Development Student Activity Sheet of Natural Sciences with Authentic Inquiry Learning Approach to Improve Problem-solving Skills of Junior High School Students

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Abstract: This study aims to determine the feasibility of the Student Activity Sheet with authentic inquiry learning approach based on the results of the expert judgment assessment and also the students’ responses as well as to determine the improvement of problem-solving skills. This research is a development research (R&D) with a 4-D (four-D) model. The stages of this research included to define, design and develop. Research subjects were the experts, science teachers, and students of class VIII B of SMPN 14 Yogyakarta. The research instruments used were the Student Activity Sheet of expert and teacher validation instrument, students’ responses instrument, problem-solving skills observation sheets, and problem-solving skills pretest-posttest. The analytical techniques used included the average score to determine the actual score, the conversion of scores into four categories, the calculation of the percentage of mastery of problem-solving skills and the gain score of the mastery of problem-solving skills. Furthermore, the Student Activity Sheet was developed and considered very good by experts and teachers as well as suitable for use in natural sciences learning. (2) The students gave very good responses to the Natural Sciences Subject Student Activity Sheet with authentic inquiry learning approach from the results of development, (3) the improvement of students’ problem-solving skills in Natural Sciences learning with authentic inquiry learning gained an increase of 17.8% and the gain score of 0.74 which is included in the “high” category.

Keywords: Natural sciences student activity sheet; Authentic inquiry learning approach; Problem-solving skills.

1. Introduction

Problem-solving skills are basically the nature of learning objectives that are the needs of students in dealing with real life. According to Purba in [1] suggests that problem-solving is an attempt to find a way out of a difficulty, achieving a goal that cannot be achieved. Therefore, problem-solving is a high level of intellectual activity. Based on Munif in [2] in a study conducted by the Organization for Economic Cooperation and Development (OECD) as an international research institution, the results show that education in Indonesia is at the second lowest. Problem-solving competence in Indonesia ranks second from bottom after Tunisia with a score of 361.42 and South Korea as the number one country with a score of 550.43. In everyday life, students have been faced with a problem both in the home, school or community. Lack of trust given to students in the family environment to deal with existing problems is one factor that causes students not trained to do problem-solving. In addition, the
lack of experience possessed by students in dealing with problems in everyday life is also a factor that makes difficult problem-solving difficult. Another factor that causes the implementation of problem-solving skills is the lack of preparedness of schools, teachers, and students to conduct problem-solving activities in learning. This is due to the lack of a suitable approach to support problem-solving activities in learning.

Approach to the basic concepts of authentic learning that students are more likely to be interested in what they learn in the real world and more motivated to learn new skills concepts that are appropriate to their lives outside the school environment. Authentic learning (authentic learning) is a learning process that centers on the real activities of students. The context of this learning lies in the knowledge and skills that produce a continuous investigation to produce solutions to problem-solving. Based on the involvement of students in authentic learning, the inquiry approach or approach through inquiry is suitable to be applied. The use of inquiry approaches that are oriented towards authentic learning leads students to discover facts and concepts in science related to problems in everyday life.

An inquiry approach or better known as an inquiry approach is a process to obtain information through observation and experiment to solve problems. Made in [3] suggests that inquiry is one of the strategies used in a process-oriented class. Inquiry is a student-centered teaching strategy, which encourages students to investigate problems and find information. In addition, the inquiry approach contains higher-level mental processes, such as formulating problems, designing experiments, conducting experiments, collecting and analyzing data, drawing conclusions, having objective attitudes, honesty, curiosity, openness and so on.

From the description, it can be used to integrate approaches namely authentic inquiry learning (AIL) approach which is a learning approach that involves students to play an active role in learning activities in real terms that require students to build their knowledge through inquiry so that learning activities with the active role of students in real experience so that it can optimize learning activities in solving various problems of students in the surrounding environment.

