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The Effect of Scientific Inquiry Model Assisted Visual Media on Students' Conceptual and Procedural Knowledge

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Abstract This study aimed to analyze the gain of students' conceptual and procedural knowledge of Scientific Inquiry model assisted visual media and conventional learning; to analyze whether the gain of students' conceptual and procedural knowledge taught by Scientific Inquiry assisted visual media model was better than conventional learning. This research was a quasi- experimental research with two group pretest-posttest design. The population of this research was second semester students of Al Bukhari Moslem Integrated High School grade X academic year 2016/2017. The sampling technique was cluster random sampling that consisted of 2 groups with 68 students. Class X-1 were experimental group taught by Scientific Inquiry models consisted of 34 students and class X-3 were control group taught by conventional learning consisted of 34 students. The instrument of the research were essay test of conceptual and procedural knowledge consisted of 10 questions for each. The data were analyzed using t test statistics. The result showed that: the mean gain of students' conceptual knowledge taught by Scientific Inquiry model was in medium level and low level for conventional learning. The mean gain of students' procedural knowledge taught by Scientific Inquiry model was in high level and medium level for conventional learning. Hypothesis test showed that the mean gain of students' conceptual and procedural knowledge taught by Scientific Inquiry was better than conventional learning. This result showed that there was a positive effect of Scientific Inquiry model assisted visual media on the students' conceptual and procedural knowledge using Scientific Inquiry learning model.

Keywords: *scientific inquiry model, visual media, conceptual knowledge, procedural knowledge*

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1. Introduction

Education plays an important role for the development of all potential, skills, and characteristics of human resources to be positive. Education is a program [12]. Science is the knowledge gained through learning and proof. Science is basically concerned with how to find out and understand nature. Learning science is not only to memorize the materials but also to understand the concepts of the science [15]. Physics is one of the subjects in science that studies physical events such as processes, products and interrelated scientific attitudes, and explains how natural phenomena are measured through observation and research.

The product is a collection of knowledge in form of facts, concepts, principles, laws, and theories. The processes are the steps that need to be accomplished to get knowledge such as remembering, understanding, applying, analyzing, evaluating and creating. Scientific attitudes are formed when doing processes, such as objectivity and honesty when collecting and analyzing data [20].

These activities are the parts of scientific knowledge. Scientific knowledge is factual, conceptual, procedural and meta cognitive knowledge. Scientific knowledge is important for every student to enhance learning outcomes. Scientific knowledge also affects personal, social, and individual life in the global world, so students need to be equipped with conceptual and procedural knowledge. Conceptual knowledge is like fuel and procedural knowledge is the engine.

The reality occured in the field is not as expected, because the learning process at schools shows that Physics learning process does not equip students to develop their conceptual and procedural knowledge ability. Conceptual knowledge becomes the basic of understanding because learning physics is not only focused on facts, law, theory, principle, models, formula but also understanding basic concepts [19]. Meanwhile, understanding only conceptual knowledge is not enough but students have to understand how and when to use it so that it leads to procedural knowledge.

The reality showed that students could do the calculation by using only the basic formula and students found it difficult to complete the tasks of physics-shaped

stuffing (about the story). The students found it difficult to comprehend the content of the problems because they only knew the conceptual knowledge [2]. So comprend the content of the problems, the students showed know but conceptual and procedural knowledge. To obtain a well connected procedural knowledge with conceptual knowledge, the students need to be embedded concepts, linked to other concepts, and also trained how of using rules or procedures to complete the physics tasks.

To overcome the problems above, students requires active learning models to enhance conceptual and procedural knowledge such as Scientific Inquiry. Scientific Inquiry learning model is designed to involve students in genuine investigation by confronting students with investigations, helping students identify conceptual or methodological issues in the field, and invite students to be able to design ways to solve the problem [6].

The Scientific Inquiry Model is very suitable to enhance conceptual and procedural capabilities because in Scientific Inquiry learning, students are faced to present, formulate, identify and find ways to solve problems [10]. Students' conceptual knowledge is gained from conceptual understanding, relating one concept to another concept, so students are able to present, formulate, and identify problems. Procedural knowledge is individual knowledge to carry out steps in an activity process, so students are able to present, formulate, identify and find ways to solve the problem. As students are accustomed to do these activities , the students' learning outcomes will enhance because they have studied physics conceptually and procedurally. Some previous researchers have been done on scientific inquiry [3]

Conventional learning is the learning models usually used by teachers in teaching and learning process. In conventional learning, students listen more to the teacher's explanation and do exercises given by the teacher. Conventional learning involves lecture method, question – answer, discussion, and homework.

Although Joyce states that scientific inquiry has some advantages, but the reality shows that there are some students who are less active in learning. The lack of students' activities creates difficulties in mastering conceptual and procedural knowledge [5]. This situation allows the learning process and concentration of students less maximal.

