ATLANTIS PRESS
Advances in Social Science, Education and Humanities Research (ASSEHR), volume 330
6th International Conference on Educational Research and Innovation (ICERI 2018)

NGSS: A Standard to Improve Planning Carrying Out Investigation Skill and Crosscutting Concept

Gustin Windriyana
Postgraduate Student of Science Education
Yogyakarta State University
Yogyakarta, Indonesia
gustin.windriyana2016@student.uny.ac.id

I Wilujeng
Lecturer of Mathematic and Science Faculty
Yogyakarta State University
Yogyakarta, Indonesia
insihwilujeng@uny.ac.id

A K Prodjosantoso
Lecturer of Mathematic and Science Faculty
Yogyakarta State University
Yogyakarta, Indonesia
prodjosantoso@uny.ac.id

I G P Suryadharma
Lecturer of Mathematic and Science Faculty
Yogyakarta State University
Yogyakarta, Indonesia
samodhaya@uny.ac.id

Abstract—**Globalization has an impact to education sector; the example is next generation science standards to make science learning more meaningful and face the challenges for the future. This study was to determine the effectiveness of science learning using NGSS oriented to improve lining arraying ut investigation skill and crosscutting concept: cause effect. The science learning teaching materials developed in this study were lesson plan, worksheet, and assessment of planning carrying out investigation and crosscutting concept. This research was a quasi-experimental and used a non-equivalent control group design. The populations were all year 8 students of SMP Negeri 3, Tempel. The samples in this study were 32 students of class VIII A, and 32 students of class VIII B, as experimental and control groups, respectively. The experimental and control groups were treated by next generation science standards and conventional learning materials, respectively. The data in this study was analyzed using MANOVA test. The result of the study showed that the next generation science standards teaching materials indicated a significant effect toward the planning carrying out investigation and crosscutting concept of junior high school students with the significance level of 0.05 (95%).**

Keywords—next generation science standards, planning carrying out investigation, crosscutting concept, Manova

I. INTRODUCTION

The challenges in this globalization era which face by people is a deeper knowledge in development of science and technology. Both of them 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. It demands a broader skill in which students need to be adequately prepared to participate in and contribute to today's society [2]. Education is a tool to build the next generation into dignified and righteous people as mandated in Law No. 20 of 2003 in the national education system. Therefore, the current generation is capable of facing the challenges of globalization and can compete with the international community [3]. In order to improve the human resource quality and nation's competitiveness, along with the development of knowledge, technology and art, Indonesia has implemented a new curriculum, called Curriculum 2013 which replaced the Education Unit Level Curriculum (SBC). This curriculum change was aimed at not only cognitive but affective or psychomotor learning as well as achieving a balanced competency between attitudes and skills with holistic and fun learning [4].

The USA's science standard changed to the Next Generation Science Standard (NGSS), minimum standard or framework that learners have to achieve in science learning. Currently, K-12 science education in the United States has failed to achieve this result, in part because it is not systematically regulated in several school years, emphasizing discrete facts with a focus on the breadth of depth, and not providing students with interesting opportunities to experience how science is actually done [5]. This framework is designed to directly address and overcome it. NGSS includes eight skills, each of which has a planning carrying out investigation skill, seven crosscutting concepts, and core ideas or content, all of which are bonded together [6].

One of the practices in NGSS is Planning and Carrying out Investigation (PCOI). Scientific investigations can be done to describe a phenomenon or test a theory or model for how the world works [7]. At all levels, students should engage in teacher-trained inquiries to uncover issues or questions they may not be exploring themselves [8]. In laboratory experiments, students are expected to decide which variables should be treated as results or outputs, inputs and intentionally varied from trial to trial and which should be controlled. In the case of field observations, planning involves deciding how to collect different samples of data under different conditions, even though not all conditions are under the direct control of the investigator. PCOI may include elements of all practices [7]. In years 6-8, PCOI is built on the experience of K-5 and evolved to use that uses many variables and provides evidence to support or solutions. Students plan individually and collaboratively. In the design, they look for independent variables and controls, what tools are needed to make measurements, how many data are needed to support the claim. They conduct research and/or evaluate and/or revise experimental designs to generate data to meet basic search needs [9]. The five dimensions of PCOI as a curriculum and instruction framework are 1) Deciding what and how to measure the data; 2) Developing or selecting procedures or tools to measure and collect the data; 3) Documenting the results; 4) Devising representations for structuring data and patterns, and 5) Determining if the data are valid and reliable, need more additional data, or need a new investigation design or set of measurements are needed [10].

