAMSSCRESH model was grounded in constructivism, Bandura's social cognitive learning theory, and progressivism. These foundations informed its emphasis on active knowledge construction, social interaction, scaffolding, experiential learning, and student-centered problem solving. In particular, SCAMPER-based guiding questions served as structured scaffolding (Slavin, 2010), while verbal description and modeling drew on Bandura's social cognitive learning theory (Bandura, 1997). The model's emphasis on students' skills and creativity in solving contextual problems also aligned with the philosophy of progressivism (Meliniasari et al., 2023). SCAMSSCRESH Learning Model is a student-centered learning model. Students develop knowledge through SCAMSSCRESH Learning activities. Table 1 compares the characteristics of the SSCS and SCAMSSCRESH models.

Table 1. Comparison of the Characteristics of the SSCS and SCAMSSCRESH Models

Comparative Aspects	SSCS	SCAMSSCRESH
Brainstorming technique	Brainstorming (No structured guidelines).	Directed brainstorming (using a structured set of SCAMPER questions).
Scaffolding	The scaffolding provided was not very structured; students were asked to explore ideas freely.	Scaffolding is provided through a "verbal description model" in the form of SCAMPER guiding questions. The teacher distributes worksheets containing written instructions and SCAMPER guiding questions.
Management of cognitive fixation.	Unstructured brainstorming leads to cognitive fixation (a lack of ideas) and the Einstellung effect.	The SCAMPER method can prevent cognitive fixation (the Einstellung effect) by guiding students to think from multiple perspectives.
Instructional impact.	It primarily fosters critical thinking skills, while creative thinking skills are not fully developed.	Fosters critical and creative thinking skills simultaneously.

The development of the SCAMSSCRESH learning model follows the components adopted from Joyce et al. (2015), including the theoretical basis for model development, syntax, social system, reaction principles, support system, and learning impact. Five experts empirically validated the model components through a Focus Group Discussion (FGD). The SCAMSSCRESH model components demonstrated very high content validity, with an Aiken's V coefficient of 0.93.

Syntax of SCAMSSCRESH Learning Model

The syntax of the SCAMSSCRESH learning model integrates the SSCS model syntax with SCAMPER to support learning outcomes. Table 2 shows the syntax of the SCAMSSCRESH learning model.

Table 2. Syntax of SCAMSSCRESH

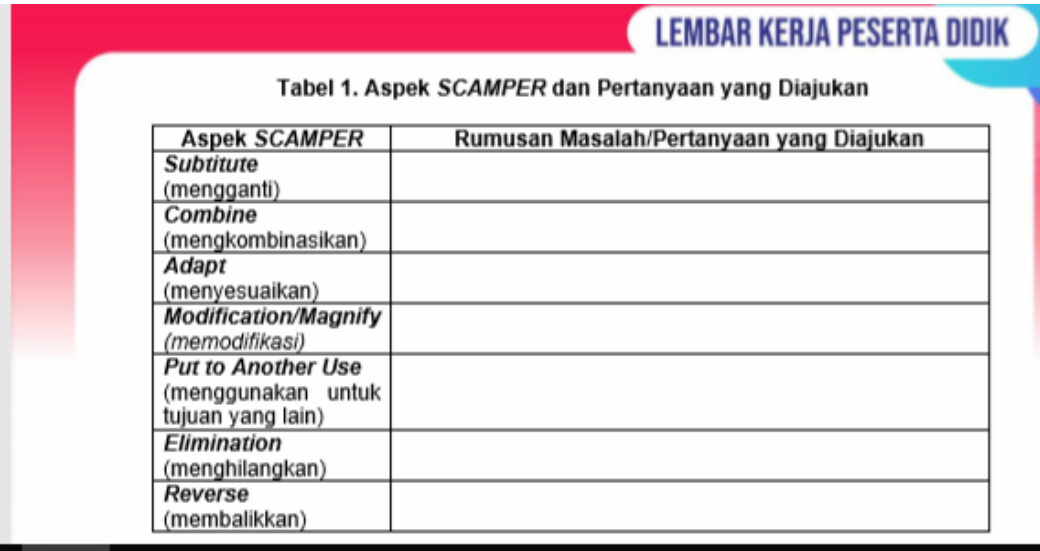
SSCS Syntax	SCAMPER	SCAMSSCRESH Syntax
Search	a. Substitute	1. Search-SCAMPER*
Solve	b. Combine	a. Substitute
Create	c. Adapt	b. Combine
Share	d. Modify	c. Adapt
	e. Put to Another Use	d. Modify
	f. Elimination	e. Put to Another Use
		f. Elimination

