Improvement of Science Process Skills (SPS) With Implementation Guided Inquiry Learning Using STEM Approach

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Abstract

This research aims to describe the implementation of guided inquiry learning using STEM approach and describe the improvement in student science process skills (SPS). This type of research is pre-experimental with one group pre test-post test design using 1 implementation class and 2 replication classes. The technique of analyzing learning implementation data uses the learning implementation sheet assessed by the observer. While the improvement of SPS using pre-test and post-test sheets were analyzed using paired sample T-test, n-gain, and ANOVA. The results showed that the implementation of learning obtained a value of 3.47 or 86.75% and in the excellent category. There is a significant difference between the value of the pre-test and post-test. The improvement of SPS in the three classes obtained a value of <g> sequentially in the amount of 0.55, 0.63, 0.62 and the medium category but the increase in the value of SPS in these three classes was inconsistent. Based on this research it can be concluded that the implementation guided inquiry learning using STEM approach can improve student science process skills.

Introduction

A curriculum that applies in Indonesia is 2013 revised 2017 curriculum, where this curriculum requires students to be active in the learning process. But based on the results of observations of the researcher by distributing questionnaires showed that most students said that in learning teachers tend to be more active than students. To involve the activity of learners can be done by experimental activities, experimental activities or scientific investigation can be used to involve the activity of students and provide responsibility to students and improve learning outcomes (Alkan, 2016).

Science process skills (SPS) are processing skills in carrying out scientific work, through the development of these skills students will find facts and concepts by themselves and develop attitudes and values that are demanded (Semiawan, Tangyong, Belen, Matahelemual & Suseloardjo, 1986). SPS has indicators such as formulating problems, making hypotheses, identifying variables, conducting experiments, analyzing data, concluding and communicating (Semiawan, Tangyong, Belen, Matahelemual & Suseloardjo, 1986). Based on observations made by the researcher on the SPS of class XII students in one of the high schools, some SPS indicators have a low value of <50%. Meanwhile, according to the data Program for International Student Assessment (PISA) in 2015, the scientific performance of students in Indonesia still scores below the standard PISA score of 403 points from 493 points (OECD, 2017).

Increasing SPS can be involving the active student in finding their knowledge. In 2016, the results of research conducted by Alkan showed that student scientific skills more effective in experimental teaching whereas scientific skills in traditional or teacher-centered teaching showed ineffective results. Implementation guided inquiry learning model is considered capable of increasing the SPS of the student. As research conducted by Hardianti & Kuswanto (2017) show that SPS is more effectively applied to level 3 inquiry than level 2 inquiry and level 4 inquiry, , this is because the teacher's role and student activities are balanced on level 3 inquiry. The role of the teacher in this learning is not as an information giver but for the learning designer and facilitates students to find their knowledge so that the knowledge will be remembered by students in a long time (Puspita & Jatmiko, 2013). Guided inquiry has syntax of learning that is in accordance with SPS indicators, these stages include (1) presenting problem, (2) making a hypothesis, (3) designing experiment, (4) conducting experiment, (5) collecting and analyzing data and (6) make conclusions (Eggen & Kauchak, 2012).

Guided inquiry always involves an inquiry process, this can be combined with the STEM approach (Science, Technology, Engineering, and Mathematics). STEM is an approach that combines aspects of science, technology, engineering, and mathematics. STEM education is an approach to teach two or more aspects of STEM with STEM practice activities in connecting each aspect of STEM to improve student learning (Kelley & Knowles, 2016). STEM education is needed to grow scientific and technology literacy, providing hands-on experience to students and giving students the opportunity to apply their knowledge in daily life (Xiaoya & Xingran, 2018). Guided inquiry syntax can be associated with SPS activities and STEM approaches as in Table 1.

Tabel 1. Guided Inquiry Learning Model linkages with SPS Activities and STEM Aspects

Syntax Guided Inquiry	Description of Science Process Skills Activities	STEM Aspect
1. Presenting the problem	1. The teacher presents a problem and guides students to submit for the formulation of the problem.	Science
2. Making a hypothesis	1. The teacher guides students to submit hypotheses based on the formulation of the problem that has been made	Science
3.Designing experiment	1. Students collect information as a supporter of experiments from various sources. 2. Learners design or design an experimental tool that will be used in conducting experiments with teacher guidance. 3. Students to determine the variables that will be used in the experiment with the guidance of the teacher.	Science, Engineering
4. Conducting	1. Learners conduct experiments using	Science,

experiment	virtual laboratories and real laboratories with teacher guidance.	Technology.
5. Collecting and analyzing data	1. The teacher gives the opportunity for students to collect data, analyze data and make temporary conclusions based on the data obtained in the experiment. 2. Learners communicate the results of experiments that have been obtained.	Science, Technolog, Mathematics.
6. Make conclusions	1. Learners make learning conclusions with the guidance of the teacher.	Science