NGSS emphasizes the linkage between crosscutting concept and core idea. Crosscutting concept has a function to supports the development of learners' understanding from simple to more complex [11]. Crosscutting concept incorporates practice, including concepts such cause and effect, to deepen the knowledge material in the realm of the core idea [12].

The most interesting question in science is why or how something can happen (NRC). This is one of the seven crosscutting concepts in the NGSS, the cause effect. Cause-effect is a follow-up step in science that links the understanding of a causative relationship of cause and effect. Cause-effect is the heart of science that finds the underlying cause of a phenomenon. Later, theoretical development allows prediction of new patterns, which then provide evidence to support the theory [13].

Research is directed to develop an understanding of the cause and effect relationship. Solving a problem that is central to scientific research, is intended to discover its predecessor factors and determine why it occurs. Examining relationships among variables is fundamental in the research process [14]. Interpretation of cause and effect is urgently needed to reinforce the core idea behind the present-day reality [15]. Matrix of crosscutting concept: cause effect in NGSS at grade 6-8:

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.
- Cause and effect relationships may be used to predict phenomena in natural or designed systems [13].

Domain skills that developed in the 2013 curriculum have not been studied maximally and sometimes even escaped assessment. The problem is probably that the skill expected to grow in every learning that occurred has not been explicitly and specifically stated. The study results in "Program for International Student Assessment 2015" indicated the average capacity of learners in Indonesia in science was ranked 62nd out of 70 countries with a below-average value, that is, 403 of 556 [16]. TIMSS's study confirms that Indonesian students have very low competence in (1) understanding complex information, (2) understanding the theory, analysis and problem solving, (3) operating the instruments, procedures and problem solving and (4) conducting investigations [17]. This data indicates that the curriculum has not been effective yet; there is still a challenge.

Based on the observation in SMP N 3 Tempel, the data showed that learners' skills in exploring knowledge, especially planning and investigating skills and understanding the cause effect relationship, are still quite low. Practical activities, expected to build a concept with more depth, were not optimal. Learners still rely heavily on the teacher. Sometimes, even the work steps presented in the activities are not well understood. Students always ask the teacher every step that must be done. Based on the explanation above, research is conducted to investigate how the Student Subject Pedagogy (SSP) based on NGSS affects the learner's PCOI skills and crosscutting concept: cause effect which is to discover its predecessor factors and determine why it occurs. The NGSS-based SSP was made by the researcher.

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

II. Method

Type of research was quasi-experimental research. The population of this research were taken from 156 students at SMP Negeri 3 Tempel, Sleman, Daerah Istimewa Yogyakarta, Indonesia. The sample in this research were 64 students at SMP Negeri 3 Tempel, Sleman, Daerah Istimewa Yogyakarta, Indonesia, which arraged into two groups: group-1 (students in 8 A class) as an experimental class and group-2 (students in 8 B class) as control class. Each group consisted of 32 students who took Science subject in academic year 2017/2018.

The procedures implemented in this research were: (1) a pre-test for both groups, (2) the treatment of NGSS in the experimental class and regular (conventional) learning in the control class, (3) a post-test for both groups. The design of this study was the non-equivalent control group design. The format of this research can be seen in Table 1 [18]

TABLE I. RESEARCH DESIGN OF NONEQUIVALENT CONTROL GROUP DESIGN

Group	Pre-test	Treatment	Post-test
EC	O1	X	O2
CC	O3	Y	O4

Note:
EC: Experimental Class
CC: Control Class
X: NGSS learning tools
Y: Conventional learning tools
O1: Early Ability of Experimental Class
O2: Later Ability of Experimental Class
O3: Early Ability of Control Class
O4: Later Ability of Control Class

All learning and research instruments were sets of SSP (Student Subject Pedagogy) consist of lesson plans, worksheet, and assessment to measure PCOI skills' and CC achievement. The assessment was multiple choice test consisted of 10 items for PCOI and 15 items for CC. All of the sets of SSP was validated by 4 experts. The average score for lesson plan and LKPD was 3.76 and 3.62, in high category. Item of PCOI and CC test was validated by expert too, all of them were valid due to expert judge. The assessment was valid due to empirical validation which analyzed by ITEMAN. The results indicate that the developed science learning material based on NGSS was eligible for use based on the material aspects.

