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Effectiveness of next generation science standards based 5E learning model by utilizing the local potential

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Abstract: This study aims at revealing the effectiveness of the next generation science standards-based 5E learning model by utilizing the local potential of environmental education centre Puntondo to enhance students' data literacy and problem-solving abilities. This research can be categorized as an experimental study. The subjects of this study were the seventh-grade students of State Junior High School 2 Takalar. Two classes were involved, totalling 64 students. The data collection technique was carried out by using the test instrument. The data analysis technique used the gain score test and t-test analysis. The results showed that the gain score for the two classes for both abilities was in the medium category, with a value indicating that the gain from the experimental class was greater than the control class.Meanwhile, the t-test value is Sig. (2.tailed) data literacy of 0.003 and problem solving of 0.008. The acquisition of the value of the two abilities shows that the Sig. (2.tailed) is less than 0.05. Based on the research results, it can be concluded that the NGSS-based 5E learning model by utilizing the local potential of EEC Puntondo is considered effective to enhance data literacy and problem-solving abilities.
Keywords: 5E model, NGSS, local potential, data literacy, problem-solving.

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INTRODUCTION

Human resources need to adapt to a rapidly changing world. In recent years, several countries have tried to improve education quality based on the 21st century and 4.0 industrial revolution development. The rapid development of science and technology has been placed as the main feature in the 21st century. The 4.0 industrial revolution also demands each individual to master skills and abilities that support global competition. Everyone should make sustainable innovations and hold a more complex mindset (Haviz et al., 2018). The science learning process emphasizes students' ability to build a concept, theory, and scientific attitude so that the teaching and learning should focus on students' processing skills (Trianto, 2012).

NGSS exists as a standard and a pioneer of science learning framework, including a strong integration of science to achieve the vision of science education (McComas & Nouri, 2016; Next Generation Science Standards, 2013). NGSS has three dimensions of learning that should be integrated to obtain maximum results. The first dimension is Science and Engineering Practices (SEPs) as a skill dimension to help students understand the discovery process and investigation. The second is Crosscutting Concept (CCs) as an understanding dimension that provides linkages among scientific disciplines. The third dimension is A Core Disciplinary (DCIs) as a specific content from various fields of study (McComas, 2014; Next Generation Science Standards, 2013).

The achievement of NGSS goals and visions in supporting 21st-century education requires an appropriate learning model during the learning process. NGSS has recommended the 5E learning model (R. Bybee, 2014). This model provides opportunities for students to deepen their current knowledge and facilitate them to acquire new knowledge (Tuna & Kaçar, 2013; Türkmen & Usta, 2007). The 5E model has five stages that will be carried out in classroom learning, namely Engagement, Exploration, Explanation, Elaboration, and Evaluation (Açışlı et al., 2011; R. W. Bybee et al., 2006).

The advantages of using the 5E model are motivating students to acquire knowledge (Alshehri, 2016). Teachers can integrate learning with local potentials that exist in the students' environment. It is in line with the National Education System in Law no. 32 of 2013 (Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 Tentang Perlindungan Dan Pengelolaan Lingkungan Hidup, 2009). The local potential is one of the local advantages as an identity or characteristic of an area, including natural resources, human resources, geography, culture, and history (Sya'ban & Wilujeng, 2016).

It is one of the local potentials that can be categorized as ecological utilization to be a learning resource for the community. The location of the environmental education centre (EEC) of Puntondo is in a coastal area which makes this local potential having three types of ecosystems in one location, mangrove forest ecosystems, seagrass beds, and coral reef ecosystems. Those can be used as ecological education that supports environmental management through participatory, informal, open, and stress-free education (PPLH Puntondo., 2017).

Puntondo is a natural tourist spot that offers environmental education programs to help students learn directly about things from the environment. Through several natural displays, it is hoped that it can raise awareness for visitors on the importance of education to support sustainable development that can be applied in real life (PPLH Puntondo., 2017). With a learning process closely related to the students' environment, it is expected to provide a meaningful learning process and changes in students' attitudes to think logically, critically, and proportionally regarding the encountered problems (Krajcik et al., 2014).

