Journal of Primary Education
10 (2) (2021) : 233 – 2241

https://journal.unnes.ac.id/sju/index.php/jpe/article/view/34456

The Development of Performance Assessment Instrument Integrated 4C for Measuring Science Process Skills in the Science Experiments of Elementary School Students

Betti Cahya Wulandari[1]✉, Ani Rusilowati[2] & Sigit Saptono[2]

[1] Public Elementary School Karangmlati 1 Demak, Jawa Tengah, Indonesia
[2] Universitas Negeri Semarang, Indonesia

Article Info

History Articles
Received:
September 2019
Accepted:
October 2019
Published:
August 2021

Keywords:
assessment,
sains process skill,
4C

DOI
https://doi.org/10.15294/jpe.v10i2.34456

Abstract

The purpose of this research was to develop the assessment instrument of performance integrated 4C to measure the science process skills in the experimental activities at elementary schools. This research applied the Research and Development method. The development design was adjusted with the ADDIE model. The subjects of the research were grade V teachers and students in the second semester of 2018/2019 academic year at SDN Karangmlati 1 Demak. Based on the results of this research, it was obtained that the assessment instrument of performance integrated 4C has a validity of 93.12%, meanwhile, the validity of the process skills test instrument reached to 91.87%. The reliability of the assessment instrument of performance reached to 0.95, whereas, the reliability of the science process skills test instrument reached to 0.88. The practicality of the instrument reached to 86.4%. The highest percentage of science process skills of the students grade V in the aspect of planning the experiment skills reached a percentage of 93% (very high). This research is expected to help teachers carry out assessments of performance objectively and fairly that have a positive impact on the quality of learning at schools.

✉ Correspondence address:
Demak - Bonang No.2, Karang Pandan, Karangmlati,
Demak, Jawa Tengah, 59517
E-mail: betti.cahya.wulandari@gmail.com

p-ISSN 2252-6404
e-ISSN 2502-4515

INTRODUCTION

One of the aspect developed in the 2013 Curriculum is the skill competencies contained in the Core Competencies and four Basic Competencies. The skills competencies assessed in the 2013 Curriculum include; (1) performance appraisal (process/ product), (2) project appraisal, and (3) portfolio. Progress in science and technology is happening very fast in the 21st century. The Rapid progress give a significant impact in education, teaching curriculum, teachers, and learning which should be in accordance with the students need in a future (Osman *et al.,* 2019). The educational system is responsible for preparing students to face the 21st century global challenges through the development of new skills needed today (Soh *et al.,* 2010; Wiwin & Kustijono, 2018).

The skill needed in the 21st century is known as 4C. This skill include critical thinking and problem solving, communication, collaboration, creativity and innovation. Which are important to be integrated into the education system. Since these skills are learning abilities that can bring students to be successful in working and career in the era of the global economic community and become citizens who are ready to face the challenges of the 21st century (Partnership for the 21st Century Skills, 2008; Soh *et al.,* 2010; Sunardi, 2017). One of the learning activities that can be integrated with 4C skills is a science experiment. Experimental or experimental methods also aim to improve the thinking ability of students in finding and understanding a concept or theory of science being studied. The science process skills can be seen through the experiment activities. Science process skill is a skill that can be internalized through experimentation and used to solve problems encountered by the students (Bati *et al.,* 2010; Rauf *et al.,* 2013).

The problem that occurs is the process of assessment of science learning while this is only focused on the cognitive realm with objective and subjective written tests as a measurement tool. Assessment tools used to assess students 'scientific process skills only measure cognitive aspects, namely using quizzes, final exam topics, general tests, and home assignments without assessing the performance of students. This causes an evaluation of the aspects of skills and attitudes mandated by the 2013 Curriculum in assessing the learning process in the classroom has not been carried out optimally. Student performance needs to be assessed when activities are ongoing (Akhiruddin *et al.,* 2016; Yudha *et al.,* 2014). Similar problems also occur in public elementary schools in Demak sub-district. The results of observations conducted at SDN Karangmlati 1, SDN Bintoro 1, SDN Bintoro 4, and SDN Bintoro 5 show that the performance appraisals conducted by grade IV and V teachers when carrying out experimental activities used written tests, and were not accompanied by performance assessment instruments. The 2013 curriculum requires a comprehensive assessment, in the sense that the assessment is not only aimed at mastering one particular aspect, but also includes various aspects. Based on research conducted by Susilaningsih *et al.* (2018) about the skills assessment carried out on the experimental learning method, the results obtained are the discovery of a good performance assessment instrument for the observation sheet, and all supporting instruments are in good category.

