

# Science learning tools oriented on Next Generation Science Standard

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**Abstract**—The aims of this research were to identify the appropriateness of the development of the science learning tools oriented on Next Generation Science Standard and analyzed to improve asking questions – defining problems skills. Asking questions – defining problems is one of the main skills in Next Generation Science Standard. Science learning tools which are developed in this study are the lesson plan, science worksheet, and assessment asking questions – defining problems. This research method is Research and Development. The result of the research is the validation of the development of Next Generation Science Standard oriented IPA learning tools by expert judgements, and science teachers. The research method employed used a 4-D model consisting of define phase, design phase, develop phase, and disseminate phase. The result of the research from the validation of the development of Science Learning tools oriented on Next Generation Science Standard by expert lecturers, and science teachers. Data collection techniques in this study applied non-test techniques. Instrument validation analysis in this study used V'Aikens. Research results show that the developed lesson plan with Aiken's V value of 0.93, science worksheet with Aiken's V value of 0.92, and assessment asking questions – defining problems with Aiken's V value of 0.9. The results showed that the eligibility of the science learning tools oriented on Next Generation Science Standard was categorized as appropriate and effective to improve asking questions – defining problems skill.

**Keywords**—asking questions – defining problems, next generation science standard, science learning tools

## I. INTRODUCTION

Entering the 21st century, technology and information develop more rapidly. The challenges faced by the people in this globalization era require a deeper knowledge regarding the development of science and technology. Both science and technology play an important role to accelerate the development of a nation and meet various human needs [1]. Besides globalization as well as science & technology improvement, there are many changes happen in the world, including the increasing number of job opportunities which increases the workforce demands, and economic improvement which brings international competitiveness, which become 21-st century challenges. It demands a broader skill in which students need to be adequately prepared to participate in and contribute to today's society [2]. Various innovations and reforms in the field of education began to take on the challenges of globalization, both

nationally and internationally. This change is done to prepare the next generation of quality. In the international sphere, one of the efforts made by various countries in the world is by preparing the Next Generations Science Standard (NGSS) [3].

The NGSS was developed through the collaborative effort of 26 the lead states in the United States to create a science education standard that reflects the knowledge and advances by enabling students to learn science by doing science. This standard was constructed based on three main dimensions. There are science and engineering practice, used by scientists and engineers to build the world through scientific inquiry and design, Disciplinary Core Idea that contains the main ideas in four disciplines, and the crosscutting concept, a concept or theme that bridges the scientific disciplines [4].

The NGSS present standards by expressing them as performance expectations (PEs). PEs integrate the three dimensions of NGSS to help students build an integrated and integrative understanding to enrich the relationship between concepts. The more connections developed, the greater the ability of students to solve problems, make decisions, explain phenomena, and make sense of new information [5]. A series of PEs is a first step in the development of lesson planning, curriculum, and evaluation in science learning to the NGSS [6].

The framework is designed to help realize a vision for education in science and engineering by ensuring that all students are college and career ready by the end of high school and gain the vision for education in the twenty- first century [7]. The Framework for K–12 Science Education and the Programme for International Student Assessment (PISA) emphasizes the importance of engaging students in scientific practices as they learn core ideas in science [7]. However, science is not just a knowledge that reflects the understanding of the world today; but also a set of practices that are used to build, expand and improve that knowledge [4]. The importance of the engaging practice in science activity has been realized in the first dimension of NGSS—scientific and engineering practice.

The asking questions – defining problems challenges emerging in the 21st century require innovative solutions based on scientific knowledge and scientific discovery [4]. Therefore, the people will need a prospective educated scientist to undertake the research and innovations in science and technology that are essential to meet the economic,

social and environmental challenges to be faced in the future world. The integration of engineering process within NGSS is able to engage students in meaningful tasks ranging from asking questions – defining problems [8]. According to that challenges, the NGSS requires teachers to move away from simply presenting information to supporting students in building explanations of phenomena and proposing solutions to the problems [6].

The asking questions – defining problems become an essential part of science literacy. This has been followed up by the PISA question, in the aspect of explaining the phenomena scientifically [7]. However, this AQDP skill has not been fully mastered by the students. PISA results show that the quality of students in Indonesia is in level 2 with the score of 403. At this level, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific inquiries and interpret data in some given familiar life situations that require mostly a low level of cognitive demand. They are able to distinguish some simple scientific and non-scientific questions and make some valid comments on the trustworthiness of scientific claims. Students can develop partial arguments to question and comment on the merits of competing explanations, and proposed experimental designs in some personal, local and global contexts [7].