Data literacy is the students' ability in collecting, managing, evaluating, and applying data that can be used in evidence-based decision-making processes (Ridsdale et al., 2015). Learning models that emphasize data literacy needs to gradually build awareness of data use in education (Zhou, 2018). Data literacy education requires a method that attracts students' motivation. The achievement of data literacy skills can be realized with a diverse and creative learning environment. Teachers must facilitate students with a conducive learning environment and formal and informal teaching methods (Ridsdale et al., 2015).

Today's global competition also requires problem-solving skills that should encourage students' creativity, awareness, and thinking processes (Gök & Sýlay, 2010). The main focus is on problem-solving skills, where students must identify problems, formulate problems, and make appropriate problem-solving decisions (Pressman, 2019; Trilling & Fadel, 2009).

The use of the NGSS-based 5E model, which is integrated with the local potential of EEC Puntondo, will be a novelty in this study compared to the design of the learning process that has been carried out so far in the science teaching and learning process in class. The integration of local potential that is around the environment where students live is very rarely done because several things constrain it. The existence of the NGSS and the 5E model are two things that help each other in the teaching and learning process in the classroom so that learning is more structured, focused on the abilities and skills that students want to train and is also more meaningful.

Students' abilities in data literacy and problem-solving must be supported by a consistent teaching and learning process. The NGSS-based 5E model with the integration of the local potential of the Environmental Education Center of Puntondo can be used as an alternative in training the students' abilities. The learning process with the standards and the NGSS framework is expected to be able to train the students' skills. The aspects of determination in the NGSS dimension are adjusted to the students want. In this case, data literacy and problem-solving skills can be supported by using the analyzing and interpreting data skills in the SEPs dimension, understanding Cause and Effect on the CCs dimension, and the DCIs dimension of ecosystem materials that are in line with the material of the interaction between living things and the environment in the 2013 curriculum for the seventh-grade students in the second semester. The materials selection was adjusted to the student's understanding level about their surrounding environment. Based on the above foundation, the research was conducted to determine the effectiveness of the NGSS-based 5E learning model by utilizing the local potential of Puntondo EEC to enhance the required students' skills in the 21st century, i.e. data literacy and problem-solving skills among junior high school students.

METHOD

The type of study can be categorized as experimental research to determine whether the given treatment to the research subject can affect controlled conditions (Sugiyono, 2015). The implementation

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of this study used a Quasi-Experimental design with a nonequivalent control group design model among the selected samples.

The research population involved all students from the seventh grade of State Junior High School 2 Takalar in the even semester of the 2019/2020 academic year. The sample in this study was selected through a purposive sampling technique based on certain considerations (Sugiyono, 2015). The purposive sampling technique is used based on considering that the two sample groups had the same average ability. The sample was defined as two classes, namely VII 5 as the control class and VII 1 as the experimental class, with the number of students in each class was 32. The trial was carried out in two homogeneous classes, where one class was given treatment with the 5E learning model based on NGSS integrating with the local potential of EEC of Puntondo, while the other class as the control class used the 2013 curriculum with discovery learning model. Data collection was carried out from January to February 2020. This research design can be described in Table 1.

Table 1. Research Model

Group	*Pretest*	Treatment	*Posttest*
Experimental	O_1	X	O_2
Control	O_3	-	O_4

(Sugiyono, 2015)

The data collection instrument was using a test of pre-test and post-test to each student in the experimental and control class at the beginning and end of the meeting. The test instrument consisted of 10 essay questions. The entire test instrument was prepared by integrating the local potential of EEC of Puntondo and three dimensions of NGSS, i.e. data analysis and interpretation for SEPs dimension, cause and effect for CCs dimension, and material for the interaction of living things and the environment as one of the selected materials in DCIs dimension. The selection of essay form was based on the theory that this kind of test is precise and useful to measure complex achievement indicators, including the ability to provide, interpret, and apply data (Miller et al., 2013).

