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DEVELOPMENT OF STUDENT WORKSHEET WITH PROJECT-BASED LEARNING-ORIENTED TO IMPROVE SCIENCE PROCESS SKILLS IN GREEN CHEMISTRY USING ORANGE PEEL WASTE

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Abstract

This study aimed to determine the feasibility of a Project Based Learning-oriented SAS to improve students' science process skills on green chemistry material. The focus of this study was the development of a project-based SAS incorporating green chemistry principles to improve science process skills, including observing, classifying, predicting, measuring, concluding, and communicating. This study employed a Research and Development (R&D) method using the 4D development model (define, design, develop, and disseminate), but was limited to the develop stage. The subjects of this study were 36 tenth-grade students at a high school in Surabaya. The feasibility of the developed SAS was evaluated based on aspects of validity, practicality, and effectiveness. The validity results showed that the SAS obtained a mode score of 4–5 with good and very good criteria. The practicality results showed a learning implementation percentage of 87,5%, student activity observation results of 84,6%, and student response questionnaire results of 94%, all categorized as very good. The effectiveness results showed a classical completeness score of 97,2% and an improvement in students' science process skills, with N-Gain scores ranging from medium-g to high-g categories. Therefore, the developed SAS is feasible to be used as a chemistry learning material.

Keywords: project based learning, student activity sheet, science process skill, green chemistry

INTRODUCTION

Chemistry is one of the science subjects in the Merdeka Curriculum, which aims to equip students to respond to global issues and play an active role in solving problems in their surrounding environment. Chemistry is not only understood as a collection of concepts, facts, and theories, but also as a scientific process that emphasizes students' critical thinking skills and scientific attitudes [1]. One area of chemistry closely related to daily life and sustainable development is green chemistry, a concept focused on waste reduction, the use of environmentally friendly materials, and energy efficiency [2].

Although closely tied to daily life, chemistry is still considered difficult by the majority of students [3]. Preliminary research revealed that 65,6% of students found the chemistry subject difficult. Regarding green chemistry material, 43,8% of students stated that the material was difficult to understand. Additionally, the results of the preliminary study on science process skills showed the "High" category at 3,13%, "Moderate" at 25%, "Low" at 62,5%, and "Very Low" at 6,25%, with the classification aspect receiving the lowest score. These results indicate that students' science process skills still need to be improved through more active and contextual learning.

One relevant learning model is Project-Based Learning (PjBL). This model emphasizes contextual learning through project activities so that students are more active in the learning process and problem-solving [4]. Additionally, the implementation of PjBL can help improve students' science process skills, such as observing, measuring, classifying, predicting, drawing conclusions, and communicating learning outcomes [5]. In green chemistry lessons, the implementation of PjBL can be realized through a project utilizing orange peel waste to create an eco-friendly cleaning solution as a practical application of green chemistry principles in daily life [6].

To support the implementation of this model, appropriate learning media are required, one of which is the Student Activity Sheet (SAS). The SAS is a learning material containing a summary of the material, activity instructions, and learning activities that can help students achieve learning competencies [7]. Previous research has shown that project-based learning-oriented SASs have a high level of validity and are capable of developing students' science process skills to a very satisfactory standard [8]. Therefore, this study aims to develop a project-based learning-oriented SAS on green chemistry material utilizing orange peel waste to enhance students' science process skills, thereby meeting the criteria of validity, practicality, and effectiveness.

METHOD

The research type used in this study is research and development (R&D) employing the 4D research model (Define, Design, Develop, Disseminate), limited to the "Develop" stage, specifically the limited pilot test phase. The subjects of the limited pilot test were 32 tenth-grade students at State High School 20 in Surabaya. The instruments used to assess the feasibility of the SAS included a validation sheet, observations of lesson implementation, observations of student activities, a student response questionnaire, a cognitive test sheet, and a science process skills test sheet.

Validation was conducted to determine the validity of the SAS using a Likert scale. The SAS was deemed valid if a mode of ≥ 4 was obtained, with categories of "good" and "very good." Scoring based on the Likert scale is shown in Table 1.

Table 1. Likert Scale for Validity Assessment

Scale	Category
1	Not Good
2	Less Good
3	Good Enough
4	Good
5	Very Good

[9]

Practicality was measured based on observations of the implementation of learning, observations of student activities, and student response questionnaires.