SSCS Syntax	SCAMPER	SCAMSSCRESH Syntax
	g. Reverse	g. Reverse
		2. Solve-SCAMPER*
		a. Substitute
		b. Combine
		c. Adapt
		d. Modify
		e. Put to Another Use
		f. Elimination
		g. Reverse
		3. Create
		4. Share

Description

*= The types of SCAMPERS used are adjusted to the characteristics of the material

The Search-SCAMPER stage begins with a contextual problem that encourages students to identify and analyze it and formulate questions to investigate. Through SCAMPER-guided brainstorming, students generate and expand possible questions from different perspectives, while the teacher facilitates classifying and selecting questions that become the focus of group inquiry. The SCAMPER components incorporated into the Search-SCAMPER stage are illustrated in Figure 2.



Aspek SCAMPER	Rumusan Masalah/Pertanyaan yang Diajukan
Substitute (mengganti)	
Combine (mengkombinasikan)	
Adapt (menyesuaikan)	
Modification/Magnify (memodifikasi)	
Put to Another Use (menggunakan untuk tujuan yang lain)	
Elimination (menghilangkan)	
Reverse (membalikkan)	

Figure 2. SCAMPER Aspect in Search-SCAMPER Step

In the Solve-SCAMPER stage, students use relevant literature to develop hypotheses and formulate problem-solving plans. SCAMPER-guided brainstorming generates alternative solutions, after which students choose appropriate investigation methods and collect data to test their hypotheses. The Create stage involves testing the proposed solutions, analyzing the resulting data, and developing the findings into concrete products or representations, such as written reports, charts, graphs, posters, or videos. The teacher provides feedback and guidance during data analysis, visualization, and product development. Finally, in the Share stage, students communicate their findings, solutions, and conclusions through presentations or other forms of communication, receive feedback from peers and the teacher, and reflect on and evaluate their solutions. These activities may also generate further questions for subsequent inquiry. Thus, integrating SCAMPER into the Search and Solve stages provides structured guidance for exploring problems, generating questions, and developing alternative solutions. In contrast, the Create and Share stages support developing and communicating the resulting solutions. Figure 3 presents the overall conceptual framework of the SCAMSSCRESH learning model.