Besides that, it can also improve mental processes at a high level. To guide the activities of students in conducting a real investigation, teaching materials are used in the form of Student Activity Sheet. Depdiknas [4] suggests that Student Activity Sheet (Student Activity Sheet) contains sheets that are used as a guide in learning and contains tasks that must be done by students in certain studies. Andi in [5] suggests that the function of Student Activity Sheet itself as teaching materials can minimize the role of educators, but rather activate the role of students. From some of these descriptions, it can be seen that the Student Activity Sheet is very important as an alternative learning to change educator-centered learning into a learner-centered learning. In addition, Student Activity Sheet is also one of the right learning for students because the Student Activity Sheet can help students add information about the concepts being studied through systematic activities.

Therefore, these problems had attracted the attention and concern of the researchers and are the background of researchers to develop the Student Activity Sheet using an authentic inquiry learning approach. The development of the Student Activity Sheet is expected to be able to find out the improvement of problem-solving skills of junior high school students.

The rest of this paper is organized as follow: Section 2 is about literature review. Section 3 describes the proposed research method. Section 4 presents the obtained results and following by discussion. Finally Section 5 concludes this work.

2. Related Works

This section presents literature review.

2.1. Student Activity Sheet of Natural Science with Authentic Inquiry Learning Approach

According to Sukardjo in [6], Natural Sciences is a science that was originally obtained and developed based on experiments (inductive) but in subsequent developments, the Natural Sciences was also obtained and developed based on theory (deductive). Carin and Sund [7] defined Natural Sciences as "systematic knowledge and organized regularly, generally (universal), and in the form of a collection
of data from observations and experiments.” Chiappetta in [8] states that science is a way of knowing about the world. In science, the explanation is limited to those on observation and experiments that can be substantiated by other scientists. The explanation that cannot be based on empirical evidence is not part of science.

Trianto in [9] argues that Natural Sciences is knowledge gained through collecting data with observations, experiments, and drawing conclusions to produce reliable explanations of natural phenomena in the surrounding environment. Based on the description, the Natural Sciences is a systematic science and arranged in a regular, general (universal) manner, and in the form of a collection of data from observations, experiments and draw conclusions to produce reliable explanations of natural phenomena in the surrounding environment in the form of facts, concepts, or principles but also a process of discovery.

This statement is strengthened by Kaufelt in [10] suggests that authentic learning allows students to explore, discover, discuss, compile concepts and relationships in a meaningful context that involves real and relevant and interesting problems and projects for learners. Herrington and Oliver in [11] suggests authentic learning incorporates the principle that scientific knowledge and attitudes can be combined by creating real learning that allows learners to learn by connecting between school environments and community needs. Edelson in [12] suggests that using authentic learning in scientific practice in the classroom because it is very necessary for students to face uncertainty during learning. Adapting to scientific practice, learning is more easily focused on scientific knowledge, tools, and techniques in scientific practice. Scientific attitudes and social interaction also define roles in scientific practice. For students, scientific attitudes and social interaction are very important to understand the process and results in science. Lombardi in [13] suggested that authentic learning provides students with experience ranging from experiments to solving real problems through various sources of information.

This statement is strengthened by Gulo [14] suggests that inquiry is a series of activities that involve the maximum ability of students to search and investigate systematically, critically, logically, and analytically. Trowbridge, et al. [15] stated that “inquiry is the process of defining and investigating problems, formulating hypotheses, designing experiments, gathering data, and drawing conclusions about problems”. Therefore, inquiry is the process of defining and investigating problems, formulating the hypothesis, designing experiments, finding data, and drawing conclusions from these problems.

Based on the description explained previously, authentic inquiry learning approach is a contextual learning that is conducted based on the real problems in daily life that directs the students to actively collaborate in activities by using various learning resources which are close to the students through the process of investigating problems, formulating hypotheses, designing experiments, finding data and drawing conclusions that have the positive effect on cognitive outcomes, process skills, problem-solving skills and attitudes towards the natural sciences.

The stages of authentic inquiry learning approach are contextual problems, collaboration, the variation of learning resources use, and investigation activity [16], [11], [13], [17]. Furthermore, the investigation activity in the inquiry stage is formulating problems, formulating hypotheses, designing experiments, finding data and drawing temporary conclusions.