The PCOI test consist of 4 aspects derived into 7 indicators referring to the PCOI indicator adapted from Duscl (2013)

TABLE II. INDICATORS OF PLANNING CARRYING OUT INVESTIGATION SKILLS

Aspect	Indicators
Deciding	Identity multiple variables (dependent, independent, and control)
	Make a hypothesis
Developing	Determine the tools and material in the experiment
	Determine sequences of procedures in experiment
	Draw the table or chart
Documenting	Put the data into table
Devising	
Determining	Evaluate the method and data

The second variables, Crosscutting Concept consisted of 2 indicators derived into 15 items test. The Crosscutting Concept: Cause Effect indicators adapted from NSTA (2011).

TABLE III. INDICATORS OF UNDERSTANDING THE CROSSCUTTING CONCEPT

No	Indicator
1	Explain the relationship between phenomenon (causative or correlative
2	Predicting phenomena in nature or systems designed on a causal basis

The students' Planning Carrying Out Investigation skills improvement and Crosscutting Concept can be known through normalized gain score calculation [19]. The formula to calculate the improvement PCOIn skills and CC is:

$$g = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

According to Hake the normalized gain score can be explained in Table 4 [19].

TABLE IV. CATEGORY OF NORMALIZED GAIN SCORE

No	Normalized gain score	Category
1	g > 0.7	High
2	0.7> g > 0.3	Medium
3	g < 0.3	Low

III. RESULT

A. *Planning Carrying Out Investigation Skills*

Data achievement of PCOI skills of learners gained from the pretest and posttest scores were given to the control and experimental classes. The results of both test scores are used to find the value of the gain score. The following data are presented research results on Table.5

TABLE V. STUDENTS' ACHIEVEMENT ON PLANNING CARRYING OUT INVESTIGATION SKILL

Criteria	Control Class		Experimental Class	
	Pretest	Post-test	Pretest	Post-test
Min	30	40	30	50
Max	70	90	70	100
Average	47.81	63.12	46.25	77.18
SD	10.82	11.575	11.38	10.96
Gain Score	0.29		0.59	

Based on Table 5 it can be seen that the average score of pretest in control class was 47.81 whereas in the experimental class was 46.25. This problem was reasonable because learners have not learned 'Fluid Pressure' before. The students' posttest score in the control class was in the range of 40 to 90 and the average was 63.1. The posttest score in the experimental class was in the range of 50 to 100 and the average was 77.1. The data shows that the gain score in the control class was 0.29 in low category, while the experimental class was 0.59 in medium category. It can be concluded that NGSS-oriented learning tools can improved the skills of PCOI learner.

The gain score analysis was also performed on each aspect of the PCOI skills in the experimental and control classes. The gain score recapitulation in each aspect were presented in Table 6.

TABLE VI. RECAPITULATION OF PCOI GAIN SCORE IN EACH ASPECTS

No	Aspect of PCOI	Gain Score	
		Control class	Experimental class
1	Deciding	0.22	0.52
2	Developing	0.12	0.47
3	Documenting-Devising	0.36	0.39
4	Determining	0.16	0.47
Gain Score Average		0.29	0.59
Category		Low	Medium

Table 6 shows that PCOI skills in control and experimental classes was increased in all of aspects. The gain score on most of aspects in the control class were in low category. Documenting-devising just the only aspect belongs to the medium category. Meanwhile in the experimental class, the gain score of each aspect were in the medium category. Improvement scores of experimental scores in all of the PCOI aspects were higher than the control class.