The test instrument contained five questions of data literacy and problem-solving abilities for each. Data literacy indicators to measure students' abilities consisted of 5 indicators, (1) data discovery and collection, (2) data conversion, (3) data identification, (4) data-based decision making, and (5) evaluation of data-based decisions (Ridsdale et al., 2015). Meanwhile, the problem-solving ability was measured using five indicators of (1) identifying problem components, (2) understanding the cause and effect of the problem, (3) designing problem solving, (4) implementing planned solutions, and (5) evaluating the solutions in solving problems (Bagno & Eylon, 1997; Carlgren, 2013; Ohlsson, 2012). The achievement of student results based on the answers in each question was measured using an assessment rubric with the score range of 0 to 3 representing each indicator of the students' abilities.

Data analysis was to determine the effectiveness of the NGSS-based 5E learning model integrated with the local potential of EEC of Puntondo based on the gain score to see the escalation of students' data literacy and problem-solving abilities. The pre-test and post-test scores of students were converted into a percentage using the Formula 1:

$$NP = \frac{R}{SM} \times 100\% \quad (1)$$

where NP = percent value, R = total score of each indicator, and SM = If all questions are answered with a score of 3 by students (Ngalim., 2009).

The score processing was done using the gain score. The data analysis involved the students' pre-test and post-test scores by determining the criteria for improvement. The calculation was carried out with the Formula 2:

$$(g) = \frac{Skor\ posttest - pretest}{Skor\ maksimum - pretest} \quad (2)$$

Table 2. Criteria of Score Escalation

Limitation	Category
$g \geq 0,7$	High
$0,3 \leq g < 0,7$	Moderate
$g < 0,3$	Low

(Hake, 1999)

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Furthermore, t-test analysis was carried out to determine the difference in the effectiveness of the experimental and control class methods. The effectiveness criteria can be categorized based on the Table 3.

Table 3. Criteria for Effectiveness of Gain

Presentation (%)	Category
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Effective Enough
>76	Effective

(Hake, 1999)

RESULTS AND DISCUSSION

This research was conducted to determine the effectiveness of the NGSS-based 5E learning by utilizing the local potential of the EEC of Puntondo in Takalar Regency, South Sulawesi. The results of this study were gained from several analysis processes to determine the students' abilities. The score acquisition of data literacy ability for the control class and experimental class is shown in Table 4 and Table 5.

Table 4. Score Acquisition of Students' Literacy Ability in Control Class

Component	Pretest	Posttest
N	32	32
Maximum	33	87
Minimum	7	33
Mean	27.28	53.19
Deviation Standard	11.01	17.49
Completeness	0	9
Gain Score	0.47	
Category	Moderate	

The results in Table 4 show the comparison of the students' pre-test and post-test scores in the control class for data literacy ability. The obtained gain score was 0.47 that can be categorized as a moderate category.

Table 5. Score Acquisition of Students' Literacy Ability in Experimental Class

Component	Pretest	Posttest
N	32	32
Maximum	47	93
Minimum	7	47
Mean	27.13	71.91
Deviation Standard	11.85	14.81
Completeness	0	16
Gain Score	0.60	
Category	Moderate	