Student Activity Sheet is task sheets that contain instructions for carrying out investigative activities to improve student understanding and activity and make it easier for teachers to manage the learning process, monitor student success, arouse students’ interest in learning, and develop students’ skills and scientific attitudes [5], [9], [18], [19], [20]. As for some of the functions and objectives of Student Activity Sheet in learning activities according to [5] learning is to make students more active and minimize the role of teachers in the classroom, facilitate the implementation of learning activities, make students more independent by practicing many tasks in concise material, increasing student mastery in understanding the material being studied.

The Student Activity Sheet developed must pay attention to several components according to BSNP in [21] with additional reinforcement according to Darmojo and Kaligid [18] and Devi, et al. in [22] states that the evaluation component of Student Activity Sheet is said to be good if it has several conditions, namely the feasibility of the content has aspects of suitability of content, suitability of
Based on the description explained previously, it can be synthesized that the Student Activity Sheet with authentic inquiry learning approach is a worksheet which consists of the instructions for carrying out the investigative activities to improve students' understanding and activity consisting of components of the structure including the theme/title of the activities, objectives, tools, and materials, procedures, observations, discussion material, and conclusions. Furthermore, evaluation competence in Student Activity Sheet is considered to be good as it covers several aspects such as the feasibility of content, linguistic, presentation and graphics aspects, based on real problems in everyday life that direct students to collaborate on activities in real terms using a variety of learning resources close to students and included in the authentic inquiry learning stage in the learning process which includes contextual problems, collaboration, the use of various learning resources, and investigative activities. Investigation activity is an inquiry stage which is formulating a problem, formulating a hypothesis, designing an experiment, finding data, and drawing a temporary conclusion.

2.2. Problem-solving Skills

Gulo in [14] defines problem-solving is the process of thinking and finding a way out of the problems faced. Anthony and Susan in [25] explains that problem-solving is a process of eliminating differences or nonconformities that occur between the results obtained and the desired results. The ability to solve problems related to the ability to recognize problems, find alternative solutions, choose an alternative as a solution, and evaluate the answers that have been obtained. Whereas according to O’Neil, et al. [26] problem-solving if the procedure for attaining a goal is known to students that they can complete the task with having to reason, they do not have use problems solving skills.

Bielaczyc, et al. [27] suggests that problem-solving consists of three aspects: understanding content, problem-solving strategies, and self-regulation. A good problem solver is (a) understanding the content well (content knowledge), (b) having specific intellectual skills (problem-solving strategies), and (c) being able to plan the use of resources and skills and, during the process, monitoring its own progress towards the final goal to solve the problem (self-regulation).

Several indicators on the aspects of problem-solving according to Sanjaya [17], are as follows:

a. Formulating the problem, namely students determine the problem to be solved, namely by knowing the existence of a gap, focusing on the problem to be studied, finding the priority of the problem, and using knowledge to examine, detail, and analyze problems
b. Formulating hypotheses, namely students formulating various problem-solving possibilities in accordance with their knowledge, namely by determining the cause of the problem and determining the alternative of the temporary answer to the problem
c. Collecting the data, namely students looking for and describing the information needed for problem-solving, namely by selecting data, mapping data, and presenting data in various views
d. Drawing the conclusions, students take or formulate conclusions in accordance with the acceptance and rejection of the proposed hypothesis, namely by reviewing the data, discussing the data and seeing the relationship with the problems studied and making conclusions
e. Formulating problem-solving recommendations, i.e. the students describe recommendations that can be carried out according to the formulation of the results of testing hypotheses and conclusions formulation that is by determining the problem-solving solutions that can be done and predicting the possibilities that will occur related to the solution taken.

Based on the description of the opinions of several experts that have been stated earlier, it can be concluded that problem-solving is a high-level thinking ability where students correlate or organize the knowledge acquired by someone to overcome problems in accordance with their fields of study and expertise. Knowledge of Natural Sciences that has been owned by students can be used as an initial
reference and trace library materials according to the problems to be solved. The aspects used are formulating the problem, formulating a hypothesis, collecting data, drawing conclusions and formulating problem-solving recommendations.