TABLE VII. THE STUDENTS' ACHIEVEMENT CRITERIA OF PLANNING CARRYING OUT INVESTIGATION

Interval	Score	Criteria
75,00 < X	A	Very Good
58,33 < X ≤ 75,00	B	Good
41,67 < X ≤ 58,33	C	Average
25,00 < X ≤ 41,67	D	Poor
X ≤ 25,00	E	Very Poor

B. *Crosscutting Concept Achievement*

Data achievement of Crosscutting Concept gained from the pretest and posttest scores were given to the control and experimental classes. The results of both test scores were used to find the value of the gain score. The following data are presented on Table. 8

TABLE VIII. STUDENTS' ACHIEVEMENT ON UNDERSTANDING THE CROSSCUTTING CONCEPT

No	Criteria	Control Class		Experimental Class	
		Pre-test	Post-test	Pre-test	Post-test
1	Min	30	50	30	90
2	Max	70	130	70	150
3	Average	47.5	8.2	48	120
4	SD	10.6	19.6	10.9	14.4
5	Gain Score	0.38		0.70	

Based on Table 8 it can be seen that the average score of pretest in control class was 47,5 whereas in the experimental class was 48. The students' posttest score in the control class was in the range of 50 to 130 and the average was 86.1. The posttest score in the experimental class was in the range of 90 to 150 and the average was 120. The data shows that the gain score in the control class was 0.38 in medium category, while the experimental class was 0.70 in high category. It can be concluded that NGSS-oriented learning tools can improved understanding the crosscutting concepts of learners.

The gain score analysis was also performed on each aspect of the understanding the crosscutting concept in the experimental and control classes. The gain score recapitulation in each aspect were presented in Table 9.

TABLE IX. GAIN SCORE RECAPITULATION OF CROSSCUTTING CONCEPT IN EACH ASPECTS

No	Aspect of CC	Gain Score	
		Control class	Experimental class
1	Explain the relationship between phenomenon (causative or correlative)	0.33	0.72
2	Predicting phenomena in nature or systems designed on a causal basis	0.53	0.60
Average of Gain Score		0.38	0.70
Category		Medium	High

Table 9 shows that understanding the crosscutting concept of the learners in control class and experimental class were increase in each aspect. However, in the control class, the average of gain score's learner in every aspect were lower than the experimental class. Enhancement of understanding the crosscutting concept in the experimental class is higher than in the control class.

Multivariate test is used to know the difference of planning carrying out investigation skill and understanding of crosscutting concept in experimental class and control class. Previously, it had to meet assumption tests that the data was normal and homogeny.

C. Analysis Requirement Test

Multivariate normality tests were used to determine the sample of data was from the multivariate-distributed normal population. The distance of 'mahalanobis' tends to form a straight line and more than 50% of 'mahalanobis' distance value is less or equal to qi value. It means that the data was normally distributed population.

Multivariate homogeneity tests were used to find that the covariant variants in the population came from a homogeneous population or not. The test was performed using Box'm test by SPSS 21. The significance value of the Box'm test results was 0.692 which is higher than the alpha value of 0.05. From these results, it can be concluded that the variance of control class covariance and experiment class on PCOI and CC before being treated was homogeneous.

D. Hypothesis Test

The test that used in this study was MANOVA test. The hypothesis was:

Ho : There was no significant effect of using NGSS-based learning on PCOI skills and understanding the CC in SMP Negeri 3 Tempel.

Ha : There was significant effect of using NGSS-based learning on PCOI skills and understanding the CC in SMP Negeri 3 Tempel.

The results of the MANOVA test can be seen through Wilks' Lambda. Ho was rejected if the significance value was smaller than the alpha that used (0,05) or sig <α. The results of the MANOVA test can be seen in Table 10.

TABLE X. THE RESULT OF MULTIVARIATE TEST

Effect		Value	F	Sig.
Intercept	Wilks' Lambda	0.056	509.5	0.000
Perangkat	Wilks' Lambda	0.384	49.0	0.000

Based on Multivariate test results by Wilks' Lambda, obtained that significance value was 0.000, the value <0.05 so Ho was rejected. It can be concluded that there was a significant effect of NGSS oriented learning tools on planning carrying out investigation skills and understanding crosscutting concept to the learners.

