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Development of Scientific Collaborative Learning Model to Improve Scientific Creativity Skills in Science Learning

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ABSTRACT

The development of students' scientific creativity skills is of paramount importance in science education, as it fosters conceptual understanding and critical thinking skills that are pertinent to the challenges of the 21st century. The present study aims to develop a Scientific Collaborative Learning model to enhance students' scientific creativity skills regarding circulatory system material. This research utilizes Nieveen's development model, which encompasses a series of stages including preliminary study, design, limited test, revision, field test, and dissemination. The research subjects were grade VIII students from two schools in Jember Regency. The findings indicated that the SCL learning model exhibited a validity level of 94.05%, categorizing it as "Highly valid." The efficacy of the model in enhancing students' scientific creativity skills is evidenced by the N-gain value of 0.71 in the small class test, which falls within the medium category, 0.68 in the large class test, also falling within the medium category, and 0.68 in the dissemination class test, also falling within the medium category. The Scientific Collaborative Learning model has been validated and found to be effective in facilitating science learning, particularly in the context of the circulatory system.

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1. INTRODUCTION

Technological advancements and their rapid development have given rise to novel and engaging methods of facilitating student learning and addressing the evolving demands of education. The Ministry of Education and Culture of the Republic of Indonesia has delineated four competencies deemed essential for students in the 21st century. These competencies, which are critical thinking, communication, creativity, and collaboration, are designed to equip students with the necessary skills to navigate and thrive in the 21st century. These four cognitive abilities collectively called the 4C competencies, emphasize the simultaneous and integrated development of all four competencies, rather than their sequential progression (Suyitno et al., 2021). Creativity is a pivotal skill in 21st-century education, as it enables students to navigate and solve complex problems, fostering innovation and collaboration (Arifin & Setiawan, 2020).

Creativity in students can be applied in learning activities, particularly in science subjects, which are subjects based on natural phenomena. These natural phenomena become knowledge if they begin with a scientific attitude and use the scientific method. Starting from the scientific method activities, students will gain knowledge and understanding. Creativity is associated with nature and the environment, and for this reason it is called scientific creativity (Nurmala et al., 2021). Scientific creativity is classified as a high-level cognitive ability, entails the generation of novel scientific concepts and outcomes. Scientific creativity can be delineated as the capacity to employ scientific knowledge and skills to generate products that are both original and possess specific social or personal values (Siew et al., 2014). Indicators of scientific creativity include unusual uses, problem finding, product improvement, scientific imagination, creative problem solving, creative experiment design, and creative product design (Hu & Adey, 2002). Concerning 21st-century skills in problem-solving, students must be able to use creativity and innovation, critical thinking, and problem-solving.

The prevailing pedagogy in the scientific learning process continues to prioritize the transmission of factual information, thereby impeding the cultivation of competencies essential for addressing contemporary global challenges (Jufrida et al., 2020). The challenges inherent in the scientific learning process pertain to the prevailing emphasis on memorization, the lack of active student engagement, the monotonous learning models and media, and the dearth of scientific creativity among students (Yanti et al., 2020). The observed deficiency in students' scientific creativity can be ascribed to numerous interrelated factors, including but not limited to: the utilization of inadequate teaching methodologies, an absence of intrinsic motivation among students, and a deficit in educators' competencies regarding the development of scientific literacy and creative thinking assessment (Oktaviani et al., 2023).

Preliminary research conducted in 13 schools in Jember Regency indicates that 76% of teachers have not conducted learning that develops scientific creativity skills. The obstacles experienced by teachers include students' passive approach toward their groupmates, which hinders the generation of ideas and opinions, and students' reliance on single or two students for ideas. The prevailing learning models employed are Direct Instruction, Discovery Learning, Problem-Based Learning, and Project Based Learning. However, it is noteworthy that 24% of teachers have incorporated learning models that promote scientific creativity skills, yet student performance remains suboptimal. This underscores the necessity for learning models that can effectively accommodate scientific creativity skills. The majority of teachers concur with this necessity, underscoring the importance of developing a specialized learning model to enhance scientific creativity skills.