Based on previous research conducted by Hardianti & Kuswanto (2017), it shows that SPS is more effectively applied to level 3 inquiry than level 2 inquiry and level 4 inquiry, this is because the teacher's role and student activities are balanced on level 3 inquiry. In 2014, Supriyono, Madlazim, & Jauhariyah showed the results of research that through guided inquiry-based practicum activities were able to improve scientific abilities. Scientific ability also has aspects of SPS such as analyzing data. As well as the results of the study also showed that students after being given inquiry learning with experimental activities had an average achievement score higher than conventional learning (Nworgu & Otum, 2013). Research by Agustina, Kaniawati, & Suwarma (2017) shows that through STEM-based learning can improve student control of variables, where the control of variables is almost the same as the SPS indicator, specifically identifying variables.

As long as the research is conducted separately between the application of guided inquiry to improve the learning process with STEM to improve one of the SPS indicators whose basis is using problem-solving learning models. The approach here is intended to include aspects of STEM in guided inquiry syntax to provide direct experience to students. By implementing guided inquiry using the STEM approach, it is hoped that it can improve SPS and provide students with the experience to apply the STEM aspects that are needed in tomorrow.

Problem of Research

The problem of this research is to describe the implementation of the inquiry learning model using STEM approach and increasing score SPS students after the implementation guided inquiry learning model using the STEM approach. Implementation of learning is measured using the observation sheet observed by 2 observers. The increase in SPS was measured using the results of the pre-test and post-test and analyzed by (1) paired sample t-test to determine whether there was a significant difference between the pre-test and post-test values, (2) n-gain to determine the increased category SPS and (3) ANOVA is used to determine the consistency of improvement between groups.

Research Focus

This research focus on the problem: (1) How the implementation of guided inquiry learning model using STEM approach in class XI on global warming topic and (2) How to improve science process skills of class XI student on global warming topic after implementation guided inquiry learning models using the STEM approach?

Methodology of Research

Sample and General Background of Research

This research use a type of pre-experimental with one group pretest-posttest design.

$$O_1 \rightarrow X \rightarrow O_2$$

Figure 1. Research design

(Sugiyono, 2015)

Explanation :

O_1 : giving pre-test with SPS Indicator

X : giving treatment implementation guided inquiry using STEM approach

O_2 : giving post-test with SPS Indicator

This research was done in February-March 2019 at Cerme 1 Senior High School. The sample was selected by purposive sampling which recommendation by XI grade physics teacher based on relatively similar academic abilities. There are 1 implementation class are XI IPA 1 and 2 replication classes are XI IPA 2 and XI IPA 8 which each class consists of 35 students. For the trial of the pre-test and post-test questions, it was done in the class that had already comprehended the material on global warming, specifically XI IPA 6 with 36 students

Instrument and Procedures

The instrument used in this research is the implementation observation sheet and pre-test and post-test questions that contained the SPS indicator. The pre-test and post-test questions were validated by 2 validator lecturers, then a test was conducted to determine the questions that were worthy of being used for research. The results of the validity of the two validators obtained a value of 3.42 with valid categories while reliability was calculated using a Percentage Of Agreement (POA) to obtain a percentage of 86.90% with very high reliable criteria. While the results of the test questions were analyzed based on validity, reliability, level of difficulty and the power of different questions. This calculation uses the help of the SPSS application, the results obtained are in Table 2.

Tabel 2. Recapitulation of The Test SPS

No	Validity		Level of Difficulty		Question Differentiation		Description
	r_{xy}	Criteria	LOD	Criteria	QD	Criteria	
1.	0,54	Valid	0,38	Medium	0,54	Good	Used