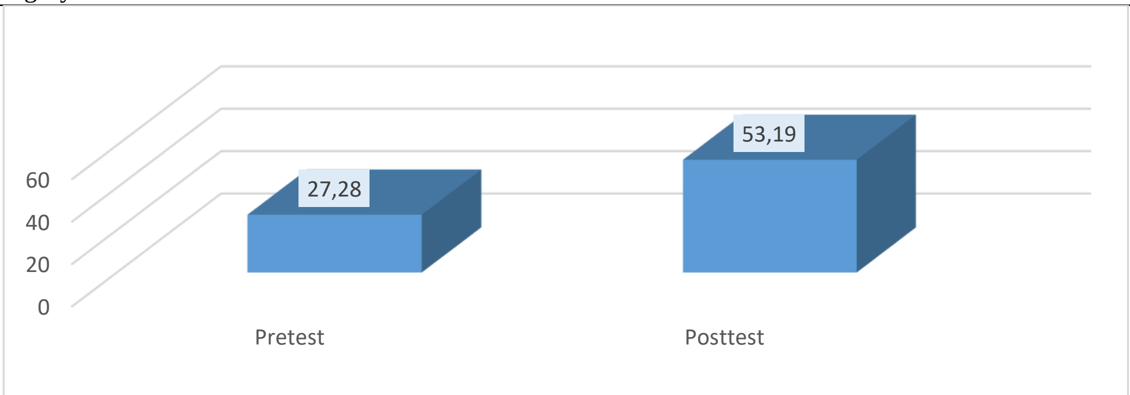

Figure 1. Pre-test and Posttest Mean Score on Students' Data Literacy Ability in Control Class

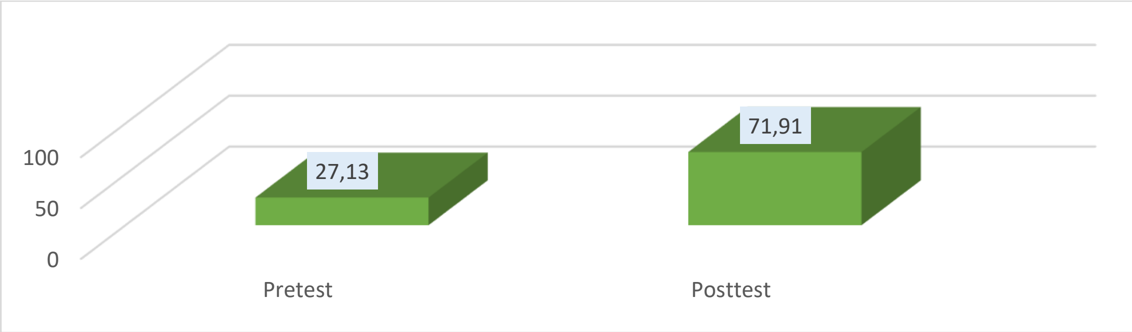

Figure 2. Pre-test and Posttest Mean Score on Students' Data Literacy Ability in Experiment Class

The results in Table 5 show the comparison of students' pre-test and post-test scores in the experimental class for data literacy ability. The obtained gain score was 0.60 that can be categorized as a moderate category. Based on Tables 4 and 5, it is known that the percentage gap between the control and the experimental class on the completeness of students' data literacy ability was 23.33%.

Figures 1 and 2 show that the students' data literacy ability in the control class had a gap in the mean score of 25.91%, while for the experimental class, the difference in the mean score was 44.78%. The results of the score acquisition on the students' problem-solving ability in both the control class and the experimental class are shown in Table 6 and Table 7.

Table 6. Score Acquisition of Students' Problem-Solving ability in Control Class

Component	Pretest	Posttest
N	32	32
Maximum	47	87
Minimum	13	40
Mean	26.84	64.34
Deviation Standard	10.88	14.57
Completeness	0	10
Gain Score	0.52	
Category	Moderate	

The results in Table 6 show the comparison of the students' pre-test and post-test scores in the control class for problem-solving ability. The obtained gain score of 0.52 fall in the moderate category.