Innovations in the learning process are essential to foster active learning environments. One such innovation entails the development of a learning model that aims to maximize the learning process in the classroom to be active. This model integrates collaborative learning with a scientific approach, termed "Scientific Collaborative Learning." This model is an innovation that applies scientific and collaborative approaches, designed to overcome the problem of low scientific creativity skills in science learning today. Hwang et al. (2020) have demonstrated that collaboration-based learning strategies have a significant impact on students' critical thinking skills and scientific creativity. They concluded that students who engaged in group discussions and scientific investigations collaboratively showed higher improvements in the ability to generate creative ideas and scientific solutions than students who studied individually. The scientific approach has also been shown to improve scientific creativity skills. This approach encourages critical thinking, problem-solving, and collaboration, which are essential for developing 21st-century skills. The collaborative approach fosters communication and teamwork skills through collaborative projects and role-playing activities (Kasi, 2022).

The material on the circulatory system poses significant challenges for students, primarily due to the intricacy of the concepts and the paucity of effective learning resources. Research indicates that students frequently encounter difficulties in mastering this material, a phenomenon attributable to various factors, including suboptimal teaching methods and an inadequate supply of learning media. The complexity of the circulatory system, involving intricate processes and specialized terminology, can prove overwhelming for students, resulting in suboptimal comprehension (Haruna et al., 2024). The underutilization of diverse learning media, such as mobile learning devices, has been identified as a hindrance to understanding circulatory system concepts (Kumalasari et al., 2024). To address these challenges, there has been an initiative to develop a novel learning model. The development of these models aims to enhance educational outcomes by addressing specific needs and challenges in various learning environments. The proposed learning model is centered on enhancing student engagement, cultivating critical thinking skills, and addressing the limitations of existing models to optimize learning outcomes (Ramadhan & Rumondang, 2023).

In light of the aforementioned description, it is imperative to devise a learning model that is capable of addressing the challenges posed by 21st-century learning, particularly concerning enhancing students' scientific creativity and collaboration skills. The learning model that has been designed integrates scientific and collaborative approaches to create learning that is active, meaningful, and relevant to the needs of today's students. The objective of this research is to develop a Scientific Collaborative Learning model that is valid and effective. This model will support the development of 21st-century skills and improve the quality of science learning.

2. RESEARCH METHOD

The present study utilizes a Research and Development (R&D) approach, defined as a form of research that aims to produce specific products and assess their effectiveness. The R&D process employed in this study involves the evaluation of a Scientific Collaborative Learning model, a pedagogical approach designed to enhance students' scientific creativity and collaboration skills. The model employed in this study aligns with the Nieveen (2007) development model, which comprises multiple stages: preliminary studies, planning, initial product development, limited test, limited test revision, field test/large class test, revision of field trial results, feasibility test, revision of feasibility test results, dissemination and implementation. The implementation of the research was carried out during the odd semester of the 2024/2025 academic year on the subject of the Blood Circulatory System. Trials and dissemination were conducted at SMPN 3 Jember and SMPN 4 Jember with 110 students. The subject of the research was the development of the Scientific Collaborative Learning model module to improve the scientific creativity and collaboration skills of grade VIII junior high school students. The data analysis techniques employed utilized the N-Gain formula:

$$N\text{-}gain = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}}$$

The criteria for the normalized gain on the effectiveness of scientific creativity skills are divided into three categories as described in Table 2.1.

Table 2.1 N-gain criteria for the effectiveness of scientific creativity skills

Value	Criteria
0,70 ≤ *N-gain*	High
0,30 ≤ *N-gain* ≤ 0,70	Medium
N-gain ≤ 0,30	Low

(Hake, 1998)

The efficacy of learning is purportedly contingent upon the N-gain value of scientific creativity skills attaining a moderate level of criteria. The analysis of scientific creativity skills is facilitated by the utilization of a normalized gain.