The Efforts within the national scope in addressing the challenges of globalization to achieve 21st-century skill is by formulating the 2013 curriculum. However, the framework of 2013 curriculum has not fully facilitated the realization of that vision. The low ability of students in developing scientific explanations and designing solutions is one caused by the standards competence in the 2013 curriculum which has not been specific to the development of scientific practice [9]. However, this requires the adoption of specific and measurable standards to integrate into the 2013 curriculum. NGSS presents an opportunity to improve the curriculum, teacher self-development, assessment, and student learning achievement [10]. This is supported by Nordman's research that science learning oriented to the NGSS can improve concept understanding by achieving 90% [11].

In this study, Science learning oriented to the NGSS is supported by learning tools on environmental solutions. These learning tools are arranged towards NGSS and has been declared valid by the expert judgments. This research was conducted at SMP N 5 Sleman class VII. The purpose of this study is to know the effectiveness of science learning tools oriented to the NGSS towards Asking Questions – Defining Problems skills.

The rest of this paper is organized as follow: Section II describes proposed research method. Section III presents the obtained results and following by discussion. Finally, Section IV concludes this work.

## II. RESEARCH METHOD

This is a Research and Development (R&D). The R&D is employed to develop product and test the effectiveness of the product. The product developed in this research was science learning tools on oriented NGSS (lesson plan, worksheet, and assessment). The target of the science

learning tools were students in junior high school grade 7th. Products were developed to improve the asking questions – defining problems skills outcomes.

The subject of this study was the seventh graders at SMP N 5 Sleman in the second semester of academic year 2017/2018. Product trials were conducted in March to April 2018 at SMPN 1 Sleman in two phases, namely the limited trial I and the main field trial II. The first trial was carried out in the non-class samples to analyze and to explore responses, reactions, comments of teachers and students. The first trial was conducted on nine students of class VII C. In the first trial students were given questioners about their response towards science learning tools oriented on NGSS about its readability. The second trial was done in two classes, the class that applied the science learning tools oriented on NGSS (as an experimental class) and the control class used science learning tools oriented on K-13 that applied as usual. The subjects to limited trial (trial I) were nine students of class VII were selected randomly. While in the main field trials (trial II) composed of class VII C and VII D at SMP N 5 Sleman.

The research method used is a Research and Development (R&D), the 4-D model consists of define, design, develop, disseminate. Define Stage (defining) is the stage of information development and literature study that discusses about the product to be developed. This stage includes four basic steps: initial analysis, learner analysis, and concept analysis. Design include media selection, drafting instruments and design products. The selection of presentation format of learning is adapted to the learning media used. Selection of format on lesson plan, science worksheet and assessment, the preparation of these assessment instruments is undertaken to develop a product assessment instrument and instrument used to measure skills and attitudes improvement in line with product development objectives, the initial product preparation phase (draft 1) begins with realizing the design of the NGSS-oriented learning tool into a real product. Learning tools developed in the form of lesson plan, student worksheet, and assessed assessments have met the systematics, formats, and content that has been determined according to the results of the analysis and design process. So, at this stage produced the initial product (draft 1) which is ready to be tested feasibility. Develop, this stage is to produce a revised learning tool based on input from experts. The experts in question are expert lecturers (media and materials). From the revised results will be obtained draft II products that are ready to be tested in a limited field. Disseminate, this phase done by way of distribution to teachers and students. Distribution is useful for obtaining feedback and feedback on the product. The spread is done in three different junior high schools.

The research used data collection instruments in the form of respective instruments for media and material instrument. The data used to evaluate the quality of the WE application product were analyzed by using Aiken's V ranging in acceptable value from 0 to 1 [12]. Analysis of the validation of the content of the descriptive and quantitative basis. Quantitative analysis using Aiken's V analysis by the following formula:

$$V = \frac{\sum s}{n(c - 1)} \tag{1}$$

Where:

- $s = r - lo$
- $n$  = number of assessor’s panel
- $lo$  = lowest score validity assessment
- $c$  = highest score of validity assessment
- $r$  = score given by an appraiser