IV. DISCUSSION

One of the methods that can improve skills is practicum. Even though practicum, we can change something that allows us to develop knowledge, essentially enriching the learning process [20]. Experimental work and inquiry-learning play key roles in science curricula throughout the world, for example, "Science and Engineering Practices". One of three dimensions of the US NGSS [5]. According to research conducted by Santoso, learning physics using NGSS-oriented PjBL learning kits was effective for facilitating students to achieve skills like PCOI and CEDS [9]. The results of this study are also relevant to research on practice in NGSS by Pamungkas, which said that using NGSS-oriented learning tools was effective to improve students' skills in analysing-interpreting data and constructing explanations-designing solution [21].

Students in the experimental class designed sets of plans about how they wanted to solve the problem before doing the experiment. Planning an investigation is based on inquiry action. The students got opportunities to design and plan investigations, allowing them to truly experience and better understand the nature of scientific inquiry. First, the teacher gave the students problems to solve. Then, they answered specific questions or tested specific hypothesis. When generating a hypothesis, they formulated the hypothesis generation between variables. They were made to create and test a hypothesis (or problem) and, through the process, were encouraged to become actively involved in the discovery of information by highlighting both the usefulness and application of the information itself. Throughout this process, students discovered facts and developed a higher-order understanding of topics and ideas [22]. Stating the hypothesis is a difficult task for many students [23]. Therefore, to bridge the students' difficulties, the teacher helped by giving them 'if-then' words on a worksheet. This was related to de Jong's opinion that students did not recognise that a hypothesis consists of variables and a relation between them and—in many scientific fields—should take the form of an "if-then" statement [24]. After that, they identified all the variables such as control, dependent and independent. The students measured many different variables, including measurements that serve as manipulation checks, measurements of intervening variables and multiple outcome measures.

The students decided the tools, material, procedures and tables of data by themselves. Finally, they evaluated the method and data they had collected. Evaluation is a reflective process that helped students to judge their own research. When students applied their research results to a new problem, they learned to evaluate whether the results fit the theory or had to be reconsidered [23]. According to the case study conducted by Garvey, investigation and / or evaluation and / or revision of experimental design to produce data used as evidence for the purpose of investigation. The requirements calling for investigations were often supported by pre-written procedures [25]. After they made their plan, the students put it into action. In carrying out the investigation, they had ownership over the process from beginning to end and actually operated as scientists and engineers. The teacher just guided and facilitated what they want to do.

V. Conclusion

Based on the results, it can be concluded that NGSS-based learning was effective in improving learners' PCOI skills with a significance level of 0.05 (95%). By conducting a set of experimental work, it was allowed to significantly to expand the knowledge limit significantly, basically enrich learning process. Student becomes accustomed to deciding what and how to measure, observe and take samples; developing procedures / tools for collecting data; documenting and designing data and determining whether the data is good (valid and reliable) and can be used as evidence. The implication of this study is the learning that science-based NGSS can be used as an alternative overcome students' low PCOI skill and crosscutting concept. To strengthen the results of this research, it is necessary to do further research in various education levels and countries

Acknowledgement

The authors express their sincere thanks to The Ministries Of Research, Technology, And Higher Education Republic Of Indonesia for the financial support to this research.

Reference

[1] Sirindhorn, M.C, "Challenges and Opportunities for Science and Technology", United Nations Educational, Scientific and Cultural Organization, Yakohama, 2007, p. 29-39

[2] ILO (International Labour Office), "in A Skilled Workforce for Strong, Sustainable and Balanced Growth A G20 Training Strategy", International Labour Organization, 2010, p. 7-25.

[3] Susanti., "Science Teaching Integrated with Local Potential of Essential Oil Clove Leaves toward Science Generic Skills", ICRIEMS 2017.

[4] Depdiknas, "Peraturan Menteri Pendidikan Nasional Nomor 22 Tahun 2016 Tentang Standar Isi Untuk Satuan Pendidikan Dasar dan Menengah" Jakarta: Depdiknas, 2016

[5] National Research Council (NRC), "Next Generation Science Standards: For States, By States", Washington DC: The National Academies Press, 2013, https://doi.org/10.17226/18290.