Table 7. Score Acquisition of Students' Problem-Solving Ability in Experiment Class

Component	Pretest	Posttest
N	32	32
Maximum	47	93
Minimum	7	33
Mean	28.53	73.34
Deviation Standard	10.65	15.83
Completeness	0	19
Gain Score	0.62	
Category	Moderate	

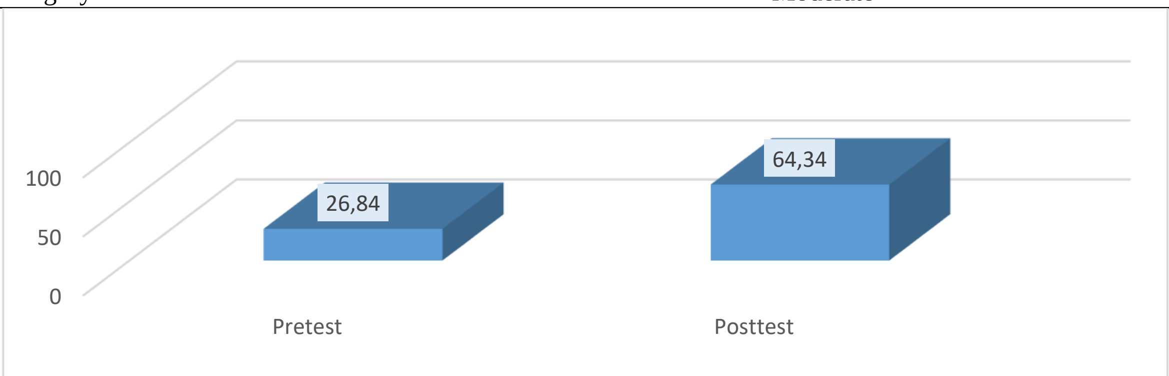

Figure 3. Pre-test and Posttest Mean Score on Problem solving Ability in Control Class

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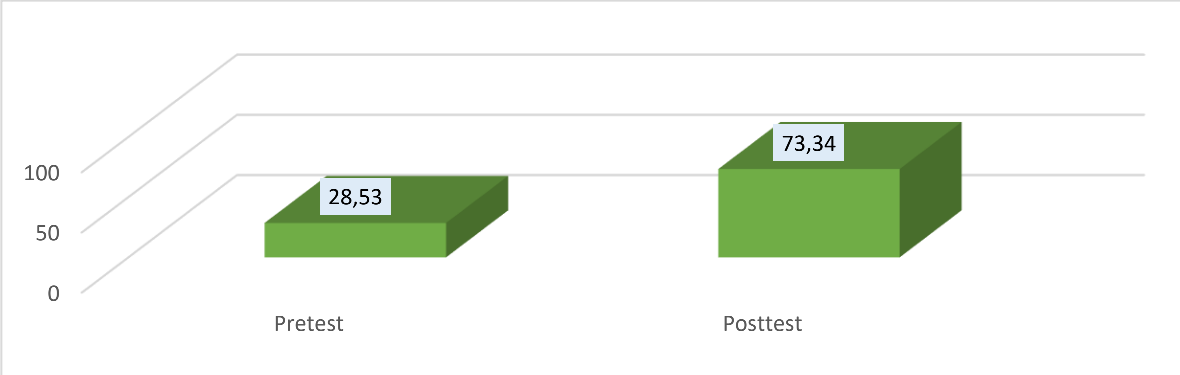

Figure 4. Pre-test and Posttest Mean Score on Problem solving Ability in Experiment Class

The results in Table 7 show the comparison of the students' pre-test and post-test scores of problem-solving ability in the control class. The gain score was 0.62 that can be categorized as a moderate category. Based on Tables 6 and 7, it is known that the percentage gap in the completeness of data literacy ability between the control class and the experimental class was 30.00%.