2.	0,47	Valid	0,31	Medium	0,47	Good	Used
3.	0,54	Valid	0,32	Medium	0,54	Good	Used
4.	0,43	Valid	0,15	Difficult	0,43	Good	Not Used
5.	0,24	Invalid	0,75	Easy	0,24	Sufficient	Not Used
6.	0,55	Valid	0,08	Difficult	0,55	Good	Not Used n
7.	0,58	Valid	0,50	Medium	0,58	Good	Used
8.	0,65	Valid	0,33	Medium	0,65	Good	Used
9.	0,53	Valid	0,50	Medium	0,53	Good	Used
10	0,39	Valid	0,44	Medium	0,39	Sufficient	Used
11	0,61	Valid	0,33	Medium	0,61	Good	Used
12	0,30	Invalid	0,38	Medium	0,30	Sufficient	Not Used
13	0,32	Invalid	0,21	Difficult	0,32	Sufficient	Not Used
14	0,56	Valid	0,32	Medium	0,56	Good	Used
15	0,65	Valid	0,31	Medium	0,65	Good	Used
16	0,27	Invalid	0,29	Difficult	0,27	Sufficient	Not Used
17	-0,16	Invalid	0,14	Difficult	-0,16	Not Used	Not Used
18	0,71	Valid	0,36	Medium	0,71	Excellent	Used
19	0,43	Valid	0,33	Medium	0,43	Good	Used
20	0,69	Valid	0,31	Medium	0,69	Good	Used
21	0,59	Valid	0,69	Medium	0,59	Good	Used

The questions were tested as many as 22 items but after being analyzed by validity, the level of difficulty and the question differentiation, that questions are worthy of being used in the research were 15 questions. The reliability of the questions can be seen in Table 3.

Table 3. Reliabilitas Soal

Reliability Statistics	
Cronbach's Alpha	N of Items
,829	22

Overall, the reliability value of pre test-post test sheet is 0.829 with a very high reliable category that is worthy of being used for research. While the observation sheet used was adapted from the implementation sheet that was available and followed the guided inquiry learning model.

Data analysis

The results of the implementation of learning obtained in each class are on average and emphasized. Furthermore, the data is interpreted as in Table 4.

Table 4. Percentage interpretation

Percentage	Category
0-20%	Very less
21-40%	Less
41-60%	Sufficient
61-80%	Good
81-100%	Very Good

(Riduwan, 2012)

Furthermore, the average value of increasing SPS of students in each class or n-gain of each class will be interpreted as in Table 5.

Table 5. Interpretation n-gain

n-gain <g>	Kriteria
<g> ≥ 0,7	High
0,3≤ <g> <0,7	Medium
<g> < 0,3	Low

(Hake, 1999)

Besides, SPS data analysis was also analyzed using paired sample t-test to determine whether there were significant differences between the values of the pre-test and post-test. As well as analyzed using ANOVA to determine consistency or not increase in all three classes.

Results of Research and Discussion

The implementation of guided inquiry learning using the STEM approach was measured using the learning implementation sheet observed by two observers. This implementation sheet refers to the syntax guided inquiry learning model. Generally, guided inquiry syntax and aspects assessed in the implementation of learning can be seen in Table 6.

Table 6. Aspects Assessed in The Implementation of Learning

Aspects of Learning	Learning Steps
Initial Activities	1. Motivation of students
	2. Communicate learning objectives
Core Activities	1. Presenting the problem
	2. Making a hypothesis
	3. Identify Variables
	4. Conducting experiment
	5. Collecting and analyzing data
	6. Communicate
Closing Activities	1. Find a concept
	2. Conclude Learning
Observation of Class Environment	1. Students enthusiasm
	2. Teacher Enthusiasm
Time Management	-

The results of the implementation of learning in the three classes can be seen in Table 7.

Table 7. The results of The Implementation of Learning in The Three Classes

Class	Meeting	Aspects Learning	Observer 1	Observer 2	Average Each Meeting	Average of Each Class
XI IPA 1	1	Initial Activities	3,67	4,00	3,50	3,58
		Core Activities	3,40	3,50		
		Closing Activities	3,33	3,67		
		Observation of class environment	3,50	4,00		
		Time management	3,00	3,00		
	2	Initial Activities	3,67	4,00	3,64	
		Core Activities	3,50	3,90		
		Closing Activities	3,67	3,67		
		Observation of class environment	3,50	3,50		
		Time management	3,00	4,00		
XI IPA 2	1	Initial Activities	3,33	3,67	3,37	3,39
		Core Activities	3,30	3,60		
		Closing Activities	3,00	3,33		
		Observation of class environment	3,00	3,50		
		Time management	3,00	4,00		