[6] Bybee, Rodger W, "The Next Generation Science Standars and Life Sciences", Journal of Sci Teacher Educ, 2014, 25:211–221, https://doi.org/10.1007/s10972-014-9381-4.

[7] NGSS Lead States, "Appendix F: Science and Engineering Practices in the NGSS. Washington DC: National Academies Press.

[8] National Research Council (NRC), "A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas", Washington DC: National Academic Press, 2014.

[9] Santoso, P.H, (Thesis, Yogyakarta State University), "Pengembangan Perangkat Pembelajaran Project-Based Learning untuk Mencapai Kemampuan Peserta Didik SMA dalam Planning Carrying Out Investigation dan Constructing Explanation & Designing Solution pada Materi Hukum Newton Tentang Gerak" Magister. pp.1, 2017, http://eprints.uny.ac.id/id

[10] Duschl, R Bybee, "Planning and carrying out investigations: an entry to learning and to teacher professional development around NGSS science and engineering practices". International Journal of STEM Education, (2014) 1:12 DOI 10.1186/s40594-014-0012-6

[11] Moyer, H.R & Jay K. H, "Innovations and Implications of the NGSS", USA: MC Grawwhills Education, 2017

[12] Penuel, R.W., Christopher.H.J, & Angela De Barger. (2015). Implementing the Next Generation Science Standards. DOI: 10.1177/0031721715575299. Diakses dari: http //journals.sagepub.com/doi/pdf/ 10.1177/0031721715575299

[13] NGSS Lead States, "Appendix G – Crosscutting Concepts". Washington DC: National Academies Pres, 2013

[14] Rogers, B, "Cause and Effect in Research", AOHN Journal VOL. 44, NO.4 http://journals.sagepub.com/doi/pdf/10.1177/216507999604400410, 1996

[15] Virtanen, P & Uusikila, P, "Exploring the Missing Links between Cause and Effect A Conceptual Framework for Understanding Micro–Macro Conversions in Programme Evaluation", Vol 10(1): 77–91. London: Sage Publisher. DOI: 10.1177/1356389004043136. 2004

[16] OECD, PISA 2015. Result in Focus

[17] TIMSS, "TIMSS and PIRLS 2011 Achievement Results in Reading", http://timssandpirls.bc.edu/data-release2011/pdf/Overview-TIMSS-and-PIRLS-2011 Achievement.pdf

[18] Sugiyono, "Metode Penelitian Pendidikan (Pendekatan Kuantitatif,Kualitatif dan R&D" Alfabeta: Bandung, p.116, 2015.

[19] R. Hake, "American Journal of Physics", 66(1), 64–74, 1998.

[20] Zhaidary, A, "Stimulating the Cognitive Activity of Students while Conducting Experimental Work", Mediterranean Journal of Social Sciences MCSER Publishing, Rome-Italy Vol 6 No 3 S1 May, 2015.

[21] Pamungkas, (Thesis, Yogyakarta State University) "Pengembangan Perangkat Pembelajaran Project-Based Learning untuk Mencapai Kemampuan Peserta Didik SMA dalam Planning Carrying Out Investigation dan Constructing Explanation & Designing Solution pada Materi Hukum Newton Tentang Gerak", Magister. pp.1, 2017, http://eprints.uny.ac.id/id

[22] Coffman, T, "Engaging Students Through Inquiry Oriented Learning and Technology" Rowman &Littlefield Education, 2015.

[23] B.Thorsten, "Collaborative Inquiry Learning: Models, tools, and challenges", International Journal of Science Education, Publisher: Routledge, 2013.

[24] de Jong, T., & van Joolingen, W. R. , "Scientific discovery learning with computer simulations of conceptual domains" Review of Educational Research, 68(2), 179–201, 1998.

[25] Michael P. Garvey, "Environmental Science and Engineering Merit Badges: An Exploratory Case Study of a Non-formal Science Education Program and the U.S. Scientific and Engineering Practices", International Journal of Science Education (IJESE)pp. 11675-11698 Published Online: November 28, 2016.