The effectiveness science learning tools oriented NGSS to improve asking questions – defining problems skills should be analyzed statistic test with independent sample  $t$  test at 0.05 significance level with SPSS 20. Normality and homogeneity tests were performed on pretest reporting-interpretative skills as pre-requisite of  $t$ -test. Normality test was performed by Kolmogorov-Smirnov test on SPSS 20 with a significance level of 0.05. The acceptance criterion  $H_a$  is  $H_a$  accepted if the significance value is greater than  $\geq 0.05$ . The acceptance criterion  $H_a$  in independent sample  $t$  test is  $H_a$  accepted when the significance value is greater than  $\geq 0.05$ . The effectiveness of science learning tools oriented on NGSS to improve AQDP was revised if the significance value is less than  $\leq 0.05$ . The  $t$  test hypothesis is as follows:

$H_0$ : Science learning tools oriented on NGSS cannot significantly to improve asking questions – defining problems skills of junior high school student grade 7th

$H_a$ : Science learning tools oriented on NGSS can significantly to improve asking questions – defining problems skills of junior high school student grade 7th

### III. RESULTS AND DISCUSSION

The results of this study are the researcher conducted an interview with one science teacher in SMP Negeri 5 Sleman. The results of the interviews indicate that teachers have not used the learning tools used to measure the ability to ask questions – defining problems, as well as causal disclosure on a problem in science. Teachers only use learning tools that are listed in the supporting books and worksheets only. If we are oriented to the international education standard (NGSS) it has in common with the curriculum we use, the curriculum 2013.

However, from the results of these interviews, teachers still do not have knowledge about NGSS. in the learning process learners are required to actively ask questions and be able to identify problems. In addition, demanding learners have a scientific attitude, one of which is a curious attitude that can provoke questions learners. However, on the observations that have been made, the attitude of curious learners is also very less. This is reinforced if teachers ask questions to learners, but learners just silent.

The main field test was done in 32 students of class C as experiment class and 32 students of class D as control class. The result of average score with observation in experiment and control class showed in Table I.

TABLE I. SUMMARY OF ASKING QUESTIONS – DEFINING PROBLEMS

| Class      | Average | Category  |
|------------|---------|-----------|
| Experiment | 3.45    | Very Good |
| Control    | 2.9     | less      |

The developed of science learning tools oriented on NGSS developed is said to be suitable for use in classroom learning is determined by the assessment of the validator. Validators that will assess the developed device are two expert lecturers, two science teachers, and nine students. Expert lecturers who become validators are materials experts and media experts who can assess the feasibility of learning tools developed science. Science teachers are also asked to assess whether science-developed learning tools are appropriate for use in classroom learning. The tool is assessed using a validation assessment questionnaire that researchers have prepared. The evaluation data could be seen in Table I.

TABLE I. SUMMARY OF STUDENTS RESPONSES

| Validation                 | Average | Category  |
|----------------------------|---------|-----------|
| Appropriateness of Content | 3.55    | Very Good |
| Language                   | 3.67    | Very Good |
| Presentation               | 3.50    | Very Good |
| Graphic                    | 3.42    | Very Good |
| Average                    | 3.77    | Very Good |

The product validation is done by two expert lecturers, two science teachers from junior high school. The average scores on the results of the two validator categories for each aspect are presented in Table 1. Table 1 shows that the validation results analyzed by using Aiken’s V is the validity lesson plan main score is 0.93 with very good category. The next validity is student worksheet with main score is 0.92 with very good category, and validity assessment with main score is 0.9 with very good category. So, the science tools oriented on NGSS worthy of use in science learning seventh grade junior high school. In addition to the obtained data from expert validation, the appropriate of science learning tools oriented on NGSS can be shown from questionnaire response data of students. Questionnaire response data of students were tabulated in Table II.

TABLE II. AIKEN’S V SCORES FOR THE DEVELOPING SCIENCE TOOLS ON NGSS

| Validity    | Average  | Aiken’s V |
|-------------|--|-----------|
| Lesson Plan | Identity of lesson plan                          | 1         |
|             | Framework NGSS                                   | 1         |
|             | Formulation of indicators and learning objective | 0.91      |
|             | Material of teaching                             | 0.83      |
|             | Selection of method                              | 0.81      |
|             | Learning Resources                               | 1         |
|             | Step of learning                                 | 0.83      |
|             | Assessment                                       | 0.93      |