Observations of the implementation of learning and student activities were analyzed using a Likert scale. The scoring on the observation sheets is presented in Table 2.

Table 2. Likert Scale for Observation

Scale	Category
1	Not Good
2	Less Good
3	Good Enough
4	Good
5	Very Good

[9]

Student response questionnaires were analyzed using the Guttman scale. The scoring for response questionnaires is presented in Table 3.

Table 3. Guttman Scale Score

Response	Positive Statements	Negative Statements
Yes	1	0
No	0	1

[9]

The observation and questionnaire data were then analyzed using the following formula.

$$P(\%) = \frac{\text{total score per statement}}{\text{number of respondents}} \text{ x } 100\%$$

The results of the observations and student response questionnaires were used to determine the practicality of the developed SAS as a learning material using the interpretations presented in Table 4.

Table 4. Practicality Interpretation Criteria

Percentage (%)	Category
0-20	Not Good
21-40	Less Good
41-60	Good Enough
61-80	Good
81-100	Very Good

[9]

Based on Table 4, the developed SAS is interpreted as practical as a learning material if a percentage of ≥ 61% is obtained.

The effectiveness of the SAS was measured based on the results of learning outcome completeness analysis and improvement in students' science process skills. Individual student completeness can be calculated using the following formula.

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$$\mathrm{IC} = \frac{\text{total score obtained}}{\text{maximum total score}} \text{ x } 100$$

[10]

Students are declared complete if they obtain a score of ≥ 75 or in accordance with the school's minimum passing criteria (KKM) [11]. Classical completeness was then analyzed using the following formula.

$$\mathrm{CC} = \frac{\text{number of students who pass}}{\text{total number of students}} \text{ x } 100\%$$

[10]

The SAS is declared effective as a learning material for improving learning outcomes if classical completeness of ≥ 85% is obtained [11].

Improvement in students' science process skills was reviewed through the N-Gain score using the following formula.

$$< g > = \frac{< G >}{< G > \max} = \frac{\text{S post} - \text{S pre}}{\text{S max} - \text{S pre}}$$

[12]

Where <g> is the normalized gain, <G> is the average maximum gain, Spost is the posttest score, Spre is the pretest score, and Smax is the maximum score. The normalized gain scores obtained are interpreted in Table 5.

Table 5. N-Gain Score Interpretation Criteria

N-gain Score (<g>)	Category
(<g>) ≥ 0,7	High-g
0,7 > (<g>) ≥ 0,3	Medium-g
(<g>) < 0,3	Low-g

[13]

Improvement in science process skills is achieved if the N-Gain obtains a score of ≥ 0.3 with a minimum category of medium-g.

RESULTS AND DISCUSSION

This study aimed to develop SAS with project-based learning-oriented that is feasible to use based on the aspects of validity, practicality, and effectiveness. The development model used was the 4D model, limited to the develop stage. The 4D development stages that were carried out are described as follows.

Define Stage

The define stage aimed to identify needs, student characteristics, tasks, and concepts. The analysis was conducted by collecting pre-research data and conducting a literature review.

1. Front-End Analysis

   Preliminary research conducted using questionnaires and skills tests showed that 65,6% of students stated that chemistry is a difficult subject. The results of the preliminary research on science process skills showed that 62,5% of students' individual scores fell into the low category.

2. Student Analysis

   Tenth-grade students of a high school are approximately 16–18 years old. According to Piaget's theory, students are in the "Formal Operational" stage, which means they are capable of abstract, logical, and idealistic thinking [14].

3. Task Analysis

   The tasks compiled in the SAS aim to improve students' science process skills in accordance with the PjBL syntax.

4. Concept Analysis

   The main concept developed was the green chemistry concept, particularly on green chemistry principles and their application in everyday life. This concept was then broken down into sub-concepts: the definition of green chemistry, the 12 principles of green chemistry, the impact of chemical substances, and the use of natural materials as eco-friendly alternatives. The results of the conceptual analysis are presented below.