Measurement of learning activities in appropriate experimental activities is a performance-based assessment known as performance assessment/ performance appraisal (Suryawan *et al.,* 2015). Performance assessments are useful for educators to find out student learning outcomes so that they can be used as material for evaluating further learning programs (Blackburn & Kelsey, 2013; Hariyati *et al.,* 2018; Serevina & Muliyati, 2018). Therefore, in this research, the assessment instrument of performance integrated 4C was developed to measure the science process skills in the science experiment activities. This research was conducted at the level of primary education, particularly at elementary schools.

METHODS

The type of research method used in this study is the Research and Development method. The development design is aligned with the ADDIE (Analyze-Design-Develop-Implement-Evaluate) model. In the analyze phase, we analyzed the need for the development of new performance assessment instruments by observing, interviewing, preliminary studies at SDN Karangmlati 1, SDN Bintoro 1, SDN Bintoro 4 and SDN Bintoro 5 Demak and distributing questionnaires to 21 teachers in one of the Teachers team work in Demak. In the design phase, we design the blueprint of performance assessment instruments, formulate materials, determine methods, choose tools and learning resources, and arrange schedules. In the development stage, we produce the initial product that is developed (performance assessment instruments), carry out expert validation, plan trials. In the implementation stage, researchers prepare teachers, observers, and students, as well as various supporting facilities and infrastructure for the implementation of field trials. In the evaluate stage, clarifying data obtained related to the validity, reliability, and practicality of the product, assessment instruments from the opinions of teachers and observers.

This research was conducted at SDN Karangmlati 1 Demak in the 2018/2019 academic year. The data collection techniques include (1) interviews to find out the preliminary data before conducting the research; (2) observations was made before the research to obtain an overview of the activities of the teaching and learning activities, as well as observations during the research to obtain data on the science process skills; (3) questionnaire was used to analyze the needs before research was carried out and used to determine the responses of teacher related to the practicality of using instruments; and (4) test instruments were used to measure the science process skills.

The subjects this research were Grade V teacher at Karangmlati 1 Demak Elementary School, The data obtained include qualitative data on the character of the assessment instruments of performance, quantitative and qualitative data on the validity and reliability of the assessment instruments of performance, the practicality of the assessment instruments performance, and the profile of the measured of science process skill.

RESULTS AND DISCUSSION

The steps of development in this research include the stages of analysis, design, development, implementation, and evaluation. The results and discussion in each step is described as follows.

The *Analyze* Step

In the analysis step, we identifies gaps between current learning conditions, such as practical performance skills and desired outcomes. This was done by conducting observations, interviews, and preliminary studies in SDN Karangmlati 1, SDN Bintoro 1, SDN Bintoro 4 and SDN Bintoro 5 Demak. To reinforce the facts, we also conduct a literature review on performance assessment theory and review the previous similar researchs.

The Design Step

At the design step, we plans learning objectives that were broken down from four core competencies of the curriculum, the form of instruments, instructions for the use of design on the performance assessment process in the classroom. In this process, the main design or plan was obtained from the performance assessment instrument book, or it can be called as blueprint. The first design step was designing the performance assessment instrument blueprint. The integration of 4C skill in the aspects of science process skills assessment in detail is list in Table 1.

Table 1. The Integration of 4C Skill in the Aspect of Science Process Skill

Science Process Skill (SPS)		The integrated 4C Skill	
Types of SPS	Aspects	Type of 4C	Activities of Students
Skill in Conducting Experiment	Group Cooperation	*Collaboration*	Students were collaborate each other in the group to reach the same objectives
Communication Skill	Answering questions based on the experiment	*Critical Thinking and Problem Solving*	The students analyzing, synthesizing, evaluating information in order that they can solve problems
	Presenting report	*Communication*	The students using both spoken and written language to understand and present information, concepts, and idea.
Skill in Applying Concept	Explaining the existence of phenomena/ problem presented in the question	*Creativity and Innovation*	The students create new ideas to make the idea real

The form of assessment instruments of performance that have been developed was the assessment instrument of performance integrated 4C that can be used in the experimental activities. The instruments on the observation sheet contained five types of science process skills including (1) planning experiments, (2) carrying out experiments, (3) observing, (4) communicating, and (5) applying concepts. The details on the aspects of the five types of science process skills (SPS) are presented in the following Table 2. The aspects of SPS (Science Process Skill) obtained through test instruments are presented Table 3.

