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Adapting Next Generation Science Standard to Improve using Mathematics – Computational Thinking in Science Learning

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***Abstract*—To overcome various challenges in the implementation of the 2013 curriculum, one of the efforts that can be done is to adopt the education standards of other countries. National Research Council (NRC) United States publishes a science education framework contained in Next Generation Science Standard (NGSS). The adoption of NGSS in the 2013 curriculum aims to optimize the development of practice skills in the 2013 curriculum. This study determined the effectiveness of science learning using NGSS to improve using mathematics-computational thinking and crosscutting concept understanding. The science learning teaching materials developed in this study were lesson plans, worksheets and assessments to measure using mathematics computational thinking. To improve the skill of using mathematics-computational thinking using NGSS-oriented learning materials, used quasi-experiment with one experiment and one control group. The results include the validation of teaching tools NGSS oriented based on expert lecture, science teacher, and student in preliminary field testing. The average of lesson plan validation reaches 3.75 with very good category and the average of science worksheet is 3.68 with the very good category. The result of the instrument feasibility assessment by the validator on the skills of Using Mathematics-Computational Thinking and Crosscutting Concept Understanding shows declared valid. The validation result show that, this science learning media using NGSS oriented are feasible using in science class.**

Keywords—Next Generation Science Standard, Using Mathematics-Computational Thinking

I. INTRODUCTION

Education is a measure of a nation's progress, with education, the Indonesian people are expected to have qualified human resources intellectually, spiritually, and self-contained so that ultimately expected our society able to compete with other countries where globalization is now increasingly felt presence. In the National Education System Law number 20 of 2003. it is mentioned that education is a conscious and planned effort to create an atmosphere of learning and learning process so that learners actively develop their potential to have spiritual power of religion, self-control, personality, intelligence, noble, as well as the skills required of himself, society, nation and State.

One of the developments that must be considered is the development of science education in the world. Science education is one indicator of the level of progress of a State that studies about natural phenomena with a scientific method. At TIMMS in 2007 obtained the result that the interest of Japanese students on the saintek and math is very low compared to the international score. Only 39% of junior high school students interested in math, and 58% of students interested in science. While the world average, 67% interest in mathematics, and 78% interest in science [1].

Ogawa mentions that at TIMMS 2003. Japanese students' interest in science is even lower, with only 20% of Japanese students wanting to work in science. In addition, the periodic survey conducted by MEXT show that the interest of students to study math and science tend to decline with increasing age and their grade level. This fact forced the Japanese government to overhaul the curriculum of mathematics and science education at the primary and secondary levels. At the level of basic education, experimentation and observation activities were increased and equip schools with access to laboratory facilities and research data more widely through the support of JST. At the junior level, implemented science learning through the medium of science expert, and training teachers of SMP in order to carry out the learning of science more encouraging interest and enthusiasm the students [2].

The problems faced by Indonesia related to the young generation's interest in saintek and mathematics are similar to those in Japan as well as some other countries. Saintek and mathematics learning in school has not been able to raise their interest in science, and this is evident by the lack of scientific literacy and math students Indonesia in the PISA and TIMMS. The result is of course concern. These reasons can be used as input how should the Human Resources (HR) Indonesia developed through education, especially in science lessons.

Communities must be able to act more quickly and appropriately, able to solve problems effectively, and be able to adapt to the changes that occur in order to face this era of globalization. In 2013 an association of the National Research Council, National Science Teachers Association, in the United States sparked a change in science education standards framework called Next Generation Science Standards (NGSS) [3]. The association conducts research for 3 years in 26 countries in the United States on the basis of this standard is a document from the National Research Council (NRC) entitled A Framework for K-12 Education.

NGSS is the result of a development in the field of education that is influenced by the flow of globalization and the development of science and technology. This is a challenge for a teacher to prepare students who will become the next generation. Create learning to produce learners who achieve NGSS framework is a challenge for a teacher [4]. Teachers should be able to lead their students to face a global future demands they will face for a better life.

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 [5]. 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 [6]. A series of PEs is a first step in the development of lesson planning, curriculum, and evaluation in science learning to the NGSS [7].

International education standards are required to prepare qualified human resources, the Next Generation Science Standard (NGSS) formulated by the National Science Teacher Association (NSTA) and published by the United States government. The Next Generation Science Standard (NGSS) is an international standard of integration that integrates the three dimensions that characterize the NGSS of Science and Engineering Practices (SEPs), Crosscutting Concepts (CCs), and Disciplinary Core Ideas (DCIs). NGSS stressed the importance of providing opportunities all learners to build and improve their knowledge and skills through their involvement in SEPS. Then the students are expected to gain an understanding of the material in-depth learning associated DCIS which became the basis for SEPS, and ultimately NGSS can improve the ability of learners in SEPS by involving the three dimensions that exist in NGSS.