Based on Figures 3 and 4, the students' problem-solving ability in the control class obtained the mean gap score of 37.50%, while for the experimental class, the gap was 44.81%. Based on the analysis results in Tables 4, 5, 6 and 7, which show the gain score between the experimental and control classes for the two abilities, there is a difference in the results of the gain score for the data literacy ability in the control class with 0.47 and 0.60 for the experimental class. Each class can be categorized as moderate in terms of improvement, but there is a gap of 0.13. Meanwhile, the gain score for the control class and the experimental class for problem-solving ability showed a gap of 0.10. Both classes were in the moderate improvement category where the control class got 0.52, and the experimental class had 0.62. Each class was at an increased interval of $0.3 \leq g < 0.7$, which is also categorized as moderate. However, the gap indicates that the experimental class experience a better improvement. It can be concluded that the NGSS-based 5E learning model by utilizing the local potential of EEC of Puntondo in the seventh-grade students of State Junior High School 2 Takalar has a positive impact on students' data literacy and problem-solving ability.

Furthermore, t-test analysis was carried out to see the real difference in effectiveness between the control class and the experimental class for students' data ability and problem management in Table 8 and Table 9.

Table 8. Data on Acquisition of Data Literacy Ability Effectiveness

Class		N	Mean	Std. Dev	Srd. Error Mean
Gain_Persen	Eksperimental	32	62.25	16.76	2.96
	Control	32	45.57	24.94	4.40

Based on Table 8, it is known that the average value of gain's data literacy ability in the experimental class was 62.25% which was in the quite effective category. In contrast, for the control class, it was obtained that the Gain average value was 45.57% in the less effective category.

Table 9. Data Acquisition of Problem-Solving Ability Effectiveness

Class		N	Mean	Std. Dev	Srd. Error Mean
Gain_Persen	Eksperimental	32	63.75	18.46	3.26
	Control	32	51.72	16.86	2.98

The results in Table 9 show that the average score of gain in the problem-solving ability of the experimental class is 63.75% which is in the quite effective category. In comparison, the average score of gain in the control class is 51.72% which is also quite an effective category. Based on the results of the analysis in Tables 8 and 9, it can be concluded that the use of the NGSS-based 5E learning model by utilizing the potential of EEC Puntondo in the experimental class is quite effective in increasing data literacy and problem-solving ability in science subjects in the interaction of living things with the environment in-class students. VII Junior High School 2 Takalar Academic Year 2019/2020. Further-

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more, to determine whether the effectiveness of the two methods is significant or not, it can be seen in Table 10 and Table 11.

Table 10. Data Acquisition Independent Samples Test Data Literacy Ability

		Levene's Test for Equality of Variaances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tail)	Mean Diff	Std. Error Diff	95% Confidence Inter of the Diff Lower	Upper
Gain_Persen	Equal variances assumed	3.875	.053	3.141	62	.003	16.68	5.31	6.06	27.30
	Equal variances not assumed			3.141	54.26	.003	16.68	5.31	6.03	27.33

Table 10 shows the acquisition of the Sig. (2.tailed) of 0.003, which is smaller than 0.05 for data literacy ability.

Table 11. Data Acquisition Independent Samples Test Problem Solving Ability

		Levene's Test for Equality of Variaances		t-test for Equality of Means						
		F	Sig.	t	df	Sig.(2-tail)	Mean Diff	Std. Error Diff	95% Confidence Inter of the Diff Lower	Upper
Gain_Persen	Equal variances assumed	.347	.558	2.721	62	.008	12.030	4.42	3.19	20.86
	Equal variances not assumed			2.721	61.49	.008	12.030	4.42	3.19	20.86

Table 11 shows the acquisition of the Sig. (2.tailed) of 0.008, which is smaller than 0.05 for problem-solving abilities. Based on the Sig. (2-tailed) from Tables 10 and 11, which show a smaller value than 0.05, it can be concluded that there is a significant (real) difference in effectiveness between the use of the NGSS-based 5E model by utilizing the local potential of EEC Puntondo compared to the discovery learning model to improve Data literacy and problem-solving ability in science subjects in the interaction material of living things with the environment in class VII students of Junior High School 2 Takalar, South Sulawesi for the 2019/2020 academic year.