Table 2. The Detail of the Aspect in each of the SPS (Science Process Skill) in the Observation Instrument

Types of SPS	Aspects
Skill in planning the experiment	Preparing the tools of the experiment
	Preparing the material of the experiment
Skill in conducting experiment	Applying the tools
	Conducting experiment based on steps
	Determining the data that should be obtained
	Cooperation in group
Skill in Observing	Observing the object of the experiment
Skill in Communicating	Answering questions based on the questions of the experiment
	Formulating the conclusion of the report
	Arranging report
	Presenting the result of the report
Skill in Applying concept	Explaining the existence of phenomena/ problems presented in the question
	Giving other related phenomena

Table 3. The Detail of Aspect in each SPS in the Test Instrument

Types of SPS	Aspects
Skill in planning the experiment	Determining tools and material of experiment
Skill in conducting experiment	Determining the data that should be obtained
Skill in communicating	Answering question based on the experiment *(Critical Thinking and Problem Solving)*
	Formulating the conclusion of the report *(Communication)*
Skill in applying concept	Explaining the existence of phenomena/ problems presented in the question
	Giving other related phenomena *(Creativity and Innovation)*

Second, formulating material. The scope of the material in this study covers Theme 9 "Things Around Us", Subtheme 1 "Single and Mixed Objects", and Subtema 2 "Objects in Economic Activity". In learning Subtema 1, science learning is focused on discussing the understanding, characteristics of single substances and examples of mixed substances. In Subthema 2, science learning focuses on the material of a mixture of substances divided into homogeneous and heterogeneous mixtures. In this research, the aspects measured were psychomotor aspects, basic competencies and indicators on psychomotor aspects as Table 4.

Table 4. The Basic Competence and Indicator of Psychomotor Aspect

Basic competence	Indicator
4.9 Reporting the results of observation on the nature of mixture and the components of its compiler in the daily life	4.9.1 Observing on the differences of single and mix substance 4.9.2 Making report on the result of the differences of single and mix substance 4.9.3 Conducting experiment to differentiate the homogenous and the heterogeneous mixture 4.9.4 Making report of the result of experiment in differentiating the homogeneous and heterogeneous mixture 4.9.5 Conducting experiment to identify the nature of homogeneous and heterogeneous mixture 4.9.6 Making report on the result of experiment in identifying the nature of homogeneous and heterogeneous mixture

Third, determine the method, the experimental method carried out in this research was a verification experiment. Verification laboratory activities are defined as a series of observations or measurements, data processing, and conclusion drawing aimed at proving concepts that have been learned (Trowbridge & Bybee, 1990).

Fourth, choosing tools and learning resources, the tools and learning resources provided to student worksheet at each meeting can be seen in the Figure 1.