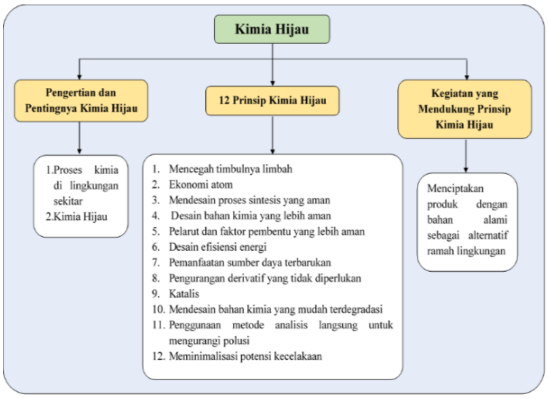


Figure 1. Green Chemistry Concept Map

5. Learning Objectives Formulation

   Learning objectives were formulated based on the results of task and concept analysis, and were adjusted to the learning model used. The learning objectives to be achieved are that students can formulate problem statements and hypotheses, design and carry out projects based on green chemistry principles, and explain their connection to green chemistry principles in everyday life.

Design Stage

The design stage aimed to produce the initial design of the Project Based Learning-oriented SAS to improve science process skills on green chemistry material.

1. Media Selection

   The learning material developed was the Student Activity Sheet (SAS) to improve science process skills on green chemistry material. Based on research by Eris & Praptomo (2023), which showed that SAS using the PjBL model on green chemistry material was effective in improving students' learning outcomes.

2. Format Selection

   The format in the SAS includes a title, preface, table of contents, SAS description, material summary, and student activities.

3. Initial Device Design

   The initial design of the SAS was created using Canva and Microsoft Word software in accordance with the predetermined format. At this stage, SAS Draft I was produced.

Develop Stage

1. SAS Review

   SAS Draft I was reviewed by the supervising lecturer, who provided suggestions and comments on the content and construct aspects. The review results served as the basis for revision, resulting in the improved SAS Draft II.

Table 6. Review Results

Draft I	Draft II
Text and image layout on the cover page were not proportional.	The text and images on the cover page were adjusted to be proportional.
The learning outcomes to be achieved were not indicated.	The learning outcomes were bolded at the relevant points.
The text box shape for the SPS component in the SAS did not point in the appropriate direction.	The text box shape was adjusted to match the intended activity.
No appropriate illustration was available for the environmental problem in phase 1.	Illustrations of orange peel waste and commercial cleaning liquid were added for the environmental problem in phase 1.
The schedule planning column in phase 3 had no column for PIC (person in charge).	A person-in-charge column was added after the date column.

2. SAS Validation

   The reviewed and revised SAS was then validated by three validators: two Chemistry Education lecturers and one chemistry teacher from State High School 20 in Surabaya. The validation sheet used a Likert scale assessment by Riduwan (2018) on the content and construct validity aspects.

   The content validity results obtained a mode score of 4 with a good category. Content validity includes the appropriateness of the presented phenomena, the suitability of the material, and the alignment of the SAS content with the Competency Achievement targets (CP), Learning Objectives (TP), learning model, and learning to improve Science Process Skills (SPS).

   Construct validity obtained a mode score of 5 with a very good category. Construct validity includes the alignment of the SAS with the PjBL learning model, its suitability as a guide for science process skills, and its appropriateness in terms of presentation and language aspects. The revisions made during the validation stage are as follows.

Table 7. SAS Validation Revision Results

Draft II	Draft III
The SPS component in the SAS was not displayed on the student sheet.	The SPS component for each phase was displayed in the student SAS so that students can understand the SPS component applied at each PjBL phase.
The SPS component in the SAS needed a brief explanation of the activity to be carried out by students.	A brief explanation was added for each SPS component displayed in the SAS.

Based on the content and construct validity results, the developed SAS can be interpreted as valid learning material.

Other devices and instruments were also validated by three validators. The validation results are detailed in Table 8.

Table 8. Validation Results of Devices and Instruments

No.	Device/Instrument	Mode
1	Teaching Module	4
2	Learning Implementation Observation Sheet	4
3	Student Activity Observation Sheet	5
4	Cognitive Pretest and Posttest Sheets	5
5	Science Process Skills Pretest and Posttest Sheets	5
6	Student Response Questionnaire	5

Based on Table 8, the devices and instruments obtained mode scores of 4 and 5, with good and very good categories. After revisions were made in accordance with the suggestions and comments, the devices and instruments could be used in the limited trial.

The science process skills components are presented in the validated SAS to help students carry out the activities in the SAS in accordance with the skills being assessed.