The results showed that the difference in effectiveness between the experimental and control classes was due to the different methods used. In the experimental class, the teaching and learning process involves the latest suggested teaching and learning methods that will help improve the ability needed by students in the 21st century. The 5E learning model in the experimental class was applied four times in each meeting consisting of 5 stages. This model is one of the learning models suggested by NGSS to be applied in the learning process to support the vision and goals of NGSS in training the students' abilities and skills in the field of science to face the 21st challenge (Next Generation Science Standards, 2013).

The 5E learning model contains inquiry-based learning (Türkmen, 2006) to enhance and train students' interest to make investigations in obtaining the desired knowledge (Tuna & Kaçar, 2013). One of the 5E model stages is exploration, which gives students space to use concrete experiences in making observations, collecting data, predicting, and fixing hypotheses. In the elaboration stage, students are given new problems to be solved with the insight of new knowledge obtained (Wilder & Shuttleworth, 2005). Students are trained to have higher-order thinking at these two stages and build confidence in solving a problem. If the students get used to collecting data critically, it can improve their data literacy skills (Ridsdale et al., 2015). The stages in the 5E model also provide space for students to rely on data in solving a problem so that their data literacy and problem-solving skills are trained at each stage. It is in line with the view that the learning process should gradually emphasize the awareness of data usage to solve every problem (Zhou, 2018).

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The NGSS-based learning process is the proven ability to help students in improving their problem-solving data literacy skills. The selection of the right aspects of the three dimensions of the NGSS will affect learning objectives as performance expectations. In this study, the SEPs aspect of data analysis and interpretation is effective in training students to answer a problem by analyzing data (Krajcik et al., 2014; McComas, 2014; Next Generation Science Standards, 2013). For the CCs dimension, the Cause and Effect aspect is included to assist students in understanding the cause and effect of a certain problem (McComas, 2014). Meanwhile, the third dimension of DCIs is the content selection based on the local potential, which is integrated into learning, i.e. the ecosystem. The achievement of the Nature of Science can be supported by a learning process that is connected to the local potential around students (Wilujeng et al., 2017).

The learning process that involves motivation and relates to diverse and creative learning environments can train students' data literacy skills (Ridsdale et al., 2015). The integrated learning with local potential is a form of diversity and creativity in creating classroom learning that can foster the students' curiosity. Students can easily understand the learning content that is presented correctly and contextually (Dash et al., 2016; Laurens et al., 2014). The three dimensions of NGSS are raised as features in the learning process that can train students' skills and understanding of the subject matter. The use of NGSS in the teaching and learning process greatly helps students' data literacy and problem-solving abilities.

Learning with the 5E model can develop students thinking skills to solve a problem (Temel et al., 2013) since students are more actively involved in the learning process (McComas, 2014). Besides the obtained results, it should be noted that each student needs time to train their abilities in various aspects. It means teachers should continuously train the students' skills, especially high-order thinking skills crucial in this modern era. Moreover, students' data literacy skills are also influenced by several things, such as a conducive learning environment, supporting technology, and students' motivation (Ridsdale et al., 2015). Meanwhile, the improvement of students 'problem-solving abilities is influenced by several aspects, such as initial knowledge of the problem and students' personalities like self-confidence (Rusyna, 2014).

CONCLUSION

The research results show that the different gain scores between the control class and the experimental class with an increased score of 0.13 % for data literacy ability and 0.10% for problem-solving ability. The t-test results value is Sig. (2.tailed) data literacy ability of 0.003 and problem-solving ability of 0.008. The acquisition of the value of the two abilities shows that the Sig. (2.tailed) is less than 0.05. Therefore, it can be concluded that the use of the Next Generation Science Standards-based 5E learning model by utilizing the local potential of environmental education centre Puntondo is effective in improving students' data literacy and problem-solving abilities. The results of this study can be a reference for science educators to be able to use the Next Generation Science Standards-based 5E model, which is integrated with the local potential that exists in the environment around students during the learning process to help the abilities needed in learning 21st century and students better understand learning material through their surroundings.

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