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Scaffolding Based On Scientific Creativity Learning (SSCL): An Innovative Learning Model To Improve Student's Skill in Scientific Creativity

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ABSTRACT

Objective: Describe The development of the SSCL model, including validity, practicality, effectivity, and student response with the implementation of learning and student activities. This study aimed to obtain validity, practicality, effectivity, and student responses to the SSCL model in Junior high school. **Method**: This type of research is Research and Development (R&D) research oriented towards product development using the ADDIE development model—determination of the research location using a purposive sampling area. The sample in this study was student class VIII. **Results**: The results showed (1) the validity and reliability are very valid and very reliable, (2) an improved indicator of achievement with high category, (2) most of the students gave responses that scaffolding based on Scientific Creativity Learning (SSCL) models enabled them to practice scientific creativity skills in junior high school. **Novelty**: This research emphasizes using scaffolding for Proximal Zone Development (ZPD) approach students and students' initial conceptions of learning science. The result findings show that each phase of SSCL significantly contributes to increasing the achievement of indicators of scientific creativity.

INTRODUCTION

Today's learning requires teachers and students to master life skills, especially 21st-century skills. The skills needed include critical thinking skills and problem-solving, communication, collaboration, creativity, and innovation (Dilekçi & Karatay, 2023; Irwan et al., 2024; Nurhayati et al., 2024; Sari et al., 2024; Thornhill-Miller et al., 2023; Xu et al., 2023). According to Astutik et al. (2024), higher thinking skills are complex thinking processes in describing material, drawing conclusions, constructing representations, analyzing, and constructing relationships involving the most basic mental activity. These are 21st-century skills, commonly called the four C's (4C's) (Saphira & Prahani, 2022; Sari et al., 2024). The 4-C approach is oriented towards higher-order thinking skills (HOTs), which are thought to improve student achievement and improve students' higher-order thinking skills as scientific creativity skills.

The research results were conducted by PISA on an ongoing basis and started in 2003, 2009, 2012, 2015, and 2018. PISA specifically assessed creative problem skills (OECD, 2013). The results of studies based on TIMSS and PISA show that Indonesian students' collaborative problem-solving skills are classified as low-level. Minister of Solving Education and Culture Regulation No. 54 of 2013 concerning Competencies for Middle School Student Graduates states that the competency that Middle School students must achieve through science learning is the ability to think and act effectively and creatively in abstract and concrete domains by what is learned at school and other similar sources. This indicates that in science learning, students are not yet skilled and creative in creative problem-solving. Hence, they need to develop skills in science learning, especially science process skills and scientific creativity skills.

Scientific creativity skills in learning activities play an important role in identifying problems, exploring various methods, and exploring alternative solutions. These alternative methods or solutions must be analyzed and evaluated for further implementation (Prahani et al., 2021). Creativity is a divergent production of ten, also called creative thinking. Divergent thinking aims to produce many answers to one question and is a characteristic of creativity or creative thinking. Divergent production has four components: fluency, flexibility, elaboration, and originality. Beetlestone (2012) views creativity as an important and necessary component because creativity provides ample space for children's cognitive development. This is closely related to the role of the teacher as a facilitator who leads agents of change to produce creative processes and creativity. Creativity as a whole can be interpreted as a person's cognitive thinking process and skill to produce something unique and wholly new or a combination with existing things that no one else has thought of before.

Scaffolding is providing assistance to a student during the early stages of learning and then reducing the assistance and allowing the student to take over responsibility once he can do so. Scaffolding can also be interpreted as a bridge to build on students' knowledge to arrive at something they do not know. The conceptual framework of collaborative creativity is supported by constructivist theory, especially socio-cognitive. In addition, teachers provided feedback on the learning process by making corrections and strengthening the students' work to achieve Proximal Zone Development (ZPD).