3. Research Method

This section presents the results obtained and following by discussion.

3.1. Data

The research data were obtained from the Student Activity Sheet validation sheet, student responses to the Student Activity Sheet, observation sheets and tests. The Student Activity Sheet validation sheet is used to assess the suitability of the Student Activity Sheet developed with the stated objectives and determine eligibility by using the Student Activity Sheet. Respondents involved in data collection were science experts and teachers. The students’ response to the Student Activity Sheet is basically the same as the Student Activity Sheet questionnaire used by experts and science teachers but in a simpler language so that it is easier for students to understand. Respondents involved in data collection are students. Problem-solving skills observation sheets are used to determine the improvement of problem-solving skills during learning takes place in four meetings. Tests in the form of pretest-posttest are used to determine the improvement of problem-solving skills before and after using the Student Activity Sheet.

3.2. Method

The type of research used in this study was Research and Development (R&D). The subjects of this study were 25 students of Class VIII B of SMPN 14 Yogyakarta as the respondents. The object of the research is the Student Activity Sheet of Natural Sciences Subject as a result of the development and improvement of problem-solving skills. The research design used is the research and development design of 4-D Models which consists of four stages, i.e. to define, design, develop and disseminate.

3.3. Equations and Mathematical Expressions

The feasibility analysis of Student Activity Sheet of Natural Sciences subject was done by calculating the average score, the average score was then converted to a scale of 4 which is presented in Table 1.

| No | Score Range      | Value | Category   |
|----|------------------|-------|------------|
| 1  | $X > \bar{X} + 1 \cdot SBx$ | A     | Very Good  |
| 2  | $\bar{X} + 1 \cdot SBx > X \geq \bar{X}$ | B     | Good       |
| 3  | $\bar{X} > X \geq \bar{X} - 1 \cdot SBx$ | C     | Adequate   |
| 4  | $X < \bar{X} - 1 \cdot SBx$ | D     | Poor       |

The students’ response to the Student Activity Sheet from the development results was analyzed by calculating the actual average score then converting it to a four-scale value as presented in Table 1. Then, the qualitative value of the students’ response questionnaire was changed to a quantitative value in accordance with the Table 2.

| Answer Choices | Statement Scores |
|----------------|------------------|
|                | Positive | Negative |
| Definitely agree | 4        | 1         |
| Agree           | 3        | 2         |
| Quite Agree     | 2        | 3         |
| Disagree        | 1        | 4         |

Problem-solving skills improvement was analyzed by counting the n-gain using the equation as follows:
\[ <g> = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}} \]

The value of \(<g>\) was then interpreted to be the categories shown in Table 3.

| No. | \(<g>\)          | Category |
|-----|-------------------|----------|
| 1.  | \(g \geq 0.7\)    | high     |
| 2.  | \(0.7 > g \geq 0.3\) | medium   |
| 3.  | \(g < 0.3\)       | low      |

To find out the improvement of students’ problem-solving skills after the development of Student Activity Sheet is done by recapitulating each item of statement observation problem-solving ability for each meeting, calculating the score of each indicator for each meeting, calculating the average score of each indicator for each meeting, calculating the percentage of scoring results from each student using the equation of

\[ \bar{X} = \frac{\sum S_i}{s} \times 100\% \]

4. Results and Discussion

The feasibility of the developed Student Activity Sheet of Natural Sciences subject was validated by two experts and two Natural Sciences teachers. The Student Activity Sheet component that is assessed includes content eligibility, presentation, linguistic, graphics, authentic inquiry learning coverage, and problem-solving ability coverage. Based on the overall score of the validator, the Student Activity Sheet Natural Sciences from the results of the development get an average score of 131.25 from a maximum score of 148 which is in the very good category and declared eligible for use in learning Natural Sciences (see Table 4 and Figure 1).