Class	Meeting	Aspects Learning	Observer 1	Observer 2	Average Each Meeting	Average of Each Class
	2	Initial Activities	3,33	3,33	3,42	
		Core Activities	3,40	3,50		
		Closing Activities	3,33	3,33		
		Observation of class environment	3,50	3,50		
		Time management	3,00	4,00		
XI IPA 8	1	Initial Activities	3,00	3,67	3,46	3,43
		Core Activities	3,10	3,50		
		Closing Activities	3,67	3,67		
		Observation of class environment	3,00	4,00		
		Time management	3,00	4,00		
	2	Initial Activities	3,33	3,67	3,41	
		Core Activities	3,10	3,50		
		Closing Activities	3,33	4,00		
		Observation of class environment	4,00	4,00		
		Time management	2,00	3,00		
		Average				**3,47**
		Percentage				**86,75 %**
		Category				**Very good**

The results of the implementation of learning in the three classes obtained an average value of 3.47 or 86.75% and were in the excellent category. From these results, it can indicate that the implementation of learning at each stage and step can be carried out well.

Furthermore, to analyze the improvement of the science process skills of students, it can be done by testing the values of pre-test and post-test students using the paired sample t-test , n-gain, and ANOVA. But before conducting paired sample t-tests and ANOVA there are prerequisite tests this is a normality test and homogeneity test to determine whether the sample is normally distributed and the sample comes from a homogeneous population. This test is assisted by the SPSS application, assuming:

- Sig. > 0,05 then samples are normally distributed
- Sig. < 0,05 then samples are not normally distributed

The results of the normality test obtained are shown in Table 8.

Table 8. The results of The Normality test

Tests of Normality

Class	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
PRETEST CLASS XI IPA 1	,123	35	,197
PRETEST CLASS XI IPA 2	,125	35	,182
PRETEST CLASS XI IPA 8	,128	35	,162
POSTTEST CLASS XI IPA 1	,137	35	,062
POSTTEST CLASS XI IPA 2	,143	35	,030
POSTTEST CLASS XI IPA 8	,130	35	,197

a. Lilliefors Significance Correction

Based on the table, the significance values (sig.) of the pre-test and post-test of the three classes> 0.05 showed that the samples from the three classes were normally distributed. While the homogeneity test is assumed:

- Sig. > 0,05 then the sample from a homogeneous population
- Sig. < 0,05 then the sample not from a homogeneous population

The homogeneity test results can be seen in Table 9 and Table 10.

Table 9. The Homogeneity Pre-test Results

Test of Homogeneity of Variances

Pretest			
Levene Statistic	df1	df2	Sig.
,752	2	102	,474

Tabel 10. The Homogeneity Post-test Results

Test of Homogeneity of Variances

Posttest			
Levene Statistic	df1	df2	Sig.
,477	2	102	,622

Based on Table 9 and Table 10, the significance value of pre-test and post-test> 0.05 indicates that the sample comes from a homogeneous population. After the prerequisite test is done and shows the results of the sample are normally distributed and come from a homogeneous population, a paired sample t-test is performed to determine whether or not there is a significant difference between the pre-test and post-test scores in the three classes. The assumptions used in this paired sample t-test are

- Sig. (2-tailed) < 0,05 then there is a significant difference between the value of the pre-test and post-test
- Sig.(2-tailed) > 0,05 then there is not a significant difference between the value of the pre-test and post-test

The results of the paired sample t-test can be shown in Table 11.

Tabel 11. The Results of The Paired Sample t-test

Paired Samples Test

	Paired Differences					T	f	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
XI 'A 1	-31,600	1,581	,788	-35,235	-27,965	-17,669	4	,000
XI IPA 2	-38,057	1,819	,829	-41,774	-41,774	-20,810	4	,000
XI IPA 8	-38,114	2,461	,106	-42,395	-42,395	-18,095	4	,000

Table 11 can show the results of the paired sample t-test. The mean values for the three classes score -31,600, -38,057 and -38,114, this value showed a negative result which meant there was an increase. Significant value (2-tailed) < 0,000 which indicates that there are significant differences between the value of pre-test and post-test of students in the three classes. The values obtained are in line with the research (Sunarti, Prahani, Wasis & Madlazim, 2018) which showed the results of the paired sample t-test with p <.05 and the mean values obtained are negative, this shows there are significant differences between the pretest and posttest values and there is improvement in scientific literacy after the CPI teaching model was implemented. This result is also in line with the research conducted by Alkan (2016), with analysis Wilcoxon Signed Rank Test showing that there were significant differences between the results of the pre-test and post-test in the group given experimental treatment or learning. As well as the research conducted by Wicaksono, Wasis & Madlazim (2017) showed a value of P <0.05 in the nine classes after applying the Virtual Science Teaching Model (VS-TM) which meant there were significant differences between the results of the pre-test and post-test. VS-TM syntax has similarities with a guided inquiry such as (1) formulating problem-solving, (2) designing and implementing virtual experiments and (3)

describing experimental results (Wicaksono, Wasis & Madlazim, 2017). To find out how much improvement in science process skills students will be analyzed using n-gain analysis. The average n-gain results in all three classes can be seen in Table 12.