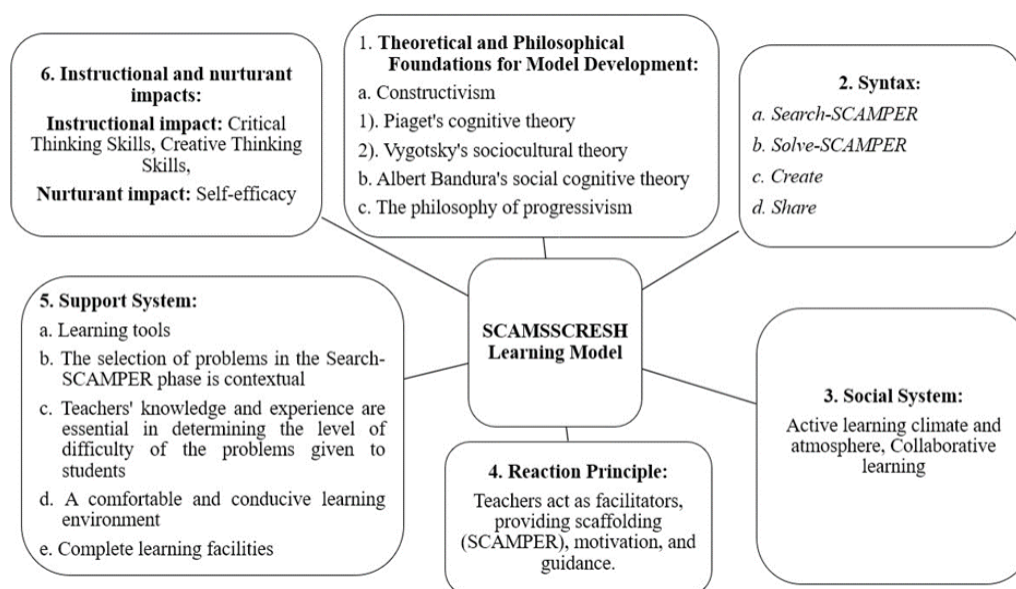


Figure 3. SCAMSSCRESH Conceptual Model Framework

Table 3 summarizes each SCAMSSCRESH stage's potential contribution to students' critical and creative thinking skills.

Table 3. Potential of SCAMSSCRESH Syntax on Critical and Creative Thinking Skills

SCAMSSCRESH Syntax	Critical Thinking Skills	Creative Thinking Skills
Search-SCAMPER	Interpretation, Analysis, Self-regulation	Fluency, Flexibility, Originality, Elaboration.
Solve-SCAMPER	Analysis, Inference, Evaluation, Self-regulation	Fluency, Flexibility, Originality, Elaboration
Create	Inference, Evaluation, Explanation, Self-regulation	Originality, Elaboration
Share	Evaluation, Explanation, Self-regulation	Fluency

Feasibility Test Result

The development of the SCAMSSCRESH learning model conducted in this study consists of several products that support the implementation of the model, including: SCAMSSCRESH model book, SCAMSSCRESH model guidebook, Teaching Modules in accordance with the Merdeka Curriculum syllabus, Handouts, student worksheets (LKPD), and evaluation instruments for creative and critical thinking skills in the subject of the human digestive system. The five experts revised these model products and then tested their feasibility for each assessment aspect. Table 4 presents the results of the expert assessment of the learning model.

Table 4. Expert Judgment Results

SCAMSSCRESH Learning Model Product	V Index Average
SCAMSSCRESH model book	0.93
SCAMSSCRESH model guidebook	0.94
Teaching Modules	0.98
Students Worksheet (LKPD)	0.90
Handouts	0.98
Critical Thinking Skills Instrument	0.90
Creative Thinking Skills Instrument	0.90

All seven SCAMSSCRESH products obtained Aiken's V values above 0.80, ranging from 0.90 to 0.98, indicating very high content validity. The highest values were obtained for the teaching modules

and handouts ($V = 0.98$), whereas the student worksheet and the critical- and creative-thinking instruments obtained $V = 0.90$.

Practicality Test Results

Before use in science learning, the SCAMSSCRESH learning model was tested for practicality. The practicality test assessed the readability of the student worksheets and handouts through a questionnaire, as well as students' responses to the SCAMSSCRESH model. Several factors that contribute to a high practicality score are: a) the activities in the worksheets support the achievement of learning objectives and the development of critical and creative thinking skills; b) the presentation of contextual problems in the worksheets (for example, the use of the Solo Serabi case study in the Search-SCAMPER stage) makes learning relevant to everyday life; c) the worksheets use language that is communicative, simple, easy to understand, and appropriate for the students' level of thinking.

Readability Test of the Student Worksheet and Handout of the SCAMSSCRESH Learning Model

The student worksheet and handout readability questionnaire responses were divided into two aspects: ease of understanding and interestingness. Both assessment aspects were presented in ten statements. The students' readability questionnaire responses were then analyzed using the average value for each aspect and the percentage of the practicality level. Figure 4 shows the practicality test results for the student worksheet and handout readability questionnaire.