| No. | Aspects                          | Assessment | Average Scores | Maximum Scores | Value | Category      |
|-----|----------------------------------|------------|----------------|----------------|-------|---------------|
| 1.  | Feasibility of Content           | Lecturer 28 | 30             | 36             | A     | Very Good     |
|     |                                  | Teacher 32 |                |                |       |               |
| 2.  | Presentation                     | 13.5       | 14             | 16             | A     | Very Good     |
|     |                                  | 14.5       |                |                |       |               |
| 3.  | Linguistic Aspect                | 21.5       | 14             | 16             | A     | Very Good     |
|     |                                  | 19.5       |                |                |       |               |
| 4.  | Graphics Aspect                  | 14         | 15             | 16             | A     | Very Good     |
|     |                                  | 16         |                |                |       |               |
| 5.  | Coverage of authentic inquiry learning | 34     | 34             | 36             | A     | Very Good     |
|     |                                  | 34         |                |                |       |               |
| 6.  | Coverage of problem-solving skills | 18         | 17.5           | 20             | A     | Very Good     |
|     |                                  | 17.5       |                |                |       |               |
|     | Whole Aspects                    | 129        | 131.25         | 148            | A     | Very Good     |

The students’ questionnaire responses towards the Natural Sciences Subject Student Activity Sheet from the development results consists of 50 statements, i.e. 25 positive statement items and 25 negative statement items. Based on the overall score of the responses of students, Natural Sciences Subject Student Activity Sheet results from an average score of 126.8 from a maximum score of 168 which is included in the very good category and declared eligible for use in Natural Sciences learning (see Table 5 and Figure 2).
From Tables 6 & 7 and Figures 3 & 4, it can be referred that the average score of students’ problem-solving skills, aspects of formulating the problem get the poor category. This is because students show
less ability in focusing on the problems to be studied and finding priority problems in all four activities. Another thing might be due to giving facts about problems that are difficult for students to understand, making it difficult for students to formulate problems. Aspects formulating hypotheses get enough categories. This is because students show sufficient ability to determine the cause of the problem and determine an alternative temporary answer to the problem in the four activities. Another thing might be due to giving facts about problems that are difficult for students to understand, making it difficult for students to make hypotheses.

| Meeting | Percentage of Problem-solving Skills Achievement Value (%) |
|---------|----------------------------------------------------------|
|         | a  | b  | c  | d  | e  |
| 1       | 61 | 60 | 71 | 67 | 63 |
| 2       | 47 | 62 | 86 | 73 | 65 |
| 3       | 69 | 72 | 75 | 71 | 71 |
| 4       | 76 | 80 | 89 | 88 | 78 |

Each Aspect Average Score: 
- Formulating the Problems: 63.25
- Formulating the Hypotheses: 68.5
- Collecting Data: 80.25
- Drawing the Conclusion: 74.75
- Alternative Problem Selection: 69.25

Table 6. Problem-solving Skills Observation Results

Table 7. Problem-solving Skills Improvement Observation Results

| Meeting | Average Value | Category |
|---------|---------------|----------|
| 1       | 64.4          | D        |
| 2       | 66.6          | C        |
| 3       | 71.6          | C        |
| 4       | 82.2          | B        |

Notes:
- a. Formulating the problems
- b. Formulating the hypotheses
- c. Collecting Data
- d. Drawing the conclusion
- e. Alternative Problem Selection

Figure 3. Problem-solving skills Observation Scores in 4 Meetings
Aspects of collecting data get good categories. This is because the ability of students is good in finding and describing information needed for problem-solving. Another thing might be because at the time the experiment took place the students were not careful enough to get less accurate data. The conclusions aspect gets enough categories. This is because the ability of students is sufficient in formulating conclusions in accordance with the acceptance and rejection of the proposed hypothesis and seeing the relationship with the problem. Another thing might be because at the time of making the problem formulation and hypothesis that is not in accordance with the facts and the relationship with the pressure so that the conclusions are inaccurate.