Tabel 12. The Results of average n-gain value of each class

Class	Total Students	$\overline{< g >}$	Category
XI IPA 1	35	0,55	Medium
XI IPA 2	35	0,63	Medium
XI IPA 8	35	0,62	Medium

Based on the table can be seen the average value of gain ($\overline{< g >}$) in each class. This value is interpreted by Hake (1999) in the medium category. This result is in line with the research conducted by (Sunarti, Prahani, Wasis & Madlazim, 2018) showing the n-gain obtained in each scientific literacy indicator after the CPI learning model is applied in medium category. Where some scientific literacy indicators have similarities with SPS indicators such as interpreting data. Furthermore, research by Agustina, Kaniawati, & Suwarma (2017) explains that through STEM-based learning is able to increase the control of variables of students in the medium category. But in this research the results obtained were not in the high category because the research was only conducted during 2 meetings. To obtain an increase in value in a high category, it can be done by implementing guided inquiry learning using the STEM approach to other physics topic. From these results it can be indicated or concluded that the guided inquiry learning model using the STEM approach is able to increase the SPS of students. As well as being carried out by Supriyono, Madlazim, and Jauhariyah (2014) which shows through guided inquiry-based practicum activities able to improving scientific abilities. Scientific ability also has aspects of SPS such as analyzing data.

After knowing the value of improvement in students, then analyzed using ANOVA to determine whether the average increase in each class is consistent or the same as the other classes. The assumptions used in the ANOVA test are :

- Sig. > 0,05 then the value of improvement in all three classes did not differ significantly or consistently
- Sig. < 0,05 then the value of improvement in all three classes differ significantly or inconsistently

The results obtained from ANOVA test results can be seen in Table 13.

Table 13. ANOVA Test Results

ANOVA

SPS

	Sum of Squares	df	Mean Square	F	Sig.
Between	,118	2	,059	3	,

Groups				,211	044
Within	1,872	1	,018		
Groups		02			
Total	1,990	1			
		04			

Based on table 13 the sig value obtained is <0.05, this shows that there is inconsistency or inequality in the average value of improvement in all three classes, therefore further testing or post hoc tests are conducted to find out which classes experience inconsistency. Post hoc test results can be seen in Table 14.

Tabel 14. Hasil Uji post hoc

Multiple Comparisons

SPS

LSD

(I) KELAS	(J) KELAS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
XI IPA 1	XI IPA 2	-,07543*	,032 38	,022	-,1397	-,0112
	XI IPA 8	-,06571*	,032 38	,045	-,1299	-,0015
XI IPA 2	XI IPA 1	,07543*	,032 38	,022	,0112	,1397
	XI IPA 8	,00971	,032 38	,765	-,0545	,0739
XI IPA 8	XI IPA 1	,06571*	,032 38	,045	,0015	,1299
	XI IPA 2	-,00971	,032 38	,765	-,0739	,0545

*. The mean difference is significant at the 0.05 level.

Based on Table 14, it can be seen that the group that experienced inconsistent improvement was class XI IPA 1. It is known from the relationship between class XI IPA 1 with class XI IPA 2 and XI IPA 8 that there is a sign (*) on the difference in average columns. The sign (*) indicates a significant average difference that causes inconsistencies. Class XI IPA 1 experienced inconsistency because the post-test scores were very different from those in class XI IPA 2 and XI IPA 8, the lack of teachers in maintaining post-test conditions caused the post-test scores obtained were not good

Conclusions

This research shows the results that the implementation of the guided inquiry using the STEM approach scored 3.47 or 86.75% and was in a very good category. There is a significant difference between the pre-test values that have not been given treatment with the post-test scores that have been given treatment. The increase in the SPS of the three classes was in the medium category with a value of 0.55 in class XI IPA 1, 0.63 in class XI IPA 2 and 0.62 in class XI IPA 8. However, the increase in SPS scores obtained by the three classes was inconsistent. Through this research, it is expected that there will be further research regarding SPS improvement by exploring all aspects of SPS.

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