3. RESULT AND DISCUSSION

Scientific Collaborative Learning Model

The syntax of the learning model is comprised of five syntaxes: Orientation & Organize the Student, Scientific Question Formulation, Exploration & Collaborative Investigation, Discussion & Strengthening, and Evaluation. The syntax of the Scientific Collaborative Learning Model is illustrated in Table 3.1

Table 3.1 Syntax of Scientific Collaborative Learning Model

Phases of the Learning Model	Learning Model Activities
Orientation & Organize the Students	a) Students are expected to pay close attention to a brief explanation from the teacher regarding the learning objectives and benefits of the topic to be studied; b) Students are expected to form groups of four to five students, either independently or with the guidance of the teacher;
Scientific Question Formulation	c) Students are provided with contextual phenomena as a catalyst to ensure the objectives are clear and meaningful; d) Students engage in group discussions to formulate scientific inquiries pertinent to the designated topic; e) students are guided to hypothesize related to the scientific questions that have been formulated;
Exploration & Collaborative Investigation	f) Students collaborate with their group to design the investigation, determine the necessary tools and materials, and organize the work steps to carry out the investigation; g) Students carry out the investigation following the design that has been made, collect data, and record the results obtained; h) Students actively seek guidance or clarification from the teacher if they experience obstacles during the investigation process;
Discussion & Strengthening	i) Students present the results of their investigations to their peers; j) Students from other groups are expected to respond, pose questions, or contribute additional ideas to the presentation. k) The teacher will then provide a summary of the scientific creativity of the discussion results of the groups that have presented the results.
Evaluation	l) Students engage in individual reflection on their learning experience, noting what has been learned, and identifying areas for improvement; m) Teacher-guided learners are expected to summarize the material that has been learned and provide feedback related to their learning experience.

Validity of Scientific Collaborative Learning Model

The initial stage of research instrument validation is preceded by its implementation in small and large classes, culminating in dissemination. The following instruments have been validated: the Scientific Collaborative Learning model, the flow of learning objectives, teaching modules, student activity sheets, and scientific creativity test questions. The validation process was carried out by expert validators, who are science education lecturers with at least a doctorate, and user validators, who are teachers. The validation results for the Scientific Collaborative Learning model are presented in Table 3. 2.

Table 3. 2 Validation Results of the Scientific Collaborative Learning Model

Indicators of validation	Result (%)				Criteria
	Expert 1	Expert 2	Practitioner	Average	
Content	90	100	90	93,33	Highly valid
Construct	100	93,75	90,6	94,78	Highly valid
Average	95	96,87	90,3	94,05	Highly valid

The results of the validation of the Scientific Collaborative Learning model, as illustrated in Table 3, demonstrate that the model obtained a 95% validation rate from Expert 1, 96.87% validation rate from Expert 2, and a 90.3% validation rate from the practitioner. The average validation rate of the learning model guidelines is 94.05%, which is categorized as "Highly valid".

The validation of the learning model encompasses content and construct validity, which are indispensable for ensuring the effectiveness and practicality of the developed learning model. Content validity aims to ensure that the learning model encompasses all pertinent aspects of the subject matter (Wulandari et al., 2023). This encompasses the incorporation of learning theories that are sufficiently presented to serve as the foundation for model development, the comprehensive coverage of theories that support the learning model, the relevance of character concepts as the foundation for the learning model, and the appropriateness of the instructional impact and the accompanying impact to be achieved. The validation results indicate an average content validity percentage of 93.33%, which falls within the "highly valid" criteria. This outcome suggests that the Scientific Collaborative Learning model has met the content validity assessment criteria. Ensuring content validity is paramount for developing an effective learning model, as it ensures that the method aligns with the intended learning outcomes, enhances comprehension, and fosters an adaptive learning environment (Vainshtein et al., 2021).

