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Development of Collaborative-Based Worksheets to Improve Science Process Skills in Science Learning

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Abstract: Science process skills need to be owned by students in learning science. With science process skills, it is easier for students to conduct research and solve life problems by implementing science learning outcomes. Nevertheless, science learning involving science process skills is still challenging for teachers. This study aims to produce collaborative-based worksheets on natural science learning materials in junior high schools. The type of research used is Research and Development with the Plomp development model, which consists of 3 stages: a preliminary study, a prototyping stage, and an assessment phase. The subjects used for product trials were class VIII students of SMP Negeri 2 Ajung Jember. The results showed that the validity of the collaborative-based worksheet obtained very valid criteria with a percentage value of 93.25%. Based on the practicality test, collaborative-based worksheets are included in the convenient category and are suitable for learning with a percentage of 96.45%. In the effectiveness test, a practical collaborative-based worksheet is proven to improve students' science process skills by acquiring the N-Gain of 0.6, which is included in the moderate criteria. Based on this study's results, we can state that the science process skills can be developed in students by conditioning science learning that optimizes collaborative activities.

Keywords: collaborative; science learning; science process skills; worksheet

Introduction

Science process skills are essential skills in learning science. Science process skills can help students acquire knowledge through problem-solving activities (Ridlo & Setiawan, 2022). Students can obtain various information and knowledge using science process skills in theoretical studies, experimental activities, and activity-based learning (Afrizon et al., 2012). Science process skills prioritize direct experience so students can interact through actual practical activities in nature or the surrounding environment (Karmila et al., 2019; Barokah et al., 2022). Applying science process skills can develop students to seek the truth of problems in the form of facts by using the scientific method.

Science process skills in science learning are essential for students. Science process skills help students learn more quickly to a higher level, namely being able to conduct research and solve problems related to natural knowledge (Marlena et al., 2019). Students become more active and aggressive in seeking information related to science, especially about the natural surroundings. Students can directly develop an understanding and knowledge through the search process in investigation activities (Angelia et al., 2022; Safitri et al., 2022). Knowledge of science will increase significantly with science process skills, so students are more accustomed to finding out and studying science more deeply (Saidaturrahmi et al., 2019). Students can use science process skills to build essential competencies through research activities and the application of knowledge.

The results of interviews and observations of several science teachers show that the teaching and learning activities carried out so far rarely apply experimental-based learning using the scientific method. Education is often done conventionally by applying the lecture method assisted by PowerPoint slides with limited teaching aids. Experiment-based science learning is rarely implemented due to little

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learning media. A literature study on science process skills shows that there are still many students with low skills (Darmaji et al., 2018; Kusumaningrum & Djukri, 2016; Lepiyanto, 2017; Rahayu & Anggraeni, 2017). The results showed that science process skills test scores were deficient. The results of the study by Hartini & Miriam (2018) also show that students' science process skills are still shallow. Students still need to develop their abilities in formulating hypotheses, identifying variables, analyzing, and making conclusions.

Based on the existing problems, it is known that science process skills can be improved by applying science learning based on learning activities guided by worksheets. Andikalan et al. (2022) state that science process skills can be enhanced using student worksheet learning media. Student worksheets are a complete part of the learning design to facilitate the teaching and learning process (Indahsari, 2020; Kusumawati & Lesmono, 2020; Octaviana et al., 2022). Using student worksheets in science learning will improve science process skills because they contain instructions that serve as guidelines for carrying out science process skills activities. Using student worksheets can help students understand the concept of knowledge and skills taught by educators (Dewi et al., 2019; Supeno & Maryani, 2019). However, Masrifah et al. (2021) said that the student worksheets used by the teacher still had some drawbacks. Some of the contents of the student worksheets did not meet the description standards being tested. Student worksheets did not involve many scientific process skills and representation in the form of illustrations, pictures, and the contents of student worksheets are still less attractive.

One solution to overcome these problems is to develop collaborative-based worksheets. Supeno et al. (2018) stated that learning involving collaborative activities is an essential strategy in learning. Cooperative learning can help students learn to develop the character of being responsible for their tasks before integrating them with solutions generated by other students. Puspitaningrum et al. (2018) state that collaborative student worksheets are worksheets in which there are activities carried out in groups to solve real problems. Therefore, to prove this, it is necessary to research the development of collaborative-based student worksheets to improve science process skills in science learning. This study aimed to develop valid, practical, and effective collaborative-based student worksheets to strengthen students' science process skills in science learning.

This research is important to produce collaborative media in order to provide learning that can improve students' science process skills. Collaborative learning guided by worksheets is expected to create student activity in the process of scientific discovery so that science process skills can increase.

Method

This type of research is research and development. Research and development is a type of research used to develop a product by testing the effectiveness of the product produced. The development model used in this study is the Plomp model, which has three stages, namely preliminary research, prototyping stage, and assessment phase (Plomp, 2013). The Plomp model development research flowchart is shown in Figure 1.

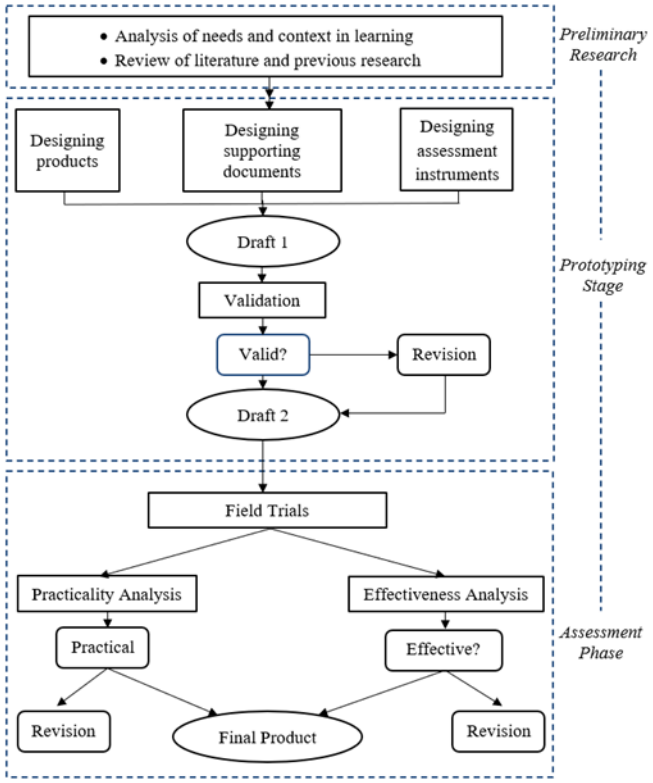

Figure 1. The Plomp model development research.

The research was conducted from August 2022 to October 2022 in the odd semester of the 2022/2023 school year. The place for conducting the study was at SMP Negeri 2 Ajung, which located on Jl. Nusa Indah No.100, Mangaran, Ajung District, Jember Regency, East Java 68175. The research subjects were 23 class VIII students.

Research data was collected using observation sheets and tests. The questionnaire includes validation sheets, observation sheets on the implementation of learning, and interview sheets. The test is used for science process skills. The data analysis technique used is the validity test, practicality test, and product effectiveness test. Product validity is obtained from validation results based on expert judgment. Product

validity was tested by applying the Formula 1 by Akbar (2013).

$$V_a = \frac{T_{SE}}{T_{SM}} \times 100\% \quad (1)$$

V_a : expert validation score
T_{SE} : the total empirical score
T_{SM} : expected total score

The product validity of student worksheets is determined by comparing the expert validation scores with the assessment criteria listed in Table 1.

Table 1. Worksheet validity criteria

Validity Score	Validity Criteria
$90.00\% \leq V_a \leq 100.00\%$	Very Good
$70.00\% \leq V_a < 90.00\%$	Good
$50.00\% \leq V_a < 70.00\%$	Less Good
$25.00\% \leq V_a < 50.00\%$	Not Good

The observer assessed the practicality of the worksheet using the learning implementation sheet. Scores obtained from observations were analyzed using the Formula 2:

$$\text{Practicality Score} = \frac{\text{Observation Score}}{\text{Maximal Sore}} \times 100\% \quad (2)$$

The practicality of student worksheets is determined by comparing the practicality scores with the assessment criteria listed in Table 2.

Table 2. Worksheet practicality criteria

Practicality Score	Practicality Criteria
$81.00\% \leq V_a \leq 100.00\%$	Very Good
$62.00\% \leq V_a < 81.00\%$	Good
$43.00\% \leq V_a < 62.00\%$	Less Good
$25.00\% \leq Score < 43.00\%$	Not Good

The effectiveness of collaborative-based worksheets is measured using a test by applying the one-group pre-test and post-test design research. The pre-test was carried out before the treatment was given, while the post-test was carried out after the treatment was given. The test used to determine the effectiveness of collaborative-based worksheets is the N-Gain test with the Formula 3by (Hake, 1998):

$$< g >= \frac{<S_f> - <S_i>}{<S_{Max}> - <S_i>} \quad (3)$$

$<g>$: N-gain score
$<S_f>$: final score average
$<S_i>$: initial score average
$<S_{Max}>$: maximal score average

The effectiveness of student worksheets is determined by comparing the gain scores with the assessment criteria listed in Table 3.

Table 3. Worksheet effectiveness criteria

N-Gain Score	Effectivity Criteria
$<g> \geq 0.7$	High
$0,3 \leq <g> < 0.7$	Medium
$<g> < 0.3$	Low

Result and Discussion

This research was conducted by applying the Plomp development model, which consisted of three stages: a preliminary study, a prototyping stage, and an assessment phase. This research aims to develop collaborative-based student worksheets with valid, practical, and effective criteria. The research results according to the stages of development can be described as follows.

Preliminary Research

This stage begins with analyzing the problems and needs to find out the initial description related to the science learning that has been done. Analysis of issues and needs is carried out through literature study activities related to research that previous researchers have carried out. Needs analysis was carried out by collecting information about the conditions of learning science at SMP Negeri 2 Ajung Jember through interviews and observations. Interviews were conducted to find out the science learning activities that had been carried out, including learning media, the application of technology in education, and student's abilities.

Prototyping Stage

The development stage begins with designing product development, supporting devices, and research instruments. When designing product development, researchers created collaborative-based worksheet product designs through the canva.com website. In the supporting device design section, the researcher developed a lesson plan. In the instrument design section, the researcher created research instruments in the form of validation sheets, observation sheets of learning implementation, and pre-test and post-test designs.

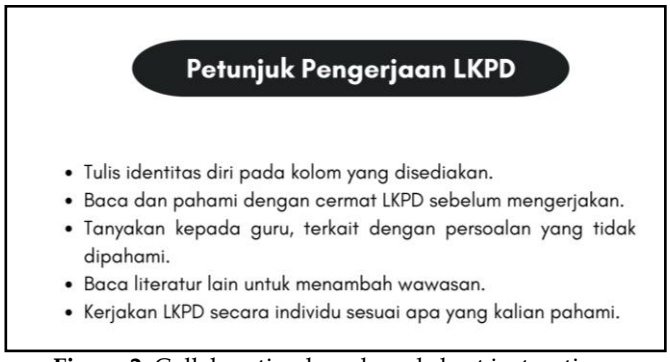

Figure 2. Collaborative-based worksheet instructions

The researcher created a collaborative-based worksheet consisting of a cover, table of contents, work instructions, competencies, competency indicators, learning objectives, three teaching activities, a glossary, and a bibliography. The collaborative worksheet design that has been created is shown in Figure 2 to Figure 5. Each learning activity has an activity component that guides students in developing science process skills. Students carry out scientific processes collaboratively by observing, measuring, and recording scientific phenomena. The science process is carried out collaboratively with other students.

Figure 3. The first learning activity on the worksheet

Figure 4. The second learning activity on the worksheet

Science learning experts then validate the worksheet. The results of the collaborative-based worksheet validation are shown in Table 4.

Table 4. Results of worksheet validation

Aspects	Validator 1 (%)	Validator 2 (%)	Validator 3 (%)	Average (%)
Content	91.67	100.00	95.83	95.83
Material	93.75	93.75	100.00	95.83
Language	90.00	90.00	100.00	93.33
Presentation	81.25	93.75	100.00	91.67
Graphics	87.50	100.00	81.25	89.58
Average				93.25
Criteria				Very Good

Based on the results of the validation analysis in Table 4, it is known that the validity of collaborative-based worksheets in improving science process skills is included in the outstanding category. Aspects assessed in the validation process include content validation and construct validation. Elements of content validation include aspects of need and novelty. Construct validity provides material, linguistic, presentation, and visual elements. Based on the validation results, it can be stated that the collaborative-based worksheets developed can then be applied to science learning.

Content validity is a primary reference in developing products (Amalia & Kustijono, 2019). The

concern underlying the development of collaborative worksheet-based products is the need and novelty. The collaborative-based worksheets were designed based on the market for students' low science process skills. For the novelty aspect, the worksheet was developed for a collaborative learning process. Students carry out the scientific method collaboratively with other students to develop science process skills. In addition, using collaborative-based worksheets is new in science learning for students.

Construct validity is a description of the construction of worksheets based on aspects of material, language, and framework (Plomp, 2013). Nieveen & Folmer (2013) state that constructs validity is related to the consistency of collaborative-based worksheet. In this study, construct validity was viewed from several aspects, namely, aspects of the material, language, presentation, and graphics.

On the material aspect, collaborative-based worksheets have been designed according to competency targets as formulated in the curriculum. In addition, worksheets have been designed taking into account the needs of students, the essentials of teaching materials, the substance of the subject matter, the insights of students' knowledge, and scientific activities. That statement follows Safitri et al. (2022) that experimental activities in science learning can help students find answers to problems and think scientifically.

In the language aspect, collaborative-based worksheets have been designed using the correct language rules, can be read correctly, have clear information, and use effective and efficient language appropriate to the student's level of ability. Proper language use is a feature of good scientific communication (Faurisiawati et al., 2022; Pramesti et al., 2020; Wati et al., 2019). Using language rules in collaborative-based worksheets can help students solve problems and develop science process skills.

In the graphical aspect, collaborative worksheets have been designed considering the type and size of fonts, attractive layouts, appropriate illustrations and images, and attractive designs. Using various fonts in learning media can attract attention and motivate students to carry out the science process. That description follows the statement of Alfarisi et al. (2022) that using fonts accompanied by an attractive design can help students understand the subject matter more quickly.

To guide the implementation of learning, researchers develop syllabi and lesson plans. Syllabus and lesson plans have been developed based on curriculum process standards. Science teaching has been designed for three lessons. Learning steps are created by considering scientific method activities so that students can develop science process skills. In addition, learning steps must be adapted to the learning activities contained in the worksheet. Instrument design is done by compiling assessment instruments, validation sheets, observation sheets of learning implementation, and science process skills tests. The test consists of 10 essay questions arranged based on indicators of science process skills.

Assessment Phase

At this stage, a trial was carried out using collaborative-based worksheets in science learning. Science learning is carried out by involving scientific methods guided by worksheets for three lessons. During the implementation of science learning, students carry out science processes and experimentation referred by worksheets. Students work scientifically collaboratively with other students when carrying out scientific investigations. The results of science learning implementation are shown in Table 5.

Table 5. Practicality of worksheet

Activity	Lessons 1 (%)	Lessons 2 (%)	Lessons 3 (%)	Average (%)
Introduction of science teaching	97.91	90.89	100.00	96.26
Science learning activities use collaborative worksheets	100.00	88.09	100.00	96.03
Closing of science teaching	100.00	94.04	97.22	97.08
Average	99.30	91.00	99.07	96.45

Based on the results of the analysis of the implementation of science learning, it is known that students in the learning process can use collaborative-based worksheets. Students can carry out scientific methods according to the instructions contained in the worksheet. The implementation of learning is 96.45% which is included in the convenience criteria. According to Mardhiyyah et al. (2022), the practicality of teaching materials is a measure of the feasibility of learning using teaching materials; learning is said to be practical if teaching materials can be used easily by students and teachers. This research, followed by Labib & Puspitawati (2018), shows that the use of worksheets in learning is considered very practical and suitable for learning at school.

The worksheets are specifically designed to develop students' science process skills in science learning. Students carry out scientific work collaboratively to construct scientific knowledge. The activity during scientific work is guided collaboratively

using worksheets. The results of the science process skills test before and after the implementation of science learning are shown in Table 6.

Table 6. The test result of science process skills

Data	Pre-test	Post-test
Number of students	23	23
Lowest score	4	40
Highest score	32	84
Average	8.78	63.56
N-Gain		0.60
Gain Category		Medium

Table 8 shows that the average pre-test value is 8.78, and the average post-test value is 63.56. The analysis results show that the N-gain value is 0.6, which means that the students' science process skills have increased with moderate criteria. Collaborative-based worksheets effectively improve students' science process skills in science learning. Effectiveness is the achievement of the objectives of a learning activity under the targets set. Wulandari et al. (2019) said that worksheets could improve students' science process skills. The results of this study indicate that worksheets can guide students to carry out the process collaboratively. Collaborative activities in groups can increase student participation and responsibility during the science process.

Based on the analysis of each aspect of science process skills, the skills to identify variables experienced a tremendous increase, namely obtaining an N-gain of 0.93. Students have good skills when identifying variables because they can determine three kinds of variables: dependent, independent, and control. The guidelines provided in the worksheets can provide learning assistance for students. The skill aspect that experienced the smallest increase was the ability to formulate conclusions with an N-gain of 3.89. Students still have difficulty acquiring decisions. Collaboration with other students has not been well done because students must elaborate on the results of analyzing various scientific information. The results of previous research by Hariningwang & Fitrihidajati (2020) state that formulating conclusions is difficult for students because of a lack of knowledge that directs students to the decision.

Students have difficulty building conclusions because elaborating on the information obtained is not done correctly. Even though students have conducted group discussions with other students, decision-making is still tricky because of a lack of knowledge and ability to make decisions. The achievement of each aspect of the science process skills of each student is different, as is the case with the statement by Santrock (2017), due to the diverse prior knowledge of students. Slavin (2019) states that the initial understanding of each student is different and can affect the final results of their learning. This problem can be overcome by doing repeated exercises. Intense training can be used as an alternative in training science process skills. Eggen et al. (2017) explain that repeating activities can make a habit that is hard to eliminate and will continue to be embedded in students. The results showed that science process skills had increased. Worksheets that are specifically designed to involve collaborative activities can improve students' ability to carry out scientific processes.

Conclusion

Based on the results, it can be concluded that the results of the validity test of collaborative-based worksheets are included in the outstanding category with an achievement of 93.25%. Worksheets are designed by considering aspects of students' needs for crucial skills. In addition, the worksheet has an element of novelty, namely collaborative activities that students must carry out while carrying out the science process. The results of observations on the implementation of learning show that students and teachers in science learning can use worksheets. Science learning takes place in a quality manner. Collaborative student activities can develop science process skills when carrying out the scientific method. Students can carry out discussions in groups to carry out scientific processes and construct scientific knowledge. Teachers can make worksheets collaboratively to develop investigative skills. Obstacles faced by students when carrying out the scientific method can be overcome by providing exercises and repetition of science activities. Students can start learning by carrying out simple investigations, gradually leading to complex discovery processes. The science process must be guided by worksheets so that learning activities are directed toward the final result. Worksheets can act as scaffolding which can provide step-by-step tutoring.

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The authors declare no conflict of interest.

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