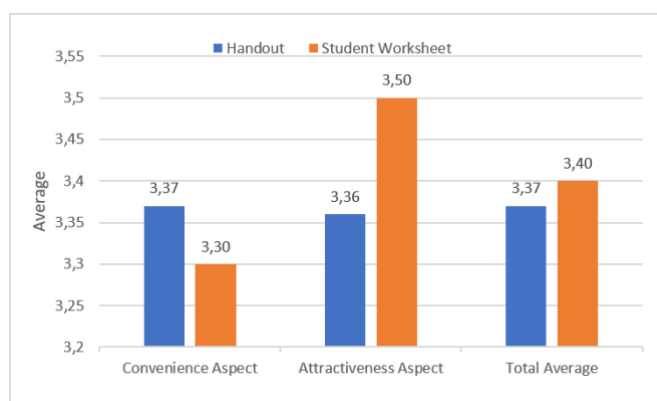


Figure 4. Average Readability Response

The readability assessment showed that both the student worksheets and handouts were rated in the 'very good' category. The student worksheets received higher readability scores than the handouts, which may be related to clear, coherent activity instructions aligned with the SCAMSSCRESH syntax. Students also reported that the handouts supported their understanding of the learning material. Figure 5 presents an excerpt from the SCAMSSCRESH student worksheet.

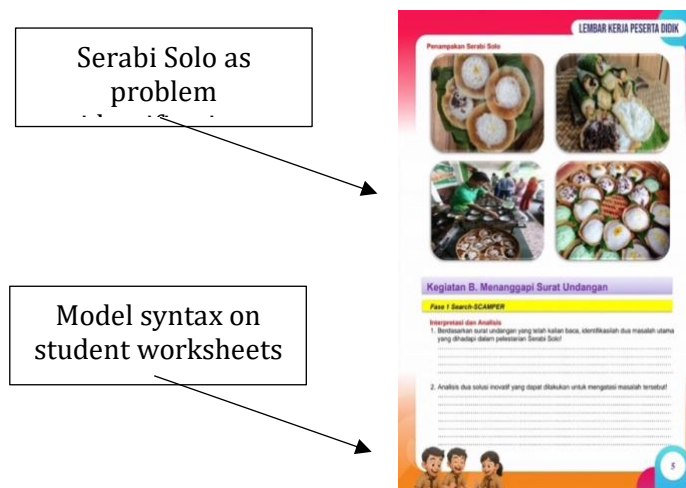


Figure 5. Students' Worksheet Excerpt

Students' Response to the SCAMSSCRESH Learning Model

The assessment of student responses to the SCAMSSCRESH learning model consists of four evaluation aspects: Syntax (Learning Steps), Social System, Reaction Principle, and Support System. These four evaluation aspects are presented in 30 statements. Next, we analyzed student responses to the SCAMSSCRESH learning model using the total average for each evaluation aspect and the total average across all aspects. Figure 6 shows the practicality test results from the student response questionnaire.