Teachers use scaffolding to help students gain experience in solving ill-defined problems. Students learn concepts best if the concept is in their closest development zone. Distributed cognition learning occurs when individuals share ideas with others to increase their understanding. They are encouraged to clarify and organize their ideas, elaborate on what they know, discover weaknesses in their reasoning, and entertain alternative views that are equally valid. With what they have (Moreno, 2010). Exploration must be complemented with appropriate guidance to help students learn as the teacher desires. Teachers facilitate social interaction to encourage students' knowledge construction and skill development.

Many learning models are considered suitable for developing students' scientific creativity skills, including the Problem-Based Learning (PBL) model (Arends, 2012; Indrawati, 2019) and the Collaborative Creativity Learning (CCL) model (Astutik, 2016). The PBL model is aimed at developing high-level thinking skills, which in this case are students' critical thinking skills (Abidin & Sulaiman, 2024; Adhelacahya et al., 2023; Bazarbayeva & Aitbayeva, 2023; Mahmudah & Nugraha, 2024). A form of learning that can encourage collaboration and involve students in investigations of their own choice, allowing them to interpret and explain real-world phenomena and build about them. Problem-based learning triggers students to solve complex and unclear problems; students work collaboratively to share information, evaluate, and provide criticism to each other when solving problems. The CCL model refers to student activities that direct students to work collaboratively to get creative ideas in learning (Astutik, 2018; Irma et al., 2023; Supeno et al., 2019). The CCL model is very supportive and can show explicitly how students play a role in exploring critical thinking and creativity.

Referring to these learning models, developing a learning model that can maximize students' scientific creativity skills is necessary.

Based on the description above, students' scientific creativity skills in learning will be implemented by orienting scaffolding based on Scientific Creativity Learning (SSCL), which is oriented towards high-level thinking skills, which is a realization of the constructivist teaching view by creating a model (Astutik et al., 2024). The scaffolding guides students' learning of scientific creativity concepts and science knowledge, and scaffolding is understood as an instructional activity that helps learners use psychological tools. Scientific creativity is the ability to perform novel and valuable thoughts, ideas, or behaviors about science (Algiani et al., 2023). This research emphasizes using scaffolding for ZPD approach students and students' initial conceptions of learning science (Irwan et al., 2024). The efforts are to develop an SSCL model by referring to the two previous models and expert opinions, which consist of the following steps: Orienting, Problematizing, Scientific Creativity, Elaborating, and Evaluating, which are applied to improve creativity skills in Junior High School student science.

The question research includes: (1) What is the validity of the SSCL model; (2) How practical is the SSCL model?; (3) How effective is the SSCL model?; and (4) How do students respond to the development of the SSCL model? The aims of the research are: 1) to examine the validity of the SSCL model development; 2) to examine the practicality of developing the SSCL model; 3) to examine the effectiveness of SSCL model development; 4) to understand student responses to the development of the SSCL model. The contribution of this research is that students gain good scientific creativity skills by using scaffolding and ZPD and referring to students' initial abilities before learning. For teachers, the SSCL model is used as a guide in teaching students scientific creativity.

RESEARCH METHOD

This type of research is development research. This development research aims to develop the SSCL model in secondary schools in accordance with validity and reliability, practicality, and effectiveness product development criteria. The research was carried out by adapting the model development stages according to ADDIE. Model development steps according to the ADDIE Model (Astutik, 2020), namely: 1) Analyze, 2) Design, 3) Develop, 4) Implement and 5) Evaluate

This research is used to determine the effectiveness, self-assessment, and student responses of the SSCL model. The SSCL model was developed to teach the scientific creativity skills of students in learning at the junior high school JHS 3 Jember, Indonesia. The SSCL model was implemented for students in the class with the syntax models, namely: 1) Orienting, 2) Problematizing, 3) Scientific Creativity, 4) Elaborating, and 5) evaluating processes and results. Implementation of the SSCL model in teaching was expressed in five (5) phases. The first phase is the class, which forms a working group of students without discrimination based on sex/gender and individual capabilities.

Figure 1. Steps of scaffolding based on scientific creativity learning model.

The syntax of the Scaffolding model based on Scientific Creativity Learning is shown in Table 1.

Table 1. Syntax of the SSCL Model.