The following is an example of how the science process skills components are presented in the SAS.

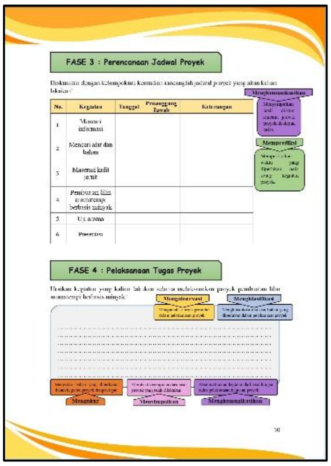


Figure 2. Example of the SPS Component Display in SAS.

After the developed SAS was validated by three validators, a limited pilot test was conducted to assess the practicality and effectiveness.

Limited Pilot Test

A limited pilot test was conducted to evaluate the practicality and effectiveness of the SAS that had been developed.

1. Practicality

SAS practicality was assessed based on the results of learning implementation observation, student activity observation, and student response questionnaires.

The overall learning implementation observation results obtained a percentage of 87,5%.

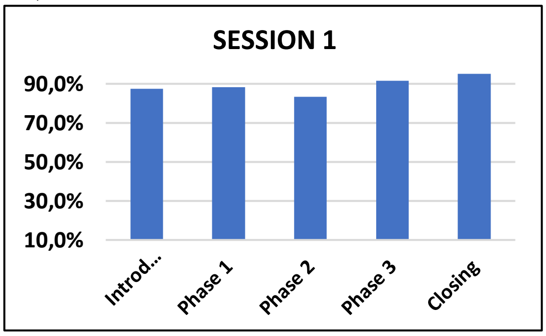


Figure 3. Results of the Observation of the Implementation of Session 1

The data in Figure 3, shows during the first session showed that all stages went very well. The introductory activities, which included greetings, a prayer and attendance, achieved an 87,5% participation rate. In Phase 1, the teacher presented environmental issues related to the hazards of volatile organic compounds, divided the students into 6 groups based on their seat numbers, and distributed the LAPD according to project type, achieving an 88,3% completion rate. Phase 2 involved project design activities by the students, including determining the title, formulating hypotheses, and establishing tools, materials, and procedures with teacher guidance, achieving a completion rate of 83,3%. Meanwhile, Phase 3 focused on comprehensive planning of the project schedule, ranging from the procurement of tools and materials to product testing, and concluded with a presentation of discussion results by a representative from each group, achieving the highest percentage of 91,7%. The closing activities, which included drawing conclusions, providing instructions for completing project tasks at home, as well as a closing prayer and farewell, achieved a percentage of 95%, all of which fell into the "very good" category.

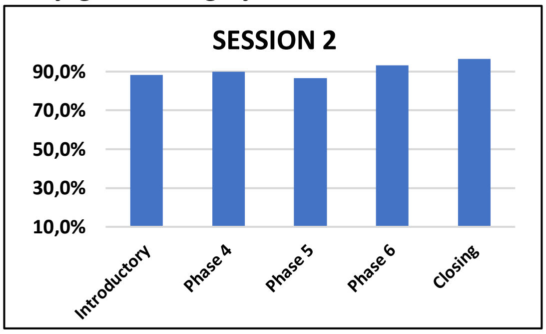


Figure 4. Results of the Observation of the Implementation of Session 2

The data in Figure 4, shows in the second session, all stages of the learning process were also carried out at an excellent level. The introductory activity, consisting of greetings and attendance check, achieved an 88,3% completion rate. Phase 4 was conducted by the teacher monitoring the project assignments completed by students at home, providing feedback to each group, and guiding students to fill out the LAPD for Phase 4, with a 90% completion rate. Phase 5 included writing the final project report on the LAPD, presenting the final results in front of the class, and the teacher providing feedback on the produced work, achieving an 86,7% completion rate. Phase 6 focuses on reflection activities, where students write down the challenges they faced during the project, present the solutions they implemented, and share the learning experiences gained, with a completion rate of 93,3%. The closing activities, which included a summary of the lesson, a prayer, and closing remarks, again achieved a 95% success rate, demonstrating excellent consistency in the implementation of the lesson during both sessions.

Based on the learning implementation observation results, all learning activities obtained a percentage of ≥ 61%.

The overall student activity observation results obtained a percentage of 84,6%.