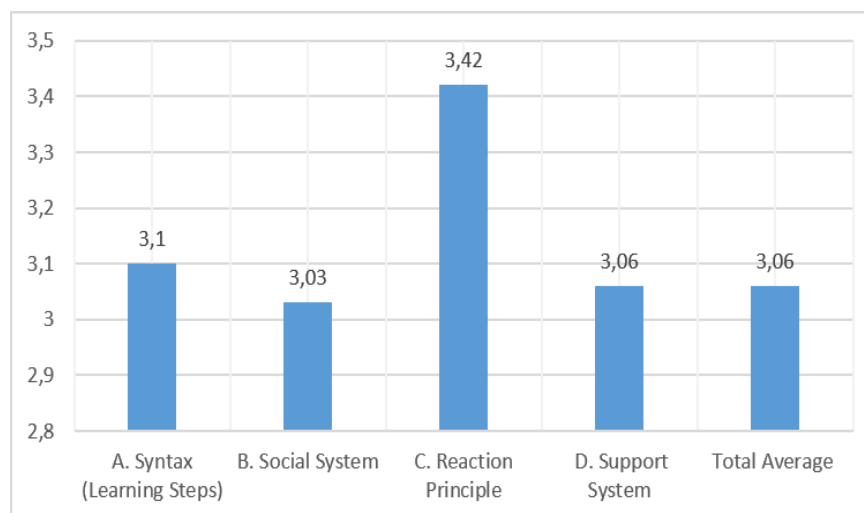


Figure 6. Student response to the SCAMSSCRESH

Based on Figure 6, students at SMP N 1 Banyudono gave the highest average score across the four assessment aspects for the reaction principal aspect, followed by syntax (learning steps). This is because, according to the questionnaire results, some students stated that they "agree" that the activities and steps of the SCAMSSCRESH learning model are more engaging and facilitate understanding of the subject matter, in this case, the human digestive system. However, some students also "agreed" that this model was more motivating for participating in learning activities, especially group discussions. This is supported by the average scores for the support system and social system, which show similar results.

The overall average of student responses to the learning model was 3.06, with a practicality percentage of 78.85%, indicating a fairly good level of practicality. Thus, based on the overall average score and practicality percentage, the SCAMSSCRESH model is practical for use in science instruction on the human digestive system.

Effectiveness of the SCAMSSCRESH Learning Model Critical Thinking Skills

The effectiveness of the SCAMSSCRESH learning model was tested twice: through a pilot study and a full-scale study. The pilot study was conducted in a single class to evaluate the initial impact of implementing the SCAMSSCRESH learning model on improving critical thinking skills. The full-scale study was conducted in two classes, a control class and an experimental class, to determine the model's effectiveness after the pilot study. Before testing the hypothesis about the model's effectiveness, we first conducted a prerequisite test.

The prerequisite analysis for the limited pilot test revealed that the distribution of pretest scores for critical thinking abilities was not normal, while the distribution of posttest scores was normal. Because the pretest and posttest scores were collected from the same respondents and the normality assumption did not hold, the Wilcoxon Signed-Rank Test was used to analyze paired data. The analysis was conducted at the 5% significance level. Table 5 presents the results of the Wilcoxon Signed-Rank Test.

Table 5. Results of the Wilcoxon Signed-Rank Test

Critical Thinking Posttest - Critical Thinking Pretest	
Z	-3.009
Sig. (2-tailed)	0.003

According to Table 5, the Z-value obtained from the Wilcoxon Signed-Rank Test is -3.009 , and the significance value is 0.003 . Because the significance value is less than the preset significance level of 0.05 , the null hypothesis is rejected. Therefore, the findings reveal a statistically significant difference between the students' pretest and posttest critical thinking scores in the pilot test. Thus, the results show that the SCAMSSCRESH learning model improved students' critical thinking skills.

Before analyzing the effectiveness of the instructional intervention in the large-scale operational test, the initial equivalence of the groups was examined based on the pretest results. The experimental group included 28 students with a pretest mean score of 38.21 ($SD = 15.39$), while the control group comprised 31 students with a mean score of 45.90 ($SD = 15.65$). Levene's test of equality of variances indicated that the two groups' variances were equal ($p = 0.977 > 0.05$). The independent-samples t-test also did not reveal a statistically significant difference between the pretest scores of the experimental and control groups, $t(57) = -1.899$, $p = 0.063$, 95% CI $[-15.80, 0.42]$.

Next, we computed N-gain scores to measure changes in students' learning performance in the two groups. Before comparing the N-gain scores, we tested the assumptions of normality and homogeneity using the Shapiro-Wilk test and Levene's test, respectively. When the N-gain scores met the assumptions of normality and homogeneity, we used an independent-samples t-test to determine whether a significant difference in learning gain existed between the two groups. When the assumptions were not met, we used the Mann-Whitney U test as an alternative nonparametric method. Therefore, the Mann-Whitney U test was the appropriate statistical test for this data. The operational field test was carried out using two groups of data: the experimental group and the control group at Banyudono 1 Public Junior High School. Critical Thinking Skills for the Experimental Group and Control Group are summarized in Table 6.

Table 6. Descriptive Statistics of Critical Thinking Skills

Descriptive	Experimental Class	Control Class
N	28	31
Mean	0.5203	0.1430
Median	0.4740	0.1250
Variance	0.037	0.057
Std. Deviation	0.19283	0.23813
Minimum	0.21	-0.44
Maximum	0.95	0.80
Range	0.74	1.23

According to Table 6, the experimental group showed a higher mean N-Gain ($M = 0.5203$, $SD = 0.1928$) than the control group ($M = 0.1430$, $SD = 0.2381$), corresponding to medium and low improvement, respectively.