Syntax	Student Activity	Lecture Activity
Stage 1: Orienting	1. Prepare in an orderly manner to form a study group 2. In groups, children pay attention and study the problems given by the teacher. 3. Together with groups of students, find problems that will be studied from Themes or Sub-Themes	1. The teacher prepares the formation of study groups 2. The teacher invites the children to prepare for that day's lesson and motivates students. 3. The teacher guides students to find problems in the essential material and, at the same time, conveys the day's learning objectives
Stage 2: Problematizing	1. Students contribute creative ideas to groups according to the theme 2. Students collaborate in groups to analyze problems and make hypotheses according to the problem (scientific work) 3. Working together with group members in finding solutions to problems (collaborating)	1. Orient Scaffolding to learning activities with integrated scientific creativity in Themes. 2. Coordinate the SSCL model by considering the ZPD
Stage 3: Scientific Creativity	1. Students carry out activities to analyze, evaluate, or create (problem-solving) with seven scientific creativity indicators 2. Contribute to preparing and conducting activities to analyze, evaluate, or create (contribution) 3. Cooperate with group members in analyzing, evaluating, or creating (cooperating)	1. Accompanying students both individually and in groups in the process of preparing and exploring activities in the wild to analyze, evaluate, or create (problem-solving) with seven scientific creativity indicators 2. Facilitating students in carrying out scientific creativity-based activities 3. Pay attention to working time.
Stage 4: Elaborating	1. Listen to the feedback conveyed by the teacher 2. Together with the teacher, make learning conclusions	1. Provide feedback to students 2. Encourage students to make conclusions
Stage 5: Evaluating	1. Convey the findings to other group members 2. Celebrate the results of work together	1. Guide the course of the discussion by presenting the findings 2. Give awards to students

Source: (Astutik, 2024)

To describe the effectiveness of the SSCL model, scientific creativity skills were developed based on indicators of achievement, self-assessment, and student responses. The draft for achieving the research objectives used a descriptive quantitative approach, which described the effectiveness of the SSCL learning model. The data were obtained on the students' scientific creativity skills based on the scores of the student's answers to the scientific creativity test. Scientific Creativity test results were based on scores obtained from responses to each indicator in the scientific creativity test. Indicators of scientific creativity skills included eight (8) indicator items, namely: 1) Unusual use, 2) Hypothesizing, 3) Finding problem, 4) Science Imagination, 5) Science Problem Solving, 6) Creative Experimental, 7) Science Product. Indicators 1 to 7 had the criteria with the indicators scoring guidelines for scientific creativity skills. The tests were assessed by rubric criteria and scored on a scale from 0 to 5 points, and all of the test questions were constructed based on indicators of achievement (Table 1 and Table 2.).

Score the scientific creativity test on the SSCM (Scientific Structure Creativity Model) model by looking at each indicator in the scientific creativity test questions. The score for tasks 1 to 4 is the sum of the fluency, flexibility, and originality scores. The subject fluency score is obtained by directly calculating all of the student's answers to each task carried out by the student by paying attention to the quality of the answers. If the number of correct answers is more than 4, a score of 3 points is given to the answer; if the answer is 2-3 correct, a score of 2 points is given to the answer; and if the number of correct answers is 1, a score of 1 point is given; If you do not answer, you will be given a score of 0 points. The flexibility score for each task is obtained by counting the number of approaches or content areas used in that answer. If the number of approaches is greater than 3, a score of 3 points is given to the answer; if the number of approaches is 2-3, a score of 2 points is given, and if the number of approaches is 1, a score of 1 point is given. The originality score is developed from the frequency tabulation of all the answers obtained. The frequency and percentage of each answer were calculated. If the answer probability is less than 5.00%, it is scored 2 points; if the probability is from 5 to 10.00%, score this answer 1 point. If the probability of a response is more significant than 10.00%, this answer is given a score of 0 points (Astutik, 2018).