| Validity   | Average  | Aiken's V |
|--|--|-----------|
|  | Main Score   | 0.93      |
| Science worksheet                                  | Compliance with Core Competencies and Basic Competencies of SMP / MTs                          | 1         |
|  | Truth substance of learning materials  | 0.91      |
|  | Usefulness for participants to broaden   | 0.66      |
|  | Completeness of the NGSS Foundation box and connection box                                     | 0.83      |
|  | Compatibility of the NGSS Framework with the objectives achieved                               | 0.91      |
|  | Conformity with the good and true Indonesian Rules   | 0.75      |
|  | Utilization of language effectively and efficiently  | 0.91      |
|  | Presentation of logical and systematic learning activities                                     | 0.91      |
|  | Presentation of discussion questions   | 0.83      |
|  | Design view  | 1         |
|  | Using fonts (types and sizes), and layout  | 1         |
|  | Main Score   | 0.92      |
| Assessment of asking questions – defining problems | Asking questions about understanding environmental pollution                                   | 0.75      |
|  | Identify the type of environmental pollution   | 0.91      |
|  | Identify the factors that cause environmental pollution  | 1         |
|  | Asking questions about an impact of environmental pollution presented in the form of a problem | 1         |
|  | Ask questions about an environmental pollution impact that can be investigated by experiment   | 0.75      |
|  | Suggest ideas / ideas to reduce the occurrence of environmental pollution                      | 1         |
|  | Main Score   | 0.9       |

Based on Table I, the experimental results are 3.45 with very good category and control class score of 2.9 with less category. From these results obtained that the experimental class obtained a higher value than the control class. It means an effective experimental class to improve the skills of asking questions - defining problems. This is proved by the results of homogeneity test, normality test and significance test.

*T*-test sample to know the significance. Before the independent sample *t*-test was performed, the average observed outcome was tested for normality (see Table IV) and homogeneity using the Kolmogorov-Smirnov (see Table V) and Levene tests (see Table VI).

TABLE IV. THE RESULT OF NORMALITY TEST

| Levene Statistic | df1 | df2 | Sig. |
|------------------|-----|-----|------|
| 1.049            | 1   | 62  | 0.31 |

TABLE V. RESULT OF SIGNIFICANCE ASKING QUESTIONS – DEFINING PROBLEMS

|                        | Score |
|------------------------|-------|
| N                      | 64    |
| Kolmogorov – Smirnov Z | 1.062 |
| Asymp. Sig. (2-tailed) | 0.208 |

TABLE VI. THE RESULT OF HOMOGENEITY TEST

| Levene Statistic | df1 | df2 | Sig. |
|------------------|-----|-----|------|
| 1.049            | 1   | 62  | 0.31 |

The results of these tests show that  $H_0$  is received in both classes. The normality test results show the result of 0.208, it shows the test distribution is normal while the homogeneity test significance is 0.31 indicating that the sample of homogeneous. The acceptance of  $H_0$  on both tests means that both the control sample and the experimental class have the normal and homogeneous data distribution.

After through the prerequisite test, the independent sample *t* test was done. The result of *t* test shows the amount of significance value on the average asking questions - defining problems score of reporting-interpretative skills is 0.005 that is smaller than 0.05. The smaller significance indicates that  $H_a$  was accepted. It means that the science learning tools oriented on NGSS effective to improve asking questions - defining problems skills of grade VII students. The effectiveness of science learning tools oriented on NGSS usage is indicated by a greater increment score in the experimental class than the control class.

Science learning oriented to the NGSS that is implemented in science learning process can improve various aspects of scientific and engineering practice, one of them is the Asking Questions - Defining Problems [5]. When students are involved in developing an explanation by integrating the scientific principles into thinking, speaking, and writing activities, it creates a class of scientists who use concrete evidence to support ideas and make connections to their daily experiences.

The development of explanation skills can support the learning process as well as writing ability to build a deeper understanding of the content, concepts, and nature of the science so that it leads to the achievement of science literacy [7]. The integration of engineering in the learning process encourages students to be able to link and be equipped with the ability to solve various social problems and challenges around them that they will face in the future [13]. Students can also understand the scientific principles can use the concept of science explicitly when discussing in writing or orally and present facts to support the asking questions – defining problems [8].

#### IV. CONCLUSION

Based on the data and result analysis, it could be concluded that science learning tools oriented on NGSS: (1) appropriate to use for material teaching in environmental

pollution; (2) effective in improving asking questions - defining problems skills of students grade VII of JHS. Science teachers are expected to use this science learning tools oriented on NGSS during learning process. Students will also understand more about environmental pollution that around them.

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