Based on the pretest results from the large-scale test data set, the N-Gain score data sets in the control and experimental groups were homogeneous and normally distributed. Thus, we assessed model efficiency on the limited test set using an independent t-test at the 5% significance level. Table 7 presents the results of the model efficiency test.

Table 7. Results of the Independent t-Test

Data Type	df	<i>Sig (2-tailed)</i> P-value = ½ sig	Decision
The difference in pretest-posttest scores (N-Gain score)	57	0.000	H ₀ is rejected

The independent-samples t-test showed a statistically significant difference in N-Gain scores between the experimental and control groups ($p < .001$). The effect size was large (Cohen's $d = 1.732$), indicating a substantial difference in learning gains.

Creative Ability

The prerequisite test on the limited test data showed that pretest and posttest scores for creative thinking ability varied unequally (non-homogeneous). Furthermore, the pretest and posttest data for creative thinking ability were not normally distributed. Therefore, the effectiveness of the model tested in the limited sample was analyzed using the Wilcoxon Signed-Rank Test at a 5% significance level. Table 8 presents the results of the model effectiveness analysis.

As a result of the prerequisite test conducted for the pilot study, the pretest and posttest scores for creative thinking skills were not normally distributed. Because the pretest and posttest scores came from the same respondents and the normality assumption could not be met, the Wilcoxon Signed-Rank Test was used as a nonparametric test for paired data. The significance level chosen for this test was 5%.

Table 8. Results of the Wilcoxon Signed-Rank Test

Creative Thinking Posttest - Creative Thinking Pretest	
<i>Z</i>	-2.464
<i>Sig. (2-tailed)</i>	0.014

From Table 8, the Z-value of the Wilcoxon Signed-Rank Test for Creative Thinking Ability is -2.464. In addition, the significance value of the Wilcoxon Signed-Rank Test is 0.014. As the significance value was below the predetermined significance level of 0.05, the null hypothesis was rejected. This indicates a statistically significant difference between students' pretest and posttest creative thinking scores in the limited pilot test. Therefore, the findings show that the SCAMSSCRESH learning model improved students' creative thinking abilities.

The field test was conducted in two data groups: the experimental group and the control group of Banyudono 1 Public Junior High School. Table 9 shows the descriptive statistics of creative thinking skills for the experimental and control groups.

Table 9. Descriptive Statistics of Creative Thinking Skills

Descriptive	Experimental Class	Control Class
N	28	26
Mean	0.6750	0.0724
Median	0.6845	0.0991
Variance	0.028	0.096
Std. Deviation	0.16602	0.30945
Minimum	0.28	-0.54
Maximum	0.91	0.89
Range	0.63	1.43

Table 9 presents a descriptive analysis of creative thinking for the experimental and control groups. The experimental group ($N = 28$) has obtained a mean N-gain of 0.6750 ($SD = 0.16602$), with a score range of 0.28-0.91. In contrast, the control group ($N = 26$) obtained an average N-gain of 0.0724 ($SD = 0.30945$), with a score range of -0.54 to 0.89. Based on the N-Gain scores, the experimental class met the "medium" criterion (0.6750), whereas the control class met the "low"

criterion (0.0724). This implies that, descriptively, the experimental group showed a greater increase in creative thinking ability than the control group. However, these descriptive statistics describe the data and cannot determine whether a statistically significant difference exists between the two groups. A hypothesis test on the N-Gain scores can determine whether a statistically significant difference exists between the two groups, after testing the prerequisites.

The assumption tests showed that the N-Gain scores for both the experimental and control groups follow a normal distribution but do not have equal variances (not homogeneous). Therefore, to analyze the effectiveness of the model used in the pilot study, the Mann-Whitney U Test was performed at the 5% significance level. Table 10 presents the results of the Mann-Whitney U test.