Data was collected using an essay test and questionnaire with a self-assessment sheet and learning activities response sheet. The data needed to achieve the goal resulted from the data learning outcome of scientific creativity skills. Data was collected using an essay test and questionnaire with a self-assessment sheet and learning activities response sheet. The effectiveness of students' scientific creativity skills was determined by the n-gain < *g* >.

Normalized Gain < *g* > = (score post-test – score pre-test) / (100 – score pre-test)… (1)

The test scores were analyzed using average normalized gain < *g* >, which was defined as the ratio of the actual average gain to the maximum possible average gain, i.e., where Sf and Si are the final (post-test) and initial (pre-test) class average (Hake, 1999). Hake (1999) defines g score >0.70 as a highly engaged activity to promote particular understanding, 0.70>g>0.30 as a medium-engaged activity, and g<0.3 as a poor-engaged activity. The response sheets for the self-assessment and learning activities were analyzed descriptively (Anh et al., 2023; Ifenthaler et al., 2023; Tari & Safitri, 2023). Analysis of the data on answers to the problem and achieving the research goal was done using descriptive (Kumar et al., 2023; Panadero et al., 2024). The SSCL Model development research procedure is shown as in Figure 3.

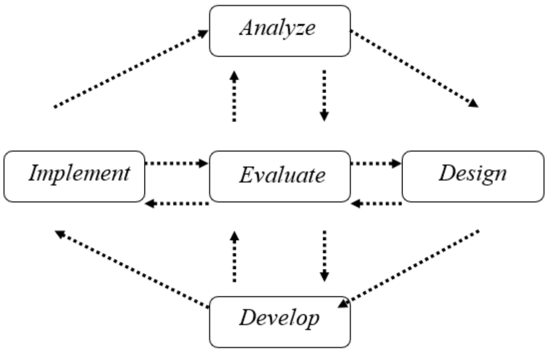

Figure 3. Research procedure by ADDIE (Irwan et al., 2024).

RESULTS AND DISCUSSION

Results

Validation and reliability of the SSCL model were carried out to determine its validity and reliability before being tested in the field; validation was carried out by experts on learning tools, namely learning models, syllabi, lesson plans, and questions. The results of model validation and learning tools are presented in Tables 2 and 3.

Table 2. Content validity results of the SSCL model.

No	SSCL Model Components	Score Validation (%)	validity	Reliability Coefficient	Reliability
1	(Need of development model)	97.50%	Very Valid	94.63%	Reliable
2	(State of the art of knowledge)	96.50%	Very Valid	96.42%	Reliable
	Average	97.12%	Very Valid	95.53%	Reliable

Table 2 shows that the average value of model content validation is 97.12%, which is classified as a very valid criterion. Based on the results of expert validation on the SSCL model, the syllabus, lesson plans, and questions are declared valid and can be used in elementary school learning.

Table 3. Construct validity results of the SSCL model.

No	Component Model	Validation Score (%)	Validity	Coefficient Reliability	Reliability
1	Rational learning model	97.50	Very Valid	100.00%	Reliable
2	Theory support	93.50	Very Valid	89.28%	Reliable
3	Model syntax	95.25	Very Valid	91.83%	Reliable
4	Social system	95.75	Very Valid	91.42%	Reliable
5	Reaction principle	96.00	Very Valid	92.06%	Reliable
6	Support system	80.00	Valid	94.04%	Reliable
7	Instructional and accompaniment impact	83.50	Valid	90.47%	Reliable
	Average	91.64	Very Valid	92.71%	Reliable

Table 3 shows that the mean value of model construct validation is 91.64%, classified as a very valid criterion. Based on the results of expert validation of the SSCL model, it can be used in junior high school learning. Students' scientific creativity skills are obtained through tests of scientific creativity skills questions before and after learning the SSCL model in secondary school. Small-scale trials were conducted to determine the learning implementation and the effectiveness of the SSCL model in improving secondary school scientific creativity skills. The learning implementation criterion values are obtained from the trials, as shown in Figure 2.