Visual media shows images and presentations clearly so that students will be able to absorb the meaning of the lesson. Rahayu in her research use visual media, concludes that the learning model of Community Technology Science (STM) assisted by significantly effects science learning outcomes of elementary students Class V Cluster I Dalung Kuta Utara Lesson Year 2013/2014 [13].

Visual media is a great medium to be remembered which allows to arrange facts and thoughts in such a way so the natural workings of the brain are involved from the beginning. By using visual media, long lists of information can be diverted into a colorful, highly organized, and memorable diagram that works in harmony with the natural workings of the brain in doing many things. So, Scientific Inquiry learning model assisted visual media can be applied more effectively and able to optimize the students' conceptual and procedural knowledge.

2. Method

The research was quasi-experimental research with two group pretest-posttest design. The population of this research was second semester students of Al Bukhari Moslem Integrated High School grade X academic year 2016/2017. The sampling technique was cluster random sampling that consisted of 2 groups with 68 students. Class X-1 were experimental group taught by Scientific Inquiry models consisted of 34 students and class X-3 were control group taught by conventional learning consisted of 34 students. The instrument of the research were validated essay test of conceptual and procedural knowledge consisted of 10 questions for each based on indicators [1]. The data were analyzed using t test.

3. Result

At the beginning of the study, the two groups were given pretest which aimed to measure the students' ability in each class. The result of pretest and posttest from experimental and control group can be seen in Table 1. After applying different learning models, it was obtained post test score for the two groups control and experimental groups were given different model of learning, the results of post test had been obtained [16]. The post test score of experimental and control group can be seen as the following:

Table 1. Pretest and Post test Data

Variable	Group	Pretest	Post test
Conceptual Knowledge	Control	48.85	70.97
	Experimental	49.12	76.56
Procedural Knowledge	Control	33.24	66.91
	Experimental	34.62	76.09

It can be seen from Table 1, there is gain of post test score of conceptual and procedural knowledge after applying Scientific Inquiry model.

Then, the result obtained from pretest and post test were analyzed by using item analysis for conceptual and procedural knowledge instrument. It can be seen in Table 2.

Table 2. The Mean Gain of Post Test Score for Each Item Analysis of Conceptual Knowledge in experimental and control group

No	Conceptual Knowledge Dimension	Questions	Mean Score of Item Analysis	
			Control	Experimental
1	Classification and Categories	1	8.21	8.71
		3	7.74	7.97
		Mean	7.97	8.34
2	Principle and Generalization	2	7.74	8.09
		4	6.76	7.53
		7	6.53	7.50
		10	6.15	7.12
		Mean	6.79	7.56
3	Theory, Model, and Structure	5	7.56	7.71
		6	6.91	7.62
		8	6.74	7.15
		9	6.65	7.18
		Mean	6.96	7.28

Table 3. The Mean Gain of Post Test Score for Each Item Analysis of Procedural Knowledge in experimental and control group

No	Conceptual Knowledge Dimension	Questions	Mean Score of Item Analysis	
			Control	Experimental
1	Skills and Algorithm	3	6.76	7.76
		4	6.88	7.88
		Mean	6.82	7.82
2	Technique and Method	1	6.76	7.82
		2	6.85	7.91
		7	6.59	7.38
		8	6.32	7.38
		9	6.44	7.41
		Mean	6.59	7.58
3	Right Procedural Criteria	5	6.85	7.79
		6	6.76	7.50
		10	6.68	7.24
		Mean	6.76	7.51

Then, the pretest and posttest data were related to the gain of conceptual and procedural knowledge with normalized gain. According Hake gain was used to measure the students' conceptual and procedural knowledge gain from pretest and posttest in learning process [4]. The category of normalized gain can be seen in Table 4.

Table 4. Normalized gain Score Category

Gain Score	Category
0.00-0.20	Very Low
0.21-0.40	Low
0.41-0.60	Medium
0.61-0.80	High
0.81-1.00	Very High

Students' conceptual knowledge gain category in control and experimental class can be seen in Figure 1.

From Figure 1, it can be concluded that students' conceptual knowledge gain of control group is in low category and medium category for experimental group.

Students' procedural knowledge gain category in control and experimental group can be seen in Figure 2.