Table 10. Results of the Mann-Whitney U Test

	Statistic Result
N	54
Z	-5.627
<i>Sig. (2-tailed)</i>	0.000

As shown in Table 10, the significance value (2-tailed) from the Mann-Whitney U test is 0.000, which is less than the significance level of 0.05. Therefore, we reject H_0 and accept H_1 , indicating a significant difference between the control and experimental groups.

The Mann-Whitney U test showed a significant difference between the experimental and control groups ($Z = -5.627$, $p < .001$). The effect size was large ($r = .7658$), indicating a substantial difference in N-Gain scores between the two groups. This value indicates not only a statistically significant difference between the two groups ($\text{sig 2-tailed} < 0.05$), but also a large practical difference. Therefore, one can conclude that the SCAMSSCRESH model improves creative thinking skills, with an effect size of 0.7658.

Discussion

The findings show that the SCAMSSCRESH learning model effectively improved students' critical and creative thinking skills. The small- and large-scale trials showed a significant difference between the experimental and control groups, with a large effect size for critical thinking (Cohen's $d = 1.732$) and a substantial effect for creative thinking ($r = .7658$). These findings indicate that integrating SCAMPER into the SSCS framework can support the development of both forms of higher-order thinking. The model's effectiveness stems from combining SSCS's structured problem-solving sequence with SCAMPER's guided brainstorming. SSCS provides a systematic sequence for identifying problems, developing solutions, testing ideas, and communicating findings, whereas SCAMPER provides structured prompts that encourage students to examine problems and solutions from different perspectives (Karina, 2017; Putri et al., 2022). Thus, students are not only guided to solve problems systematically but are also encouraged to generate and consider alternative ideas throughout the problem-solving process.

Improvements in critical thinking may relate to the sequential cognitive demands embedded in the SCAMSSCRESH syntax. During Search-SCAMPER, students were presented with the contextual "Serabi Solo" problem and guided to identify relevant information and formulate scientific questions. This activity supported interpretation and problem identification, consistent with previous findings that contextual problems presented at the beginning of learning can help students focus on problems and develop critical thinking (Harahap et al., 2020; Hardika, 2020; Ramadhani & Fuadiyah, 2023). Guiding questions also helped students identify problems and formulate questions, consistent with research showing that questioning activities can foster critical thinking (Aziz et al., 2021; Hidayati, 2016). During Solve-SCAMPER, students formulated hypotheses, considered alternative solutions, and developed investigation plans based on relevant literature, requiring analysis and evaluation. These problem-solving activities can strengthen students' analytical and synthesis skills (Efiana et al., 2025), while brainstorming and idea exchange can support the development of alternative solutions (Kohn & Smith, 2011; Putman & Paulus, 2009; Redhana, 2013). In the Create stage, students tested their proposed solutions, analyzed the results, and concluded, supporting inference and evaluation. This aligns with previous research indicating that idea testing and solution development can support rational and critical thinking (Aviyanti et al., 2025; Maskur et al., 2022; Ramadhani &

Fuadiyah, 2023). Finally, the Share stage required students to explain their findings, compare solutions, respond to feedback, and reflect on their decisions, thereby supporting evaluation, explanation, and self-regulation (Anugraheni, 2020; Milama et al., 2017). Overall, these findings suggest that SCAMSSCRESH contributes to critical thinking by sustaining the cognitive process from problem interpretation to solution evaluation and reflection.