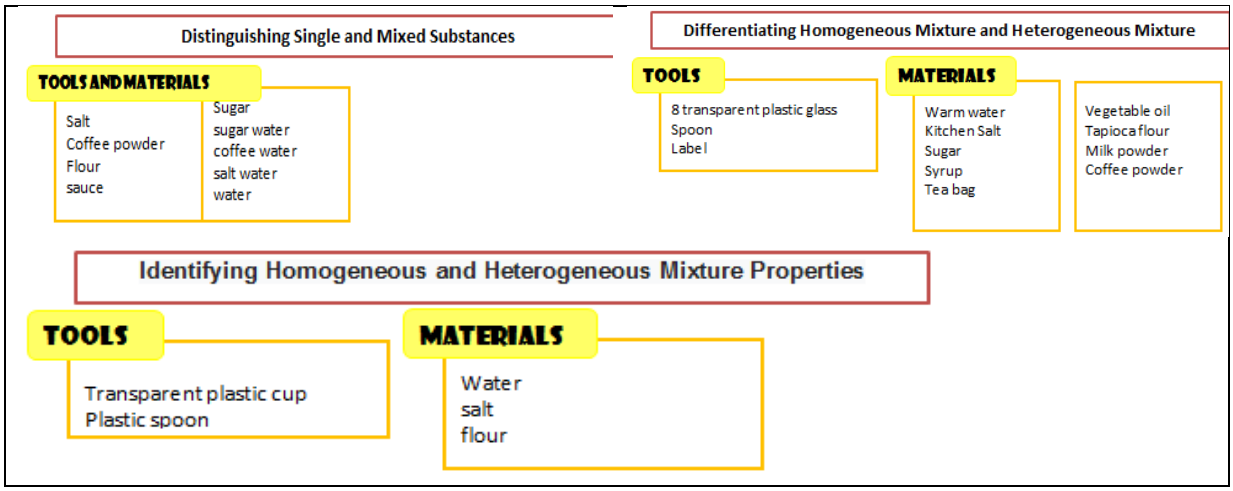

Figure 1. Tools and Learning Resources in Each Meeting

The material at the first, second and third meeting each includes distinguishing single and mixed substances, distinguishing homogeneous and heterogeneous mixtures, and identifying the nature of homogeneous and heterogeneous mixtures. The fifth design phase, arranging schedules. This research was carried out on Theme 9, sub-themes 1 and 2 namely the first week and second week of May 2019.

The *Develop* Step

General procedures related to the first development phase are to produce initial products and teacher guidelines. The prototype of the performance assessment instrument developed is displayed in Figure 2.

Second, carry out expert validation and revision. Content validity testing is performed before the assessment instrument of performance integrated 4C was applied to the trial. The results of the assessment of performance assessment instruments on the observation sheet by the validator reached an average of 93.125%. This performance assessment instrument has very valid criteria to be used in measuring the science process skills and student learning outcomes. The following is a list of suggestions from experts and the follow-up is presented in Table 4.

SHEET OF OBSERVATION ASSESSMENT OF SCIENCE PROCESS SKILLS ON TRIAL ACTIVITIES

Class : School : Sub theme :
SMT : Theme : Subject :

Step	No.	Aspect \ Score	Group Number																								Sum	Precentage (%)
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Pra Experiment	A.	Experiment Planning Skills																										
	1	Provides trial tools																										
	2	Provide trial material																										
	B.	Skills for Carrying Out Trials																										
Do Experiment	3	The ability to use tools																										
	4	Experiment according to steps																										
	5	Determine the data that must be obtained																										
	6	Collaboration between groups																										
	C.	Observing Skills																										
	7	Observe the object of the experiment																										
	D.	Communication Skills																										
The End of Experiment	8	Answering questions based on experimental results																										
	9	Formulate report conclusions																										
	10	Prepare a report																										
	11	Delivering report results																										
	E.	Skills in Applying Concepts																										
	12	Explain the reasons for the occurrence of a phenomenon / problem presented																										
	13	Give examples of other similar phenomena																										
		Sum																										
		Score																										

Figure 2. *Prototype* Performance Assessment Instrument

Table 4. List of Suggestions from Experts on Performance Assessment Instruments and Follow Up

Aspect	Comment and Suggestion	Follow Up
6	Improve the description material for individual assessment	Add individual assessments using test instruments
9, 10, 11	Statements in the rubric are sharpened by using the word "without supervision"	Add the word "without supervision" to the rubric

The results of the assessment of the science process skills test instrument by the validator reached an average of 91.88%. This science process skills test instrument has very valid criteria for use in measuring science process skills and student learning outcomes. The following is a list of suggestions from experts and the follow-up is presented in Table 5.

Table 5. List of Suggestions from Experts on SPS Test Instruments and Follow Up

Number of items	Comments and Suggestions	Follow Up
6	The mixture of water and topsoil should be changed to a beverage mixture (syrup/ honey)	Changing the mixture of water and topsoil into a mixture of drinks (syrup/ honey)
8	The word "water" is better replaced with "warm/ hot water"	Replace the word "water" to "warm water"
10	Questions and answer choices should be on the same page	Make the questions and answer choices on the same page

The analysis of the results of testing the validity of the test instrument was carried out after the implementation of the trial. The results of the validity test of the science process skills test instrument using the biserial point correlation formula showed that of the 20 questions, there were 15 questions that were declared valid.