NGSS is a standard, not a curriculum. NGSS is a standard, a goal, which reflects what a student should know and is capable of doing so. There are many approaches in science learning that can be in line with the vision of the NGSS. One of them, the NGSS explained that the most effective way of conveying learning is through investigation, collecting and analyzing data, logging, and communicating information [8]. One approach to learning that facilitates this activity is the approach of scientific approach that is in the curriculum of 2013 which is a 5M process in learning that includes observing, asking, exploring, reasoning and communicating.

Education in Indonesia is currently using curriculum 2013. which has the same purpose as NGSS on science learning is to maximize learners to practice skills, so that learning on the learner-centered classroom. However, in the 2013 curriculum the skills to be cultivated are too complex, so that teachers have difficulty in learning in the classroom and difficulty in measuring students' abilities. While at NGSS, each skill has been divided into eight items so that the teacher is easier to measure the ability of the student's skills.

Implementation NGSS in learning to achieve the goals set NGSS requires a systematic process that requires considerable time. In addition the students still find it difficult to do SEPS in Using Mathematics and Computational Thinking. Difficulties of students in doing this SEPs become one of the teachers challenge to overcome them. Therefore, the NGSS-oriented learning, learners requires a development of learning that require classroom atmosphere that supports the vision NGSS in science learning. So teachers should be able to align learning approaches, learning tools, and learners' activities with the vision of NGSS [9].

Efforts to educate learners in accordance with NGSS to improve the skills of using mathematics-computational thinking and understanding crosscutting concepts then required a learning tool. Learning tool that will be developed in this research take from one of science material that exist in SMP class VIII that is Vibration and Waves. The capture of this material is tailored to the SEPs expected to appear in the lesson. In NGSS, this material is contained in DCIs MS-PS4 is Waves and Their Applications in Technology for Information Transfer. In NGSS the concept of integration is contained in crosscutting concepts. Crosscutting concept is the basis of something that bridges the antari of matter with skill. One of the crosscutting concept that suits the skills of Mathematics and Computational Thingking (SEPs) and DCIs MS-PS4 is vibration and wave that is scale, proportion and quantity. Thus, in this research we will develop NGSS-oriented learning tools to improve students' skills in Using Mathematics and Computational Thinking (SEPs).

Based on the various description above there is a problem about the learning outcomes of students who are still fully reach the KKM that is equal to 75. The process of learning science in SMP N 1 Imogiri more centered on the teacher, there are only a few material that began to involve learners. Efforts in teaching learners in accordance with the NGSS to improve the skills of using mathematics-computational thinking hence required a learning device. Learning tool that will be developed in this research take from one of science material that exist in SMP class VIII that is Vibration and Waves. The capture of this material is tailored to the SEPs expected to appear in the lesson. In NGSS, this material is contained in DCIs MS-PS4 ie Waves and Their Applications in Technology for Information Transfer. In NGSS the concept of integration is contained in crosscutting concepts. Crosscutting concept is the basis of something that bridges the antari of matter with skill. One of the crosscutting concept that suits the skills of Mathematics and Computational Thingking (SEPs) and DCIs MS-PS4 is vibration and wave that is scale, proportion and quantity. Thus, in this research we will develop NGSS-oriented learning tools to improve students' skills in Using Mathematics and Computational Thingking (SEPs) and Crosscutting Concept (CCs) understanding on scale, proportion and quantity.

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

II. RESEARCH METHOD

This research is a research development (Research and Development 4-D). The 4-D model consists of define, design, develop, disseminate. Type of research applied is quasi-experimental research. This research implemented two classes, namely experimental class and control class in which both classes were treated differently. The experimental class applied science learning oriented to the NGSS, while control class applied science learning based on the 2013 curriculum. Science learning oriented to the NGSS in experimental classes was using learning tools developed and declared valid by the expert judgments. Whereas the control class was doing the learning activity according to usual instructions applied in the school. This research was implemented in class VIII F and VIII G SMP N 1 Imogiri. Class VIII F was the experimental class, while class VIII G became the control class. The population in this research was all students of class VIII SMP N 1 Imogiri consisting of 8 classes with a total of 213 students. The sampling technique used in this research was cluster sampling, therefore, there were a total of 29 students in class VIII F as the experiment class and a total of 29 students in class VIII G as the control class.