Construct validation is a process that is used to determine whether a learning model accurately reflects the theoretical constructs it is designed to measure (Sari & Yusmaita, 2022). Construct validity encompasses several key elements, including the clarity of the background of the learning model development, the purpose of developing the learning model, the clarity of the instructional impact and the accompanying impact, the clarity of the reaction principle in learning, the clarity of the support system in the model, the clarity of the learning steps, the consistency of teacher and student activities in each learning step, and the evaluation and assessment are clearly stated. The validation results indicate an average construct validity percentage of 94.78%, which falls within the "highly valid" criteria. This outcome suggests that the Scientific Collaborative Learning model has met the construct validity assessment criteria. The enhancement of construct validity in a learning model is associated with the improvement in the quality of student learning, fostered by an attractive and effective educational environment. The presence of high content and construct validity ensures effective assessment, which leads to enhanced educational outcomes and stronger learning models (Setiawan et al., 2024).

Scientific Collaborative Learning Model System

The learning system of the Scientific Collaborative Learning model is as follows:

a. Social System

The social system of this learning model is predicated on the notion that students engage in interaction with one another during the formulation of scientific questions and the collaborative investigation stage. Additionally, interaction between groups is emphasized during the discussion and strengthening stage. The integration of learner-to-learner interaction within the developed learning model is expected to enhance participation and activity levels among learners. Furthermore, the model incorporates learner-to-teacher interaction through the exploration and collaborative investigation stage, followed by the discussion and strengthening stage, wherein teachers provide feedback to students. Teachers provide opportunities for learners to construct knowledge and participate as actively as possible in the learning process.

b. Principal of Reaction

In the developed learning model, the teacher as a facilitator, responding to the opinions or answers of students and groups during the Discussion & Strengthening stage. The teacher also plays a facilitating role in experimental activities, enabling students to construct their own knowledge, thereby rendering learning meaningful. In accordance with constructivism learning theory, students form knowledge, create meaning, engage in critical thinking, and formulate justifications, thus transforming learning into a form of self-learning. The learning model under discussion fosters opportunities for interaction among students, between groups, between students and teachers, and between groups and teachers.

c. Support System

The support system required in the developed learning model encompasses all learning resources necessary for learning activities, including experimental tools and materials, student worksheets, and teaching materials.

d. Instructional Effect

The instructional impact required in the developed learning process is scientific creativity skills.

e. Nurturant Effect

The developed learning model has been shown to have several nurturant effects, including meticulous data processing, creativity, careful group investigations, the fostering of cooperation, respect for others' opinions, and the courage to convey these opinions during presentations.

Scientific Creativity skills of students using the Scientific Collaborative Learning Model

a. Small Class Test

The small class test of the Scientific Collaborative Learning model was conducted at SMPN 3 Jember in class VIIID with 12 students. The data on the N-Gain value of scientific creativity skills in the small class test is shown in Table 3.3.

Table 3.3 N-gain Value of Scientific Creativity Skills in Small Class Test

Indicators	**Average**		**N-gain**	**Criteria**
	Pretest	**Posttest**		
Unusual Use	23,33	77,5	0,71	High
Finding Problems	23,33	78,33	0,72	High
Product Improvement	19,17	77,5	0,72	High
Scientific Imagination	23,33	75,83	0,68	Medium
Creatively Problem Solving	22,62	80,95	0,75	High
Creatively Experiment Design	25	77,56	0,70	High
Creatively Product Design	25	75	0,67	Medium
Average	25,41	74,61	0,71	High

As illustrated in Table 4, the N-gain value of scientific creativity skills is evident in the small class trial on each indicator. The total mean of the pretest and posttest was 25.41 and 74.61, respectively, while the N-gain score was 0.71, which was categorized as high. The findings indicate that the Scientific Collaborative Learning model is effective in enhancing scientific creativity skills in small class tests, as evidenced by the average N-gain value.

b. Large Class Test

A large-class test of the Scientific Collaborative Learning model was administered in class VIIIH of SMPN 3 Jember with 33 students. The data on the N-Gain value of R-VGM skills in the large-class test is shown in Table 3. 4