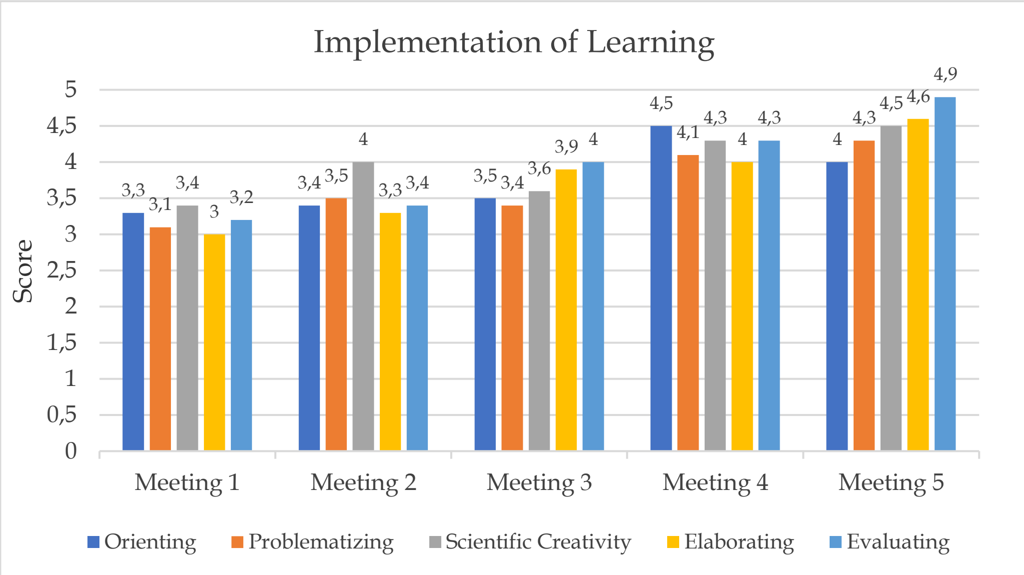

Figure 2. The learning implementation of the SSCL model.

Students' scientific creativity skills are obtained through scientific creativity skills tests before and after learning using the SSCL model for junior high school children. The value was carried out to determine the SSCL model's effectiveness in improving secondary school children's scientific creativity skills. The criteria for increasing N-Gain are obtained from the trials carried out, namely, as in Table 4.

Table 4. N-Gain values students' scientific creativity skills.

No.	Critical Thinking Indicator	N-Gain	Criteria
1.	Unusual Use (UU)	0.71	High
2.	Technical Production (TP)	0.83	High
3.	Hypothesizing (H)	0.62	Currently
4.	Science Imagination (SI)	0.74	High
5.	Science Problem Solving (SPS)	0.62	Currently
6.	Creative Experimental (CE)	0.72	High
7.	Science Product (SP).	0.64	Currently
	Average N Gain	**0.70**	**High**

The response is to students' learning using the SSCL Model. Student response data was obtained through a questionnaire given to students after learning with the SSCL Model. So, we get the response data as shown in Table 5.

Table 5. Response student SSCL Model.

No.	Question	Answering Yes	Criteria
1	The teacher's explanation came to my attention at the beginning of the learning activities.	81.80%	Very Good
2	Motivation delivered stirs my spirit to learn.	72.70%	Good
3	The learning process was exciting.	63.60%	Good
4	I was motivated by their questions about early learning	90.90%	Very Good
5	I can understand better understand the material presented by the lab	72.70%	Good
6	Teachers often assist/ scaffold students if they experience difficulty in learning.	90.90%	Very Good
7	The time for discussions, presentations, and other learning activities depends on the needs.	72.70%	Good
8	Teachers allow all students to ask about the matter who do not understand	73.60%	Good
9	Teachers guide the students in deciding on learning materials.	81.80%	Very Good
10	I understand the material and are motivated by their exercises	81.80%	Very Good
	Total	**82.35%**	**Very Good**

Discussion

The validation results and support from several theories for the SSCL model illustrate that the SSCL model is valid both in content and construct. Astutik et al. (2018) state that the development of a learning model from the results of educational research is declared valid if it meets the content and construct validity criteria. Content validity describes the need for model development (need for development model) and elements of up-to-date knowledge (state of the art). In contrast, construct validity describes the relationship between the SSCL model and the underlying supporting theory and the consistency and logicality between model components. The result showed that the validity and reliability are very valid and reliable, with average scores of 97.12% and 95.53%.