The procedures implemented in this research were (1) giving a pretest to the control and experimental classes, 2) applying treatments by implement science learning oriented to the NGSS on experimental classes, and conventional learning on the control classes, (3) conducting a posttest to both classes to determine the improvement of CEDS skills after treatment.

The research design used was nonequivalent control group design. The format of this research can be seen in Table I [10]:

TABLE I. RESEARCH DESIGN OF NONEQUIVALENT CONTROL GROUP DESIGN

Group	Pretest	Treatment	Postest
Experimental Class	O_1	X	O_2
Control Class	O_3	Y	O_4

Where:
EC = Experimental Class
CC = Control Class
O1 = Early ability of Experimental class
O2 = Later ability of Experimental class
O3 = Early ability of Control class
O4 = Later ability of Control class

Data analysis performed include feasibility science teaching tools NGSS oriented which scored by two expert lecturers, two science teacher, and nine students in a limited field test to determine the response of learners to worksheet that developed. Questionnaire validation of lesson plan and worksheet using scale conversion 4. Assessment analysis uses scale conversion by category [11].

TABLE II. CONVERSION THE RESULT OF THE USING MATHEMATICS-COMPUTATIONAL THINKING

No	Score Range	Category	Criteria
1	$X \geq 3$	A	Very Good
2	$3 > X \geq 2.5$	B	Good
3	$2.5 > X \geq 2$	C	Fair
4	$X < 2.5 \leq 2$	D	Less

NGSS-oriented learning tools in the form of lesson plans and worksheets are feasible for use in science learning if their average validation score is > 3.0. Using mathematics-computational thinking appraisal tool is feasible for use if the validation score is in a good category at 76–85%.

III. RESULTS AND DISCUSSION

In this section we discuss how to format the title, authors and affiliations. Please follow these instructions as carefully as possible so all articles within a conference have the same style to the title page. This paragraph follows a section title so it should not be indented.

The developed of teaching tools oriented NGSS suitable for use in science learning process based on the assessment of the validator. Validators that will assess the developed teaching tools oriented NGSS are two expert lecturers, two science teacher, and nine students. Expert lecturers who become validators are materials experts and media experts who can assess the feasibility of teaching tools oriented NGSS. Science teachers were also asked to assess whether teaching tools NGSS oriented are appropriate for use in classroom learning. Learners are also asked to assess the worksheet NGSS oriented which is developed.

The result of feasibility lesson plan NGSS oriented in validation sheet consisting of 9 aspects with 14 assessment indicators. The results of the RPP feasibility assessment are then converted into four-scale categories. Recapitulation of validation result of lesson plan oriented NGSS by validator is presented in Table III.

TABLE III. RESULT OF LESSON PLAN NGSS ORIENTED ASSESSMENT

No	Aspect	Average	Category
1	Identity of lesson plan	4	Very Good
2	Framework NGSS	3.67	Very Good
3	Formulation of indicators and learning objectives	3.75	Very Good
4	Material of teaching	3.60	Very Good
5	Selection of method	3.78	Very Good
6	Learning resources	3.77	Very Good
7	Steps of learning	3.65	Very Good
8	Assessment	3.86	Very Good
9	Identity of lesson plan	3.68	Very Good
Total		**3.75**	**Very Good**

Teaching tools which developed in the form of worksheet NGSS oriented is expected to improve the using mathematics-computational thinking of learners. The result of feasibility worksheet assessment is performed using an NGSS oriented validation sheet consisting of 5 aspects with 11 assessment indicators. The LKPD feasibility assessment results are then converted into four-scale categories. Recapitulation of NGSS-oriented LKPD validation results is presented in the Table IV.

TABLE IV. RESULT OF WORKSHEET NGSS ORIENTED ASSESSMENT

No	Aspect	Average	Category
1	Eligibility of Content	3.77	Very Good
2	Framework NGSS	3.62	Very Good
3	Language	3.68	Very Good
4	Presentation	3.75	Very Good
5	Graph	3.58	Very Good
Total		**3.68**	**Very Good**

The result of the instrument feasibility assessment by the validator on the skills of Using Mathematics-Computational Thinking and Crosscutting Concept Understanding shows the total of 20 items of multiple-choice questions declared valid. The feasibility of the problem instrument is also supported by empirical test results conducted in the field.

Based on the results of research NGSS oriented learning science learning developed categorized appropriate for use in science learning according to expert lecturers and science teachers. The development of NGSS oriented learning tools to measure students' practical skill. We also described the characteristics of these learning tools. From this result, the development of NGSS oriented learning tools with a very good validation score can improve the quality of education, especially in terms of practical skill assessment. These learning tools can also train students in using mathematics-computational thinking and in the crosscutting concept.