Third, planning a field trial. The trial of the science process skills test instrument was carried out at SDN Bintoro 1 Demak, whereas, the trial of the performance assessment instrument was carried out at the first meeting at SDN Karangmlati 1 Demak. The results of the trial of the science process skills test instrument reached 0.88. Thus the test instrument is reliable or can be

trusted with very high reliability criteria. Meanwhile, the reliability test results on the assessment instrument of performance integrated 4C trial reached 0.95. Thus, the instrument is reliable or can be trusted with very high reliability criteria.

The *Implement* Step

This implementation step includes preparing teachers and students, as well as various supporting facilities and infrastructure for conducting field trials. The implementation of performance assessment instruments was carried out on Subtema 1 "Single and Mixed Objects", Learning 5, and Subtema 2 "Objects in Economic Activities", Learning 1.

The *Evaluate* Step

The evaluation step was carried out at each stage. The product was repaired according to expert input for testing. The final evaluation is carried out based on the results of the practicality test and input from the user. This improvement will produce a final product in the form of performance assessment instruments that have been tested for validity, reliability and practicality. The practicality test results are presented in the following table. Teacher responses to the practicality of implementing the 4C integrated performance assessment instrument can be seen in Table 5.

Table 5. Teacher's Respons to Practicality of Implementing The 4C Integrated Performance Assessment Instrument

Code of Rater	Score	Total Score	Percentage of Score (%)	Category
R-1	38	152	86.4	Very Practical
R-2	37			
R-3	37			
R-4	40			

The mastery of science process skills was measured by looking at the results of observations and the results of science process skills-based test results developed in each category of science process skills. The following is a profile of science process skills based on observations using the assessment instrument of performance integrated 4C presented in Table 6.

Table 6. Profile of Science Process Skills through Performance Assessment Instruments

No.	Indicator	Meeting 2		Meeting 3	
		%	Category	%	Category
1	Preparing the tools of experiment	87	Very high	100	Very high
2	Preparing the material of experiment	75	High	75	High
	Skill in planning the experiment	87	Very high	93	Very high
3	Skill in applying tools	75	High	77	High
4	Conducting experiment based on steps	75	High	77	High
5	Determining data that should be obtained	67	High	68	High
6	Group cooperation *(Collaboration)*	76	High	76	High
	Skill in conducting experiment	71	High	72	High
7	Observing the object of experiment	76	High	76	High
	Skill in conducting observation	76	High	76	High
8	Answering question based on the result of experiment *(Critical Thinking and Problem Solving)*	76	High	76	High
9	Formulating conclusion on the result of experiment	81	High	83	Very high
10	Arranging report	80	High	81	High
11	Presenting the result of report *(Communication)*	80	High	81	High
	Skill in communicating	79	High	80	High
12	Explaining the existence of phenomena/ problem presented in the question	73	High	73	High
13	Giving related examples of phenomena *(Creativity and Innovation)*	72	High	72	High
	Skill in applying concept	72	High	73	High

Table 6 shows that the highest science process skills of students in grade V SDN Karangmlati 1 Demak in meeting 2 and meeting 3 were found in the skills of planning experiments with 87% and 93% respectively. The results of the evaluation questions for the fifth grade students of SDN Karangmlati 1 Demak through the science process skills test instrument are presented in Table 7.

Table 7. Profile of Science Process Skills through Evaluation Questions

Indicator	Number	%
Skill in planning the experiment	38	76.21
Skill in conducting experiment	58	77.33
Skill in communicating	80	64.32
Skill in applying concept	74	59.22

The profile of science process skills through the test instrument shows the difference with the instruments on the observation sheet. On the test instrument, the skill of planning an experiment only reached a percentage of 76.21% with a high category. This can occur because of group discussion activities in the implementation of experimental activities will make it easier for students to understand the use of tools and materials needed when planning experiments. Students can exchange ideas and remind one another, whereas, when students work on problems independently, students cannot discuss with other student.

This is supported by the research of Heller *et al.,* (1992) who focus on the research problem solving through groups and individually. The study concluded that the solution of the exercise/task context-rich problems produced by the group is better than by individuals independently, even by the best students.