Practicality is delivered from the success of learning when learning is carried out by implementing the SSCL model, which can be seen from the trials carried out on students at JHS 3 Jember. The test results gave good results. This indicates that each phase of the model scenario in the learning tool has been implemented well by teachers and students, as evidenced by the results of learning implementation, as shown in Figure 2, with five implementations of the SSCL model learning, which is very good.

Based on the scientific creativity skill data obtained by the unusual use indicator, the N-Gain value of 0.71 is classified as a high criterion. The Technical Production indicator obtained an N-Gain value of 0.83, which is classified as a high criterion. The Hypothesizing (H) obtained an N-Gain value of 0.62, which is classified as a current criterion. The Science Imagination (SI) indicator obtained an N-Gain value of 0.74, classified as a high criterion. The Science Problem Solving (SPS) indicator obtained an N-Gain value of 0.62, classified as a current criterion. The Creative Experimental (CE) indicator obtained an N-Gain value of 0.72, classified as a high criterion. The Science Product (SP) indicator obtained an N-Gain value of 0.64, classified as a current criterion.

The N-Gain of scientific creativity skills obtained by students is equal to 0.70, which is classified as a high criterion, so the SSCL Model is effective for improving Secondary School Scientific Creativity skills.

There is an increase in students' Scientific Creativity skills after learning because Scientific Creativity skills cover every step in the SSCL model—stage 1. Orienting can train indicators of scientific creativity skills, namely preparation for initial conception (Siagian et al., 2023), Stage 2. Problematizing can train indicators of scientific creativity by exploring students' problems and guiding students to ask and answer questions (Kuo, 2024)—stage 3. Scientific creativity can encourage students to observe answers by conducting investigative activities, concluding observations, and providing further explanations in class discussion activities (Algiani et al., 2023)—stage 4. Elaborating can train students to carry out activities to analyze, evaluate, or create problem-solving, contribute in preparing and conducting activities to analyze, evaluate, or create (contribution), Cooperate with group members in analyzing, evaluating, or creating (cooperating), Time management in analyzing, evaluating or creating activities (time management) (Nisa' et al., 2024; Schlimbach et al., 2023; Toader et al., 2023)—stage 5. Evaluating can train indicators of creative thinking, namely determining a follow-up action on other relevant problems through playing activities (Dewi et al., 2023).

Based on learning student response data using the SSCL model, the percentage of the total score on all indicators says yes, as much as 79.35%, and falls into either category. Thus, learning with the SSCL model gets a good response from the student. The student is unbelievably enthusiastic about participating in learning activities, and students' learning tends to be active in conducting experiments outside the classroom. Learning activities also facilitate good interaction between students and teachers and between students and students in the study group. With his students given the problem-solving process, students can understand the concepts learned (Nisa' et al., 2024; Prahani et al., 2022).

The SSCL model, implemented in the other class, went well and effectively. This is supported by the results of research conducted by Astutik (2020), which explains that the SSCL model effectively improves scientific creativity skills. Students' responses to the SSCL learning model were very good, so teachers can use this learning model to improve and train students' scientific creativity skills in learning.

CONCLUSION

Fundamental Findings: The SSCL model has syntax, namely Orienting, Problematizing, Scientific Creativity, Elaborating, and Evaluating. The results of the SSCL model showed (1) that the validity and reliability are very valid and very reliable, (2) that there is an improved indicator of achievement with high category, and (3) that most of the students gave responses. **Implication:** These research findings show that each phase of SSCL significantly contributes to increasing the achievement of indicators of scientific creativity. **Limitation:** This research's limitation is that it is still carried out within a local scope, so it needs to be developed to a broader scope to get maximum results. **Future Research:** To maintain the reliability of SSCL in enhancing students' skills in scientific creativity, conducting future research on a broader scale is imperative, as well as more varied material.

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