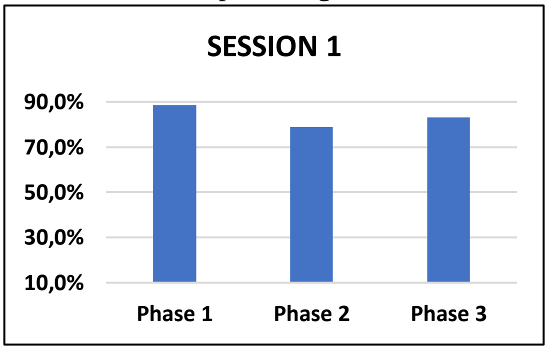


Figure 5. Results of Student Activity Observations for Session 1

The data in Figure 5, shows phase 1 student activities obtained 88,6%, phase 2 activities obtained 78,9%, and phase 3 activities obtained 83,1%.

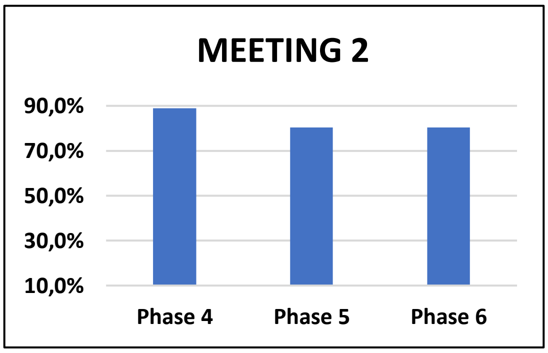


Figure 6. Results of Student Activity Observations for Session 2

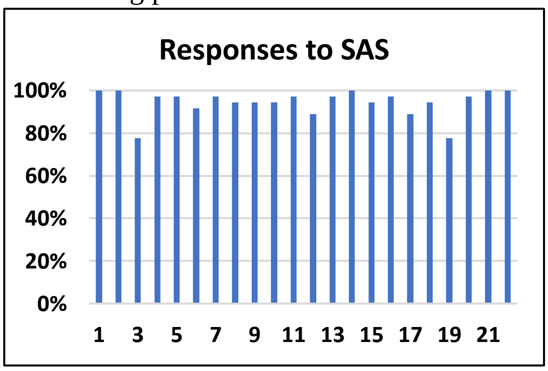
The data in Figure 6, shows phase 4 student activities obtained 88,9%, phase 5 activities obtained 80,4%, and phase 6 activities obtained 80,3%.

Based on the student activity observation results, all student activities obtained a percentage of $\geq$ 61%.

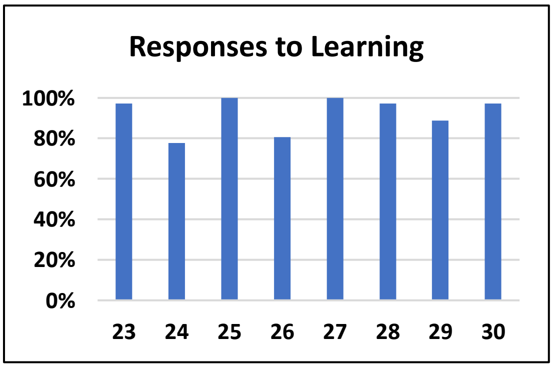
Next, examples of students' responses on the SAS during project activities are presented, demonstrating the science process skills of observing, classifying, measuring, drawing conclusions, and communicating.

Figure 7. Sample Answers for Student Activities in the SAS

The student response questionnaire was divided into two aspects: student responses toward the SAS and student responses toward the learning process.



(a)



(b)

Figure 8. Students Response Questionnaire Results (a) Students Response to SAS, (b) Students Response to Learning Process

The overall student response questionnaire results obtained a percentage of 93,9%.

Based on the learning implementation observation, student activity observation, and student response questionnaire results, the developed SAS can be interpreted as practical learning material.

2. Effectiveness

SAS effectiveness was assessed from two aspects: student learning outcome completeness on green chemistry material and improvement in students' science process skills.

Student learning outcomes were measured through cognitive pretests and posttests related to green chemistry material. The results of the analysis of student achievement are presented in Figure 9.