Table 3. 4 N-gain Value of Scientific Creativity Skills in Large Class Test

Indicators	**Average**		**N-gain**	**Criteria**
	Pretest	**Posttest**		
Unusual Use	23,03	70,91	0,62	Medium
Finding Problems	22,73	79,7	0,74	High
Product Improvement	19,70	72,73	0,66	Medium
Scientific Imagination	20,3	76,67	0,71	High
Creatively Problem Solving	32,9	82,25	0,74	High
Creatively Experiment Design	20,28	71,1	0,64	Medium
Creatively Product Design	23,16	71,65	0,63	Medium
Average	23,16	75	0,68	Medium

As illustrated in Table 5, the N-gain value of scientific creativity skills in the large class test on each indicator demonstrates a noteworthy enhancement. The total average of the pretest and posttest was 23.16 and 75, respectively, while the N-gain score registered at 0.68, categorizing it as medium. The analysis indicates that the Scientific Collaborative Learning model is effective in enhancing scientific creativity skills in large class tests.

Following the collection of substantial input from observers during both the small class test and the large class test, refinements, and improvements were made to the Scientific Creativity Learning model. Moreover, dissemination tests can be carried out in several schools in the Jember Regency.

c. Dissemination Class Test

The dissemination class test of the Scientific Collaborative Learning model was administered at SMPN 3 Jember in class VIIIF with 33 students, and dissemination test 2 was administered at SMPN 4 Jember in class VIIIB with 32 students. The data on the N-gain value of scientific creativity skills in the dissemination class test is shown in Table 3. 5.

Table 3. 5 N-gain Value of Scientific Creativity Skills of Dissemination Class Test

Indicators	SMPN 3 Jember			SMPN 4 Jember		
	Pretest	***Posttest***	**N-gain**	***Pretest***	***Posttest***	**N-gain**
Unusual Use	21,52	74,55	0,68	24,06	70,31	0,61
Finding Problems	23,03	79,70	0,74	24,06	78,13	0,71
Product Improvement	19,09	74,55	0,69	20,94	73,44	0,66
Scientific Imagination	16,97	75,76	0,71	22,81	74,34	0,67
Creatively Problem Solving	29,87	81,39	0,73	30,36	83,04	0,76
Creatively Experiment Design	21,68	73,43	0,66	20,43	73,08	0,66
Creatively Product Design	24,03	70,13	0,61	21,65	68,75	0,6
Average	22,31	75,64	0,69	23,47	74,44	0.67
Criteria	Medium			Medium		

As illustrated in Table 6, the average N-gain value of the Scientific Collaborative Learning model at SMPN 3 Jember is 0.69, and at SMPN 4 Jember, it is 0.67. These values fall within the medium category. The N-gain value indicates that the Scientific Collaborative Learning model is effective in enhancing scientific creativity skills in the dissemination class, specifically in class VIIIF at SMPN 3 Jember and class VIIIB at SMPN 4 Jember.

4. CONCLUSION

The Scientific Collaborative Learning model is characterized by a specific syntax, which includes the following elements: Orientation & Organize the Students, Scientific Question Formulation, Exploration & Collaborative Investigation, Discussion & Strengthening, and Evaluation. The model incorporates a social system, reaction principles, support system, instructional impact, and accompanying impact. The N-Gain value of the effectiveness of scientific creativity skills of the small class Scientific Collaborative Learning model is 0.71, which falls within the high category; the large class model has an N-Gain value of 0.68, which is medium; the dissemination class 1 has an N-Gain value of 0.69, which is medium; and the dissemination class 2 has an N-Gain value of 0.67, which is medium. The N-Gain value of the small class test, large class test, and dissemination test indicates the efficacy of the Scientific Collaborative Learning model in enhancing students' scientific creativity skills. The Scientific Collaborative Learning model developed in this study is not only effective in improving students' scientific creativity, but also relevant to the demands of the 21st-century curriculum, which emphasizes mastery of critical thinking, creative, and problem-solving skills. The integration of scientific and collaborative approaches within this model engenders active, meaningful, and student-centered learning environments. Future research directions include the development of more innovative learning tools and the evaluation of the sustainability of the application of this model in various other science learning contexts.

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