The finding of this study reveals that the average results of the lesson plan NGSS-oriented feasibility assessment by the validator from these various aspects is 3.75 with a very good category. The assessment by the validator shows that the lesson plan developed is feasible to be implemented in the learning process after being revised according to suggestions and input from the validator.

According to Permendiknas No. 41 of 2007, the components of the lesson plan are: Subject identity, competency standard, basic competence, competency achievement indicators, learning objectives, teaching materials, time allocation, learning methods, learning activities, assessment of learning outcomes, and learning resources.

The lesson plan is a plan that describes the learning procedures and management to achieve one of the basic competencies set out in the Content Standards and elaborated in the syllabus. Aspects used in the research of lesson plan NGSS oriented are identity, formulation of indicators and learning objectives, NGSS Framework, material selection, selection of learning methods / models, learning activities, selection of learning resources, and assessment.

The average result of worksheet NGSS oriented assessment by the validator is 3.68 with very good category. The evaluation by the validator shows that the worksheet developed is feasible to be implemented in the learning process after being revised according to suggestions and input from the validator. The worksheet of NGSS-oriented is a printed material in the form of paper sheets that contain the task or guide learners in learning activities. The aspects used in this study include the content feasibility aspects, linguistic aspects, aspects of presentation, and aspects of graph. According to Depdiknas criteria of assessment or evaluation of teaching materials that can be used as guidance for evaluation LKPD, which includes the feasibility of the content, linguistic, dish, and kegrafisan [19].

The result of the instrument assessment about the validator shows the using mathematics-computational thinking skills of 20 items stated valid after the improvement according to the suggestion and input validator. Assessment is a process or a systematic and continuous activity to collect information about the process and learning outcomes of learners in order to make decisions based on certain criteria and decision [16]. Assessment or assessment is a procedure used to obtain information about the knowledge and skills possessed by learners [17]. The application of NGSS in learning is expected to use assessment techniques that integrate the dimensions of NGSS. Assessment techniques should be designed so that assessments can accurately measure learners' understanding in SEPs, CCs and DCIs [18].

NGSS-oriented assessment is a procedure used to obtain information on the knowledge, skills and attitudes of learners. In this study, the assessment was conducted to measure one of the skills in NGSS using mathematics-computational thinking and understanding crosscutting concepts that is scale, proportion, and quantity. Aspects used in the skills of using mathematics-computational thinking include the use of data, the use of digital aids, the use of mathematical representation, the use of algorithms, and the application of mathematical concepts. While aspects of scale, proportion, and quantity include the use of scale and proportional relationship.

The NGSS presents an opportunity to improve the curriculum, teacher self-development, assessment, and students learning achievement [12]. Based on this research, science learning oriented to NGSS can improve learning outcome and develop students' using mathematics-computational thinking skills significantly. This result is supported by Nordman & Pinderi's research mentioning that students can actively engage in learning material through Project Based Learning and they had a good understanding of the topics being covered. Additionally, learning science Project Based Learning based on NGSS can help the students understand the material better and the test scores reflect that as well with a rate of 90% learning achievement [13]. The Science learning oriented to NGSS emphasizes the activity of scientific inquiry and engineering design [14]. For scientists, scientific inquiry activity emphasizes on observing a phenomenon, investigating matters to gathering evidence and then building or revising a theory based on fact or model, enabling the development of scientific explanations skill. While engineering activities emphasize on the design activities to solve the problem. The integration of design activities in NGSS allows students to be involved in defining problems and designing solutions [15]. Therefore, science learning oriented to NGSS can strongly support the development of using mathematics-computational thinking skills.

The findings of this study reveal that the NGSS oriented lesson plan and student worksheet can be categorized as very good, while the testing instruments to assess student' skill in using mathematics-computational thinking and

conceptual understanding of crosscutting concepts are valid and reliable. The application of the NGSS oriented learning tools is effective to improve skill in using mathematics-computational thinking and improve conceptual understanding of crosscutting concept in SMP N 1 Imogiri. Based on the result of this study, it can be concluded that are similarities between the structure of curriculum 2013 and NGSS. Thus, the adoption of a more operational and specific science standard that is NGSS can be done to complete the 2013 curriculum. Science learning NGSS oriented can optimize the range of practical skill and interdisciplinary understanding of students that have not been developed optimally in the 2013 curriculum.

IV. CONCLUSION

Based on the research data obtained and undertaken, it could be concluded that there is a significant effect of science learning oriented to the NGSS towards using mathematics – computational thinking skill. Science learning oriented to the NGSS is effectively improving the using mathematics – computational thinking skill in term in all UMCT aspects with moderate improvement categories.

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