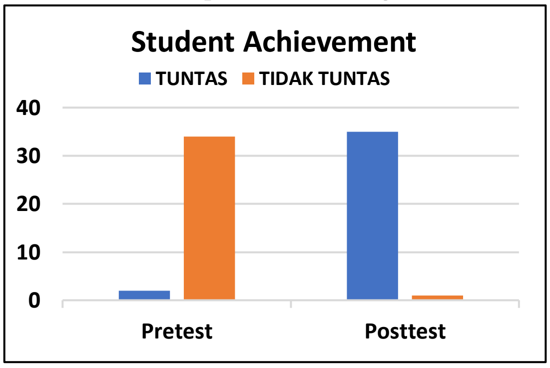


Figure 9. Analysis of Student Learning Achievement

Based on Figure 9, student achievement during the pretest was 5,6%. Meanwhile, during the posttest, student achievement was 97,2%. This indicates a 91,6% increase in the percentage of classical achievement from the pretest to the posttest, suggesting that the developed SAS is effective in improving student learning outcomes.

The improvement in students' science process skills was measured through pretest and posttest scores on science process skills, consisting of 7 questions. The pretest and posttest results are presented in Figure 10.

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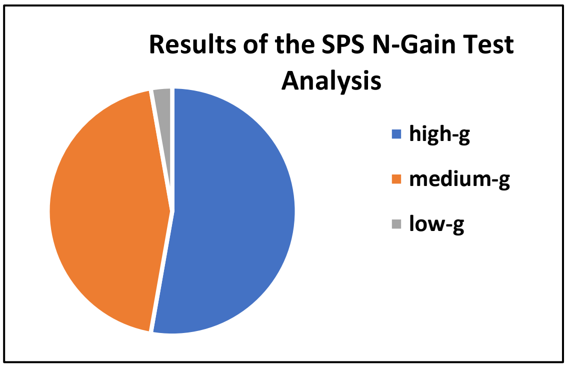

Figure 10. Results of the N-Gain Analysis of the SPS Test

Figure 10 shows the N-Gain scores obtained by the students on the science process skills test. A total of 19 students achieved an N-Gain score of > 0.7, falling into the high-g category; 16 students achieved an N-Gain score of ≥ 0.3, falling into the medium-g category; and 1 student achieved an N-Gain score of < 0.3, falling into the low-g category.

The results of the N-Gain analysis for each component of the SPS are detailed in Table 9.

Table 9. Results of N-Gain Score Analysis for SPS Components

SPS Component	N-Gain	Criteria
Observing	0.85	high-g
Classifying	0.62	medium-g
Predicting	0.85	high-g
Measuring	0.55	medium-g
Conclusion	0.60	medium-g
Communicating	0.77	high-g

Based on Table 9, the N-Gain results for each component of science process skills indicate an improvement in the medium-g and high-g categories. This aligns with Lutfi's (2021) statement that the effectiveness of instructional media lies in the alignment between reality and expectations specifically, the impact or effect of the instructional media on the difference between pretest and posttest scores [15]. This is also supported by research conducted by Solehah and Gumay (2025), which found that the use of guided inquiry-based physics worksheets was effective in improving student learning outcomes, as evidenced by an N-Gain score of 0.67, which falls within the moderate category [16].

Based on the results of the cognitive test and the science process skills test, in which students showed improvement in both learning outcomes and science process skills, it can be interpreted that the project-based SAS developed is effective as a learning material for improving learning outcomes and science process skills.

CONCLUSION

Based on the research findings and discussion, the project-based learning-oriented SAS designed to enhance science process skills in green chemistry using orange peel waste is deemed suitable for use as a learning material when evaluated in terms of validity, practicality, and effectiveness. (1) The SAS is deemed valid in terms of content and construct validity, achieving scores with a mode of 4–5, falling into the "good" and "very good" categories. (2) The SAS is deemed practical based on the results of observations of lesson implementation, which achieved an average percentage of 87,5% in the "very good" category; observations of student activities, which achieved an average percentage of 84,6% in the "very good" category; and student response questionnaires, which achieved an average percentage of 93,9% in the "very good" category. (3) The SAS was deemed effective based on the improvement in student learning outcomes, which achieved a classical mastery rate of 97,2%, and there was an improvement in students' science process skills, as evidenced by the N-Gain scores: 35 students achieved the medium-g to high-g categories, indicating an increase in scores from the pretest to the posttest.

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