CONCLUSION

The conclusion of this research is that the discovery of valid performance assessment instruments to measure the science process skills and student learning outcomes, which on average reach 93.125% in the very valid categories. In addition, the results of the assessment of the science process skills test instrument by the validator reached an average of 91.87% in the very valid category. The reliability test of the assessment instrument of performance integrated 4C trial was 0.95. Thus, the instrument is reliable or can be trusted with very high reliability criteria. The science process skills test instrument was analyzed using the theoretical basis of Kuder Richadson 20 (KR-20) showing 0.8807, therefore, the instrument is reliable or can be trusted with very high reliability criteria. The practicality of using the assessment instrument of performance integrated 4C reaches 86.4%, therefore, the instrument in the category is very practical to be used. The profile of science process skills in the science experiments at SDN Karangmlati 1 Demak in 2018/2019 academic year shows that the science process skills in grade V students in the aspect of planning experimental skill reached a percentage of 93% (very high), meanwhile, in the aspect of carrying out experiments, it reached 72% (high), the aspect of observing skill reached to 76% (high), and the communication skill reached to 80% (high).

REFERENCES

Akhiruddin, Susilo, H., & Ibrohim. 2016. "Pengaruh Penggunaan Modul Inkuiri Dipadu PJBL Berbahan Ajar Potensi Lokal terhadap Keterampilan Proses Sains Siswa SMA". *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan,* 1 (10): 1964—1968. Retrieved from http://journal.um.ac.id/index.php/jptpp/article/view/7212/3211

Bati, K., Ertürkb, G., & Kaptan F. 2010. "The Awareness Levels of Pre-School Education Teachers Regarding Science Process Skills". *Procedia Social and Behavioral Sciences,* 2 : 1993-1999. Retrieved from https://www.sciencedirect.com/science/article/pii/S1877042810003101

Heller, P., Keith, R. & Anderson, S. 1992. "Teaching Problem Solving Through Cooperative Grouping. Part 1: Group Versus Individual Problem Solving". *American Association of*

Physics Teachers - American Journal of Physics, 60 (7):627—636. Retrieved from https://d1b10bmlvqabco.cloudfront.net/attach/i5li1rs55o12sy/hsg4ulhusig4id/i6cjt6dficgt/Helleretal_92_AJP.pdf

Osman, K., Hamid, S. H. A. & Hassan, A. 2009. "Standard Setting: Inserting Domain of The 21st Century Thinking Skills into The Existing Science Curriculum in Malaysia". *Procedia Social and Behavioral Sciences,* 1: 2573—2577. Retrieved from https://www.sciencedirect.com/science/article/pii/S187704280900456X

Partnership for 21st Century Skills. 2008. *21st Century* Skills, *Education & Competitiveness: A Resource And Policy Guide.* Tucson, AZ: Author.

Rauf, R. A. A., Rasul, M. S., Mansor, A. N., Othman, Z. & London, N. 2013. "Inculcation of Science Process Skills in a Science Classroom". *Asian Social Science*, 9 (8):48—57. Retrieved from http://www.ccsenet.org/journal/index.php/ass/article/view/26883

Soh, T. M. T., Arsada, N. M., & Osman, K. 2010. "The Relationship of 21st Century Skills on Students' Attitude and Perception towards Physics". *Procedia Social and Behavioral Sciences,* 7 : 546-554. Retrieved from https://www.sciencedirect.com/science/article/pii/S187704281002077X

Sunardi, D. K., Sugiarti T., Yudianto, E. & Nurmaharani, R. 2017. "Pengembangan Indikator 4c's yang Selaras dengan Kurikulum 2013 pada Mata Pelajaran Matematika SMA/MA Kelas X Semester 1". *AdMathEdu,* 7 (2): 197-210. Retrieved from https://jurnal.unej.ac.id/index.php/kadikma/article/view/5277

Susilaningsih, E., Khotimah, K., & Nurhayati, S. 2018. "Development of Performance Assessment Instrument based Contextual Learning for Measuring Students Laboratory Skills". *IOP Conference Series: Materials Science and Engineering,* 349 (1): 1-8. Retrieved from https://iopscience.iop.org/article/10.1088/1757-899X/349/1/012018

Trowbridge, L.W. & Bybee, R.W. 1990. *Becoming a Secondary School Science Teacher.* Melbourne: Merril Publishing Company.

Wiwin, E., & Kustijono, R. 2018. "The Use of Physics Practicum to Train Science Process Skills and Its Effect on Scientific Attitude of Vocational High School Students". *Journal of Physics: Conference Series,* 997 (1) : 1-8. Retrieved from https://iopscience.iop.org/article/10.1088/1742-6596/997/1/012040