The improvement in creative thinking can be attributed to the problem-solving activities embedded in the SCAMSSCRESH model, which require students to actively generate and consider different solutions. This finding is consistent with Yusnaeni et al. (2017), who reported that problem-solving activities can stimulate students' creative thinking by encouraging more active engagement. In the Search-SCAMPER stage, students were encouraged to examine the "Serabi Solo" problem from different perspectives and generate multiple questions and ideas, supporting fluency and flexibility. Using SCAMPER as a structured set of prompts can encourage students to explore problems from different perspectives and generate a wider variety of ideas (AlZayat, 2014; Eberle, 1972; Farrokhnia et al., 2023; Özyaprak & Leana-Taşçılar, 2019; Ritter & Mostert, 2017). In the Solve-SCAMPER stage, students generated alternative hypotheses and possible solutions, such as replacing rice flour with moca flour, modifying the color using natural ingredients, or adding nutrient-rich ingredients. Generating multiple alternatives provides opportunities for fluency and flexibility in thinking, consistent with previous research on creative problem solving and idea generation (Farrokhnia et al., 2023; Ulger, 2016; Serrat, 2017a; Starko, 2022). In the Create stage, students selected, tested, and refined their proposed solutions, which supported originality and elaboration through the development of different products and outcomes. The Share stage then gave students opportunities to communicate and further develop their ideas through feedback and discussion. Overall, these findings are consistent with previous research indicating that SCAMPER can support fluency, flexibility, originality, and creative problem solving (Ritter & Mostert, 2017; Altıparmak & Eryılmaz-Muştu, 2021).

Integrating SCAMPER adds a structured creative-thinking component to the conventional SSCS problem-solving sequence. The SSCS model emphasizes a systematic problem-solving process through the Search, Solve, Create, and Share stages (Putri et al., 2022). In contrast, SCAMPER provides structured prompts for generating and developing alternative ideas (Karina, 2017). Previous research has shown that SCAMPER can support creative potential, problem-solving, and cognitive flexibility (Altıparmak & Eryılmaz-Muştu, 2021; Ariyani et al., 2025). In SCAMSSCRESH, SCAMPER is incorporated into the Search and Solve stages, where students receive guiding questions and worksheets to structure brainstorming and explore alternative solutions. This integration does not replace the SSCS problem-solving sequence but adds scaffolding for idea generation within it. Scaffolding within SSCS has also been associated with more effective and efficient learning processes and increased student engagement (Saregar et al., 2018), while SCAMPER can facilitate idea generation and redesign (Kamis et al., 2020). Therefore, SCAMSSCRESH combines the structured analytical process of SSCS with guided creative exploration, providing a framework for addressing critical and creative thinking within the same learning sequence.

CONCLUSIONS

Based on the study results and research conducted, the SCAMSSCRESH learning model is feasible, practical, and effective for science learning in junior high schools. The findings confirm that integrating the structured brainstorming technique (SCAMPER) into the SSCS model enhances students' ability to analyze problems in depth (critical thinking) and generate innovative, original, and diverse ideas or solutions (creative thinking). The operational trial results show that applying the SCAMSSCRESH approach significantly and positively influences the development of critical and creative thinking abilities compared with traditional educational approaches. This research contributes to the science education literature. This research introduces a new, scientifically tested operational framework for simultaneously developing convergent and divergent thinking abilities in one learning process. For further investigation, we suggest larger-scale trials across different science topics.

LIMITATIONS

Although this model has shown significant potential, this study has several limitations. First, its effectiveness was tested on a limited scale, with a sample of only 59 students for the critical thinking skills assessment and only 54 students for the creative thinking skills assessment (the original number of students was 64, but some students were absent during the posttest, so the number of students decreased). Therefore, further testing on a larger scale is needed to evaluate the SCAMSSCRESH model's effectiveness in improving students' critical and creative thinking skills. Second, this study was conducted on only one science topic, namely food and the digestive system, so its effectiveness needs to be tested on other science topics.

AUTHOR CONTRIBUTIONS

All authors worked collaboratively on this research. IK made significant contributions to the collection, analysis, and interpretation of data; was actively involved in the process of writing and critical revision of the manuscript for the intellectual content of the research; gave final approval of the version of the paper to be published; and accepted full responsibility for all aspects of the research to ensure its accuracy and integrity. DR made significant contributions by revising and finalizing the paper, including restructuring the content, refining the theoretical framework with additional data and concepts, and helping reanalyze the data. IW helped revise and refine the manuscript, including reorganizing the paper to improve flow and consistency; conducted the literature search and revised the methodology to suit the research objective and findings; and contributed to data reanalysis and formatting. FH contributed to quantitative data analysis and discussion.

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