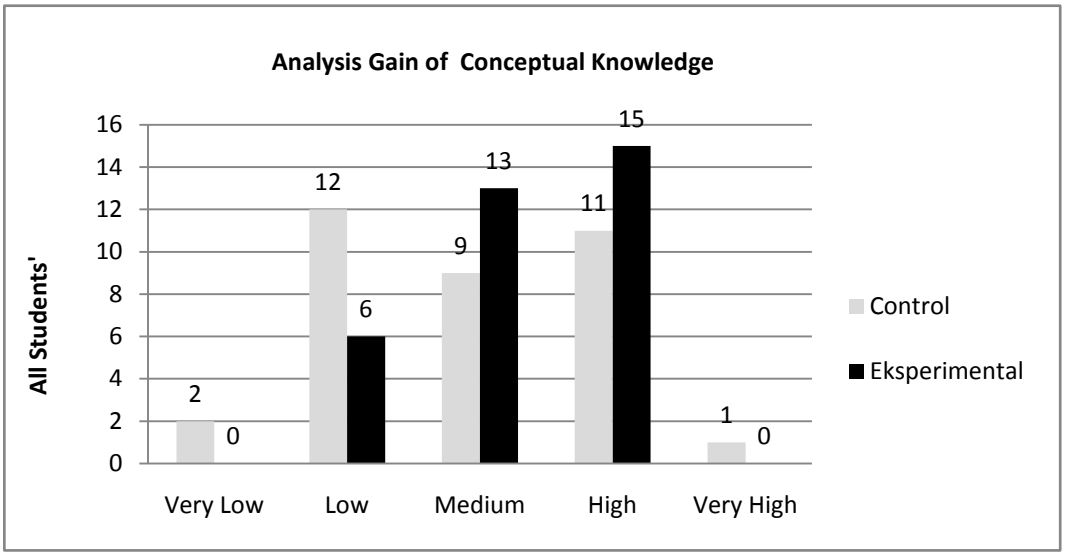

Figure 1. Gain of Students' Conceptual Knowledge

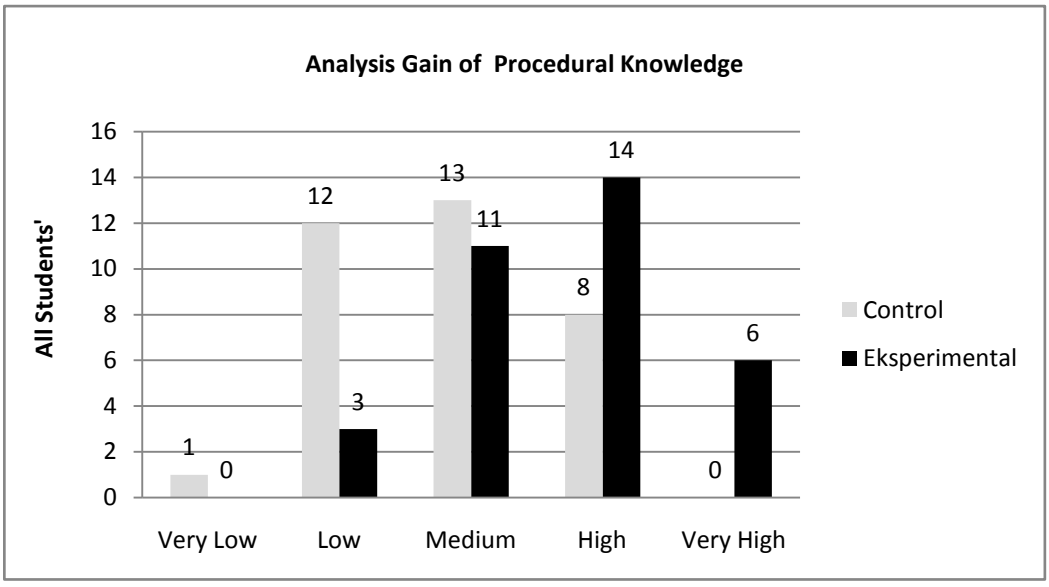

Figure 2. Gain of Students' Procedural Knowledge

It can be seen from Figure 2 that students' procedural knowledge gain of control group in very low group and very high category for experimental group.

After analyzing the gain, then testing the normality, homogeneity and similarity were done. The normality test of gain used to determine whether the sample came from normally distributed population or not. Normality test of gain data in control and experimental group was done by Kolmogorov-Smirnov test using SPSS 17 program with level of significance 0.05 where normality test result can be seen in Table 5.

Table 5. Normality Test of Conceptual Knowledge Gain in Experimental and Control Group

Group		Kolmogorov-Smirnov[a]		
		Statistic	df	Significance
Score	Experimental	.115	34	.200*
	Control	.099	34	.200*

Based on normality output in Table 5, the significance value of conceptual knowledge gain in experimental and control group is higher than 0.05, it can be said that conceptual knowledge gain data of the experimental and control group are normally distributed.

Testing the homogeneity of conceptual pretest data variance between the control and the experimental group were done by Levene test through the SPSS 17 program with a significance level of 0.05. After analyzing the data, the output can be seen in Table 6.

Table 6. Homogeneity Test of Conceptual Knowledge Gain in Experimental and Control Group

Output	Levene Statistic	df1	df2	Significance
Conceptual Gain	2.563	1	66	0.114

Based on homogeneity output with Levene Statistic in Table 6, the significance level of conceptual knowledge is 0.114. It showed that the significance level of conceptual knowledge is higher than 0.05. It can be concluded that control and experimental group came from population that have the same variance, or both classes are homogeneous.

Then, students' procedural knowledge gain test in experimental and control group can be seen in Table 7.

Table 7. Normality Test of Procedural Knowledge Gain in Experimental and Control Group

Group		Kolmogorov-Smirnov[a]		
		Statistