Indonesian Society for Science Educators

Journal of Science Learning

journal homepage: ejournal.upi.edu/index.php/jslearning

Development of SETS-Based Booklet-Assisted Student Worksheet on Environmental Pollution Material to Improve Science Process Skills

Farida Nur Azizah Fitrianasari[1], Dian Nugraheni[1]*, Erti Hamimi[2], Indra Fardhani[1], Safwatun Nida[1]

[1]Department of Science Education, Faculty of Mathematics and Sciences, Universitas Negeri Malang, Malang City, Indonesia.
[2]Departement of Natural Sciences and Science Education, Faculty of National Institute of Education, Nanyang Technological University, Nanyang Walk, Singapore.

*Corresponding author: nugraheni.fmipa@um.ac.id

ABSTRACT Understanding science process skills must be supported by learning methods and media that empower students to engage in active learning. A SET-based learning model combines scientific knowledge with real-life experiences and can encourage students to be actively involved. This study aims to develop student worksheets, supported by booklets, that are feasible, valid, effective, well-received when used in learning, and capable of improving students' science process skills. The research method used is research and development (R&D) with the ADDIE development model. The media effectiveness test was conducted using a pre-experimental one-group pretest-posttest design. The research sample used included expert lecturer validators, teachers, and seventh and eighth-grade students. The results of the validation test, as assessed by media experts, were 100%, and those of material experts were 92.8%. The media developed has received an average response of very good, based on assessments by 80.8% of teachers and 93% of students, suggesting it can be applied in learning. The media effectiveness test yielded an N-Gain value of 0.69, in the moderate category, and a 69.3% improvement in students' science process skills is considered quite effective. So it can be concluded that the results of the development of student worksheet learning media assisted by booklets have been assessed as feasible, valid, received a good response, and are pretty effective in improving students' science process skills.

Keywords: Booklet, Student worksheet, Science process skills, Environmental pollution, Science, Environmental technology, and society

1. INTRODUCTION

Science education faces challenges when the implementation of the curriculum commonly used in learning has not yet fully developed students' scientific skills (Mushani, 2021). Developing scientific process skills (SPS) helps students cultivate 21st-century skills for addressing real-world challenges (Azzahra et al., 2024). In the 21st century, SPS support prepares students to tackle challenges related to science, technology, and society that are increasingly evolving (Özgelen, 2012). Science process skills are the ability to think and act through observation, collecting and organizing information, and problem-solving through scientific activities, so that students can understand science not only through conceptual and theoretical understanding but also actively apply it in learning and life (Gizaw & Sota, 2023; Özgelen, 2012).

Science process skills are the foundation of students' competencies in comprehensively understanding science. Students' competencies in understanding science are derived from knowledge to verify the truth of science based on research results using the scientific method (OECD, 2017). The measurement of students' science competencies is one of the subjects assessed by the Programme for International Student Assessment (PISA). The results of the 2022 PISA assessment showed a decrease in average scores, particularly in science, compared to 2018. The average student score in 2018, which was 396, decreased to 383 in 2022 (OECD, 2023). Therefore, in this case, achieving science subject competencies, especially in scientific process skills, remains an issue that needs to be addressed.

Received: 18 June 2025
Revised: 30 July 2025
Published: 30 September 2025

The achievement of educational goals in learning requires an effective learning design. The selection of learning methods and media to be used needs to be prepared according to the needs of the teaching material (Mawardi, 2018). Scientific knowledge that integrates conceptual understanding, theory, and skills requires active learning methods for students to conduct investigations or experiments. The Science, Environment, Technology, and Society (SETS) learning model is considered an effective teaching method that encourages students to engage in experiments actively (Dewi et al., 2020; Yörük et al., 2010). SETS is a learning model that integrates science, environment, technology, and society to help students understand real-world problems scientifically, make responsible decisions, and actively participate in finding solutions to global issues (Ilmiyati et al., 2020). The use of SETS in learning to improve SPS is supported by research (Sarah et al., 2023), which shows that SETS can effectively produce more relevant and engaging learning experiences for students by incorporating real-life contexts, thereby fostering scientific skills.

Active student engagement in learning requires supportive media for such activities. Student worksheets are one of the learning media supporting student learning activities in the classroom (Noprinda & Soleh, 2019). Student worksheet serves as an additional student-centered learning resource and should include instructions and activities that encourage active participation, critical thinking, communication, and collaboration among students (Ismail et al., 2020). Generally, students' worksheets only contain activity instructions, problem-solving questions requiring strategic approaches, instructions for designing investigations and creations, simple guidelines, answer spaces, and activity notes (Sugiyanto et al., 2023). Therefore, additional supporting materials are needed to help students expand their knowledge of the teaching material. Booklets are one of the additional teaching resources that can support activities or tasks in students' worksheets. A booklet is a small-sized learning medium containing engaging text and illustrations presented concisely, providing supplementary information to support students' learning activities (Novianti & Syamsurizal, 2021).

Presenting the booklet's contents with supporting illustrations and colors can stimulate students' imagination and interest in learning. Student worksheets as learning activity designs developed with booklet guidance will be more effective in sparking curiosity through observation activities to identify problems as the initial stage of the SETS learning model (Nugraini et al., 2022). The activity designs presented in the student worksheets and booklet are tailored to students' needs and learning materials. Environmental pollution material is closely related to daily life in the place of residence (Pakaya et al., 2023). Studying environmental pollution material will not only make students understand the development of science, but also help them understand the impacts caused (Fredy et al., 2019).

Field observations conducted in two seventh-grade classes at a junior high school in Malang showed that students were not familiar with conducting practical activities using laboratory equipment and materials. In preparing for scientific-practical activities, students still had difficulty understanding the practical steps required because the activities were not structured. This was also supported by the results of a questionnaire completed by science teachers, who stated that SPS empowerment had not yet been fully implemented in the learning process. Teachers also still experience difficulties in guiding students to design experiments appropriately because the available teaching materials do not fully support the skills of asking questions, formulating hypotheses, conducting experiments, and interpreting data. The empowerment of science process skills needs to be improved so that students understand science comprehensively. Therefore, an in-depth literature review of appropriate learning models to improve students' SPS is needed.

Based on research (Dewanti et al., 2024)Learning using the SETS learning model to improve science process skills is considered adequate and supports science concept learning by relating it to daily life activities. However, in that study, booklets were not used as support for student worksheets. Therefore, in this study, booklets were developed to support student worksheets during the initial stages of learning, as observed and based on research. (Hayati et al., 2019)KPS can be improved through problem-solving activities focused on the interactions of living things around them, with direct student involvement in the environment. The SETS learning model has been proven effective in improving KPS by involving students in problems related to the local potential of their lives. However, this study has limitations in the materials developed, which focus only on the module on the interaction of living organisms. Additionally, in that study, the overall module development did not include skills in conducting projects or experiments in learning. Therefore, in this study, learning using the SETS model is presented through practical activities that address environmental issues in students' immediate environments.

Based on the problems and results of the needs analysis, research and development were conducted to develop innovative student worksheet learning media, supported by booklets, to improve students' scientific process skills at SMPN 2 Malang. Before it can be used for learning, the development of this media must be confirmed by experts and declared suitable for student use. The media has been confirmed to receive positive feedback from teachers and students, thereby supporting its implementation in learning. Thus, the results of this media development are expected to improve students' scientific process skills, so

that with the skills acquired, students will not only understand science through conceptual knowledge and theory.

2. METHOD

This study uses the research and development (R&D) method with the ADDIE development model. The ADDIE development model consists of several stages, including analysis, design, development, implementation, and evaluation. Next, the learning media that have been successfully developed are then tested for effectiveness to determine their suitability for use.

2.1 Development Techniques

The ADDIE development model stages were carried out using the procedures shown in Figure 1.

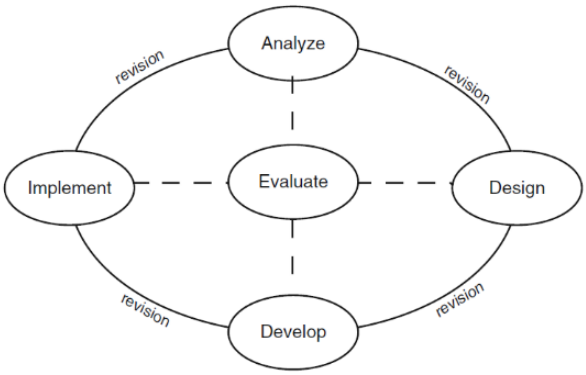

Figure 1 ADDIE Model Development
Source: (Branch, 2009)

2.2 Analyze Stage

This stage begins with a literature review of previous articles on media and learning methods. Field observations are also needed to directly understand the learning models or media commonly used by science teachers in the classroom. Quantitative data is collected from the results of a needs analysis given to science teachers and students. The results of the needs analysis and learning observations are then used as the basis for developing student worksheet learning media supported by booklets.

2.3 Design Stage

At this stage, content design related to the discussion material is carried out, including cases related to environmental pollution, booklet content that supports the invitation process with environmental issue observation activities in the surrounding environment, practical work designs to be carried out by students, determining the tools and materials supporting the practical work process, and other supporting components. In addition to the content, the design layout, color selection, and supporting designs for student worksheets and booklets are made as attractive as possible to align with the content, students' needs, and their understanding level.

2.4 Development Stage

In this stage, media development begins, tailored to the content designed. The student worksheet contains content based on the SETS learning syntax, and the booklet serves as supporting material for one of the learning syntax stages in the invitation phase. After media development is completed, a validation assessment by media and content experts is required, including completion of a questionnaire. The results of the calculations, expressed as percentages, are used to determine the product's suitability against several criteria.

2.5 Implementation Stage

At this stage, the developed media were implemented in learning in a small group trial with the research subjects being seventh-grade students at SMPN 2 Malang. This implementation stage was carried out to test the developed media on a small scale. Before the students were given treatment using student worksheet media and booklets, they were first asked to complete a pretest. After the students received the treatment, they were asked to complete a post-test to assess learning outcomes. The learning process using the SETS learning model consists of four stages: invitation, exploration, explanation, and taking action (Hunaepi et al., 2014; Yager, 1992). The invitation stage involves introducing students to real problems that align with the objectives of encouraging students' curiosity. The exploration stage can be carried out by identifying questions, analyzing scientific information or data, and conducting an experiment. The explanation stage involves proposing solutions, refining them based on suggestions and input from friends, and then presenting them in a presentation. The taking action stage is related to solutions that can then be implemented, or directly involved in proposing activities (Dass, 2005).

2.6 Evaluation Stage

The evaluation stage is conducted at the end of each ADDIE research model stage, based on data analysis from each process, suggestions, and feedback from various parties, to ensure the media is suitable and effective for use.

2.7 Effectiveness Testing

The effectiveness test of the student worksheet learning media development assisted by a booklet is conducted during the implementation stage. The media test is conducted using a pre-experimental, one-group, pretest-posttest research design. The administration of pretest and posttest in this research design aims to determine the effect of using student worksheet media and booklets by comparing the results between the two (Sugiyono, 2019). The pretest and posttest instruments used in this implementation stage had previously been validated for validity and item consistency through empirical testing. The validity criteria were determined by comparing the calculated r value (Pearson correlation) with the table r

value (Wahyuni, 2020). The reliability test of the measurement instrument was conducted by comparing the Cronbach's alpha value with the significance level (Darma, 2021).

The effectiveness test was conducted to measure the success rate of the student worksheet media assisted by booklets used in improving students' SPS (Fitra & Maksum, 2021). In this study, the subjects were 33 7th-grade students from SMPN 2 Malang. The research data collected in this study came from student worksheet completion, observations of student activities that supported SPS, and students' pretest and posttest results.

The analysis of the effectiveness test results was based on the N-Gain test for each SPS indicator. First, a paired sample t-test was conducted to examine the differences in students' learning outcomes before and after the intervention, using student worksheets assisted by booklets (Field, 2018). The data were confirmed to be normally distributed using the Shapiro-Wilk normality test for datasets with fewer than 50 samples. (Sukarelawan et al., 2024). If the data results met the prerequisite test, then the N-Gain test could be conducted to measure changes in students' understanding levels before and after the treatment in a learning situation. (Supriadi, 2021)

Table 1 Results of media expert validation

Aspect	Validator		Percentage	Category
	1	2		
Cover design	100%	100%	100%	Very feasible
Content design	100%	100%	100%	Very feasible
Mean			100%	Very feasible

Table 2 Results of material expert validation

Aspect	Validator		Percentage	Category
	1	2		
Content eligibility	87.5%	96.9%	92.2%	Very feasible
Language	75%	87.7%	81.3%	Very feasible
Presentation techniques	100%	100%	100%	Very feasible
Appropriateness of stages	100%	93.8%	96.9%	Very feasible
Appropriateness of indicators	93.8%	93.8%	93.8%	Very feasible
Mean			92.8%	Very feasible

3. RESULTS AND DISCUSSION

This study resulted in the development of a SETS-based booklet-assisted LKPD on environmental pollution materials to improve students' science process skills at SMPN 2 Malang. The LKPD media developed include activities adapted to the SETS learning syntax, supported by a booklet that complements one of the invitation-stage syntaxes. The results of the media and material validation test data analysis by experts are shown in Tables 1 and 2.

Improvements based on expert assessment results are evident in the material's language validation. Some sentences in the activity instructions in the student worksheet and information in the booklet are still tricky for junior high school students to understand. The use of language in presenting the material is closely related to the appeal of the language, clarity, and appropriate word choice, so that the instructions conveyed are represented and do not cause ambiguity. (Fahmi & Saleh, 2017). Furthermore, the information presented in the booklet does not yet reflect interactive language, and there is too much text and a lack of supporting images. The information in the booklet should be presented in an interactive, engaging language, reinforced with attractive, relevant illustrations to support understanding, enhance visual appeal, and make conveying the information to readers easier. (Wild et al., 2019). Linguistic improvements are intended to ensure that the information conveyed to students is well understood. Interactive language can encourage students' curiosity to explore further issues related to the discussion material. Booklets presented in clear and correct language can broaden students' knowledge of environmental pollution. (Novianti & Syamsurizal, 2021). Presenting the booklet's contents with less text and more images will attract students' attention and stimulate their imagination. (Pralisaputri et al., 2016).

The student worksheet media, assisted by booklets developed and deemed feasible by experts, were then tested based on responses from science teachers and students to assess their ease of use. The results of the response test for the student worksheet learning media and the teachers' booklet were 80.8% and 93%, respectively. Based on teachers' assessments, the media was deemed to help students become more active learners, particularly through practical activities, as the student worksheet guides students through the steps of conducting experiments.

The concept of environmental pollution (**science**) in Figure 2a) is linked to everyday environmental pollution (environment) in Figure 2b) by raising the issue of mounting landfill waste in several areas. The negative impact of waste on the environment can be prevented by having landfills with the best waste management systems equipped with innovative waste processing tools (**technology**) in Figure 2c) and the importance of the community's role in environmental policies (**society**) in Figure 2d). The booklet page displaying the information raised is presented in Figure 2.

The SETS learning model can help students understand how science and technology can affect society's sustainability by considering their environmental impacts. (Retno & Marlina, 2018). The information in the booklet

Figure 3 Booklet Pages Illustrating SETS Components (Science, Environment, Technology, Society)

Figure 2 Implementation of Media in Learning

is expected to encourage students to understand and observe environmental issues around them.

The learning activities outlined in the student worksheet are tailored to the SETS syntax, including an invitation stage with booklet literacy activities, an exploration stage involving questioning, formulating hypotheses, experimenting, and interpreting data, an explanation stage involving presentations and solution delivery, and a taking action stage involving the implementation of solution designs through direct participation in activities. The relationship between SETS-based learning activities in the booklet-assisted student worksheet and SPS achievement is briefly summarized in Table 3.

The learning implementation shown in Figure 3 was carried out using the SETS learning model in the student worksheet activities, supported by booklets. Thus, through the student worksheet media and booklets, students can practice scientific process skills, including observation, questioning, formulating hypotheses, classifying, experimenting, interpreting data, inferring, communication (Gizaw & Sota, 2023). The supporting images in the booklet, as illustrations, support students' imagination in understanding environmental pollution cases (Apriyeni et al., 2021).

This encourages students to develop problem statements and hypotheses during the exploration stage. The results of the problem statement and hypotheses design are presented in Table 4.

A small-scale trial of the student worksheet learning media and booklet was conducted over four sessions to assess the effectiveness of the developed product. The data obtained consisted of quantitative data from the calculation of students' pretest and posttest scores. The test instrument contained eight SPS indicators included in each test item. Based on the SPSS data analysis conducted during the empirical testing of the questions, the pretest and posttest question instruments yielded a calculated r value > the table r value and a Cronbach's alpha value > 0.7, indicating that

Table 3 SETS-Based learning activities on SPS

SETS Stage	SPS Indicators	Activities on The Student Worksheet
Invitation	Observation	Through the booklet's information literacy, teachers ask students first to observe the environmental cases or issues presented, then to read further about the impacts and causes of pollution, technological innovations, and the role of the community in preventing environmental pollution.
Exploration	Questioning, formulating hypotheses, classifying, experimenting, interpreting data, inferring	The teacher directs students to refocus on the activities in the student worksheet. Next, based on their observations and literacy skills gained from the booklet, students are asked to write down the problem statement and hypotheses related to the information in the booklet about the water pollution experiment. The teacher then directs students to conduct the water pollution experiment by observing the physical characteristics and measuring the temperature and pH of the polluted water. The data from the experiment are then grouped according to the table provided in the student worksheet. Students are then asked to answer questions related to the observation table and write conclusions based on the objectives of the experiment achieved at the end of the activity.
Explanation	Communication	Students worked in groups to present the results of their practical assignments to the class, followed by a question-and-answer session. After the presentation, the teacher guided the students in finding solutions to everyday activities to prevent and reduce environmental pollution.
Taking action	Communication	The teacher asks students to carry out activities designed together with their group at each member's home. The results of these activities are then recorded in the student activity table.

Table 4 Results of problem formulation and hypotheses

Problem Formulation	Hypotheses
"Why is water quality declining?"	Because water from the mountain of trash that seeps into the ground will damage water quality
"What is the impact of soil absorbing wastewater?"	This will hurt soil fertility and its ability to support plant growth, as well as damage water quality
"Why can waste hurt the environment?"	Solid and liquid waste can affect water quality. If this happens, it will lead to the extinction of aquatic species, while solid waste will clog waterways and cause flooding.

they are valid and reliable. Therefore, these instruments can be used to measure students' science process skills when implementing the media.

The SPS indicators developed in this study include observation, questioning, formulating hypotheses, classifying, experimenting, interpreting data, inferring, communication. (AAAS, 1971). Data analysis of the effectiveness test used the N-Gain test, which measures the effectiveness of the learning medium. Before conducting the N-Gain test on the research data, a paired-samples t-test was conducted to determine whether there was a difference between the pretest and posttest results. The paired-samples t-test can be used when the data are typically distributed. The normality test results for the pretest questions were 0.329, and for the posttest questions were 0.872. Therefore, the data are typically distributed and can proceed to the paired-samples t-test.

The paired-samples t-test yielded pretest and posttest means of 39.7 and 81, respectively. Based on these mean values, students' posttest scores increased compared to their pretest scores. The significant difference between the pretest and posttest means indicates that students have a good understanding of the skills required to learn science knowledge through the completion of the student worksheet. Students need to be aware of the initial knowledge required for implementing learning activities aimed at improving science process skills. The objectives of the learning activities to be achieved are presented at the beginning of the student worksheet. Before conducting independent learning activities, knowledge of problem formulation terms, hypotheses, the use of appropriate tools, procedures for filling in observation data, how to analyze data against the theory, and how to determine the appropriate solution is first learned through technical explanations of the learning process (Sudibyo et al., 2018). With this, students can individually assess their abilities to achieve maximum learning outcomes.

The results of the paired-samples t-test indicate a significant difference between the pretest and posttest scores, as evidenced by the Sig. (2-tailed) of 0.000. The negative t-value of -20.251 indicates that the pretest scores were lower than the posttest scores after the intervention. Additionally, an N-Gain test was conducted on the research data to assess the effectiveness of the learning media when used in instruction. The N-Gain values for each SPS indicator are presented in Table 5.

Table 5 N-Gain calculation result of SPS indicator

Indicators	*N-Gain*	Category
Observation	0.44	Medium
Classifying	0.73	High
Questioning	0.87	High
Formulating Hypotheses	0.93	High
Experimenting	0.48	Medium
Interpreting Data	0.66	Medium
Inferring	0.73	High
Communication	0.71	High
Mean	0.69	Medium

Based on the N-Gain calculation results, the SPS indicator is considered quite effective, with a percentage value of 69.3%, and falls within the moderate N-Gain criteria. The SPS indicator in Table 5, according to (AAAS, 1971; Gizaw & Sota, 2023)It is divided into two categories based on the difficulty of achieving them. These categories are fundamental skills, which include observation, classification, inference, and communication; and integrated skills (combinations) of two or more basic skills, which include questioning, formulating hypotheses, experimenting, and interpreting data. The lowest N-Gain scores for the SPS indicators were found in the observation indicator. Every experimental activity begins with observation based on information received directly through the five senses. (Ango, 2002). Therefore, before any treatment is administered, observation is a fundamental skill that students already possess and develop naturally through direct experience based on relevant facts. Students are accustomed to using various senses to observe an object by comparing it with other objects. (Sahnaz et al., 2018). The increase in pretest-to-posttest scores for each indicator is shown in Figure 4.

A comparison of students' pretest and posttest scores in Figure 4 shows an increase in their SPS for each indicator. A significant increase in pretest and posttest scores was observed in the indicators of formulating hypotheses, experimenting, interpreting data, inferring, and communication. Based on the research results (Choirunnisa et al., 2018)It is stated that basic skills based on the observation indicator have been acquired by students since elementary school, so that in Figure 4, the difference in the average pretest and posttest scores on that indicator shows the smallest increase.

However, observation skills must continue to be developed in students, as they serve as the basis for scientific thinking processes. One way to improve observation skills over time is through habit formation and continuous practice in treatment. (Fitriana et al., 2019). This is supported by research. (Lestari & Istiyono, 2025), which states that accurate and detailed observations form the basis for data collection that can be concluded precisely. With that, observation skills are closely related to other science process skills.

Assessment data is not based solely on pretest and posttest results but is also supported by activity results in the student worksheet. Data collection from student worksheet activities involves quantitative descriptive analysis of responses. Overall, all groups completed the activities in the student worksheet according to the instructions provided in each stage. The results of the student worksheet activities conducted in groups, with satisfactory answers, were from Group 6. The results of Group 6's student worksheet activities in writing conclusions and follow-up solutions are presented in Figure 5.

Based on Figure 5a, the observation data from the practical activity have been recorded according to the relevant observation aspects. Furthermore, Figure 5b) shows that the data processing results have been written down in detail based on the observation data linked to theories from other literature sources. As seen in Figure 5c, the conclusions from the learning activity have been written based on the discussion material from both the

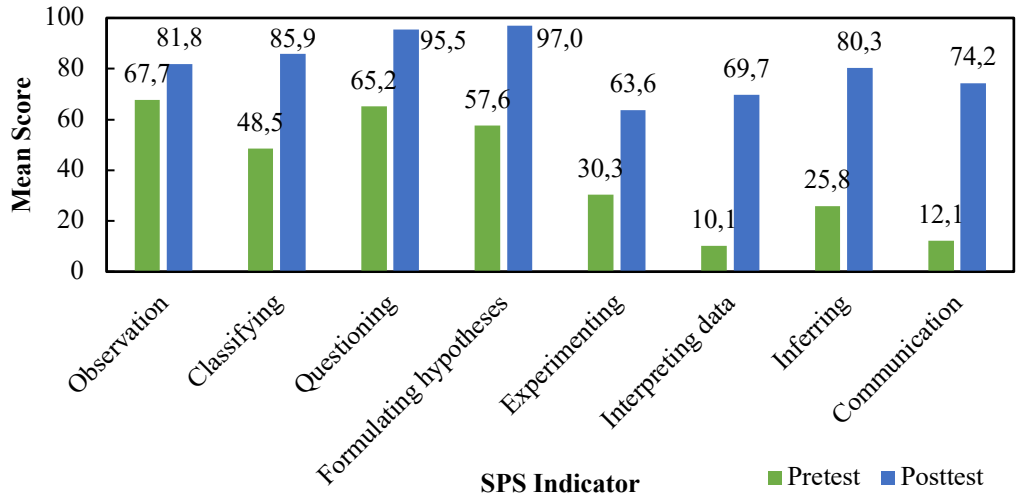

Figure 4 Comparison diagram of pretest and posttest scores

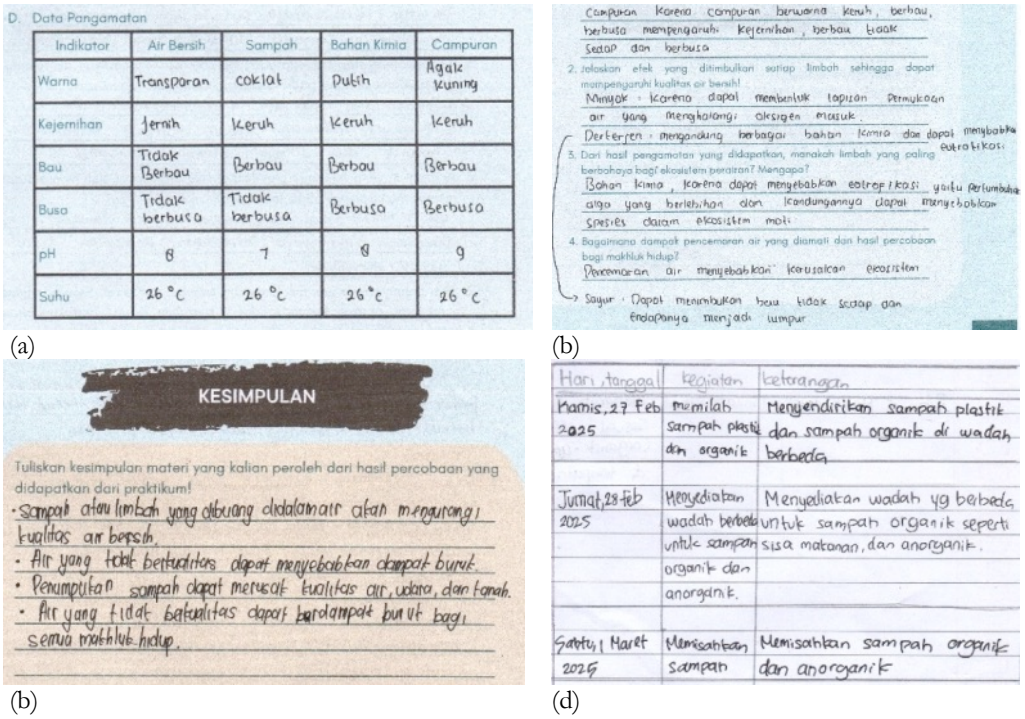

Figure 6 Results of the student worksheet implementation and taking action solutions

booklet and the results of the water pollution practical activity, and have been adjusted to the practical activity objectives. However, in the conclusion, the group concluded only from the results of interpreting the practical data and did not relate them to the learning objectives. During the exploration phase, solutions were proposed by directly participating in waste-sorting activities at home and at school, as shown in Figure 5d.

Research data on the learning activity were also obtained through observations of each student. Observations were gathered from several indicators through activities conducted directly in the learning process and experiments. Based on the observation assessment of the learning activity, 94% of students actively participated in both groups and the classroom. The assessment of students' scientific process skills in the learning activity for each indicator is shown in Figure 6.

The results of the observation were evaluated based on activities, including the ability to use tools skillfully, read measuring instruments accurately (in experiments), observe the results of experiments (observation), classify data based on observation results (classification), and present findings in a two-way manner during questioning sessions (communication). In terms of practical skills in conducting experiments, as seen in Figure 6, student assessment showed a significant improvement in results compared to the pretest results in Figure 4. Learning activities that empower SPS through practical work provide students with the opportunity to develop their thinking through direct practical discovery. Thus, through these practical

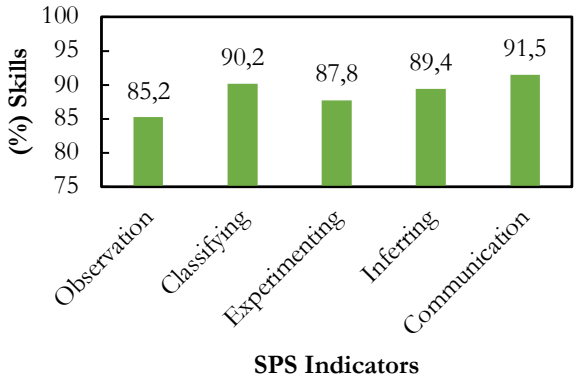

Figure 5 Learning observation results

activities, students actively implemented scientific process skills.

The use of systematically and purposefully designed student worksheet media supports active student participation, enabling them not only to acquire conceptual knowledge but also to be trained in discovering and developing concepts. (Mahmudah, 2017). This is supported by observation results, the completeness of the student worksheet, and the post-test scores of Group 4 members (9-AX, 16-KA, 29-RH), who showed increased learning activity when learning was conducted through practical activities. In the observation results, these students actively contributed to the group and demonstrated a high level of curiosity about the discoveries made. The group also appeared skilled in using and reading practical measurement tools accurately and carefully.

The development of student worksheet learning media assisted by booklets, completed through the ADDIE development model stages and analysis of effectiveness test data, has produced media deemed capable of empowering students' SPS in learning. The application of SETS-based media, incorporating scientific and technological concepts that address their societal and environmental impacts, can enhance SPS by fostering students' direct contributions to learning and by initiating actions both at home and at school. Thus, in understanding science, students not only acquire conceptual and theoretical understanding but also develop skills through scientific activities.

4. CONCLUSION

Based on the research results presented, the development of LKPD learning media assisted by booklets has been completed based on the ADDIE development model. The results of the media development have been declared suitable for use in learning, with 100% validation from media experts and 92.8% from subject matter experts. The learning media have also received very positive responses, with average teacher survey scores of 80.83% and student scores of 92.96% for implementation in learning. The effectiveness test results of the LKPD learning media assisted by booklets, based on a small-scale trial, yielded an effectiveness of 69.30%, indicating it is sufficiently effective in enhancing students' scientific process skills. The use of student worksheets and booklets is considered to encourage students to actively participate in learning through observation and practical activities, thereby strengthening their understanding of concepts and theories and developing their scientific process skills. During the research implementation, the activities provided were limited, so students did not produce tangible products.

ACKNOWLEDGMENT

Acknowledgments are extended to Mrs. Firda Awalia Putri, S.Pd., and Mrs. Fiona Setiabudi, S.Pd., as science teachers, as well as all students from classes VII H, VIII A, and VIII F of SMP Negeri 2 Malang who assisted the researcher in collecting data for the media development pilot study.

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