Alternative aspects of problem-solving get enough categories. This is because the ability of students is sufficient to determine the problem-solving solution that might be possible and predict the possibilities that will occur related to the solution taken. Another thing might be because at the time of making the formulation of the problem and the hypothesis that is not in accordance with the facts and the relationship with the pressure so that obtained conclusions and alternative solutions to problems that are less precise. In addition, the factor of understanding, the level of difficulty in the presentation of problems, and the process of students during the experiment in ongoing learning also affects the magnitude of the results of the category of each aspect of problem-solving skills.

Problem-solving skills improvement in addition to being seen in every aspect is also seen at each meeting. At the first meeting, the poor category was obtained. In the second meeting, the adequate category was obtained. At the third meeting, the adequate category was obtained. In the fourth meeting, the good category was obtained. This shows an increase in problem-solving skills for each meeting. The increase from the beginning of learning to the end of learning gained an increase from 64.4 to 82.2. This is because every meeting student have gained a good understanding of answering every aspect of problem-solving skills. In addition, the level of difficulty in the presentation of problems and the process of students during the experiment in ongoing learning also affects the magnitude of the results of the categories at each meeting is shown in Table 8 and Figure 5 below:

**Table 8. Problem-solving Skills Improvement Test Results**

| No | Aspects                  | Average Scores |   |
|----|--------------------------|----------------|---|
|    |                          | Pretest | Posttest |   |
| 1  | Formulating the problems | 0.20    | 2.72     |   |
| 2  | Formulating the hypotheses | 0.40 | 2.08     |   |
| 3  | Drawing the conclusion   | 0.76    | 2.64     |   |
| 4  | Alternative Problem Selection | 0.72 | 2.88     |   |
|    | Average                  | 0.52    | 2.58     |   |
The mastery of students’ problem-solving skills can be known from before and after using the Student Activity Sheet Natural Sciences, then the pretest was conducted at the beginning of the first meeting before using the Student Activity Sheet and posttest at the end of the learning after learning for four meetings at the last meeting. Both of these data are used to find out the improvement of the students’ problem-solving skills.

Pretest-posttest data on problem-solving skills has 4 aspects, such as formulating problems, formulating hypotheses, drawing conclusions, and alternative problem-solving. In the aspect of collecting data can be obtained through the learning process takes place so that for aspects of collecting data is not included in the pretest-posttest. Increases in the gain score value are supported by an increase in value for each aspect of the pretest-posttest problem. Then analyzed into an average pretest-posttest score. The average pretest score of students gained a score of 2.08. This is because before using the Student Activity Sheet, students work on pretest questions based only on initial experience and knowledge.

Then after learning ends at the fourth meeting, students work on the posttest questions and obtain 10.32. This is because students already have an understanding of the material that is supported by the learning experience of students during the learning process for four meetings. Through this understanding, students can answer questions from the four aspects of problem-solving skills given when the posttest takes place. Based on the pretest and posttest scores then analyzed by using gain score. The results of the analysis obtained gain score of 0.74 in the high category. This is in accordance with the theory of Kaufelt in [10] suggested that authentic learning allows students to explore, discover, discuss, compile concepts and relationships in a meaningful context that involves real problems and projects that are relevant and interesting to students. Added by Lombardi in [13] suggested that authentic learning provides students with experience ranging from experiments to solving real problems through various sources of information. The statement is strengthened by Gulo in [14] suggested that inquiry is a series of activities that involve maximally the ability of students to search and investigate systematically, critically, logically, and analytically. Based on the discussion of every aspect of problem-solving skills when learning takes place, problem-solving skills at each meeting and when doing a pretest-posttest, the Student Activity Sheet developed can help students to improve problem-solving skills.
5. Conclusion

Based on the results of data analysis and discussion, it can be concluded as follows: 1) Student Activity Sheet of Natural Sciences subject with authentic inquiry learning approach developed very well and feasible to be used in Natural Sciences learning, (2) students respond very well to the developed result of Student Activity Sheet of Natural Sciences subject with authentic inquiry learning approach, (3) improvement of students’ problem-solving skills in Natural Sciences learning by using authentic inquiry learning approach obtained an increase of 17.8% and a gain score of 0.74 which is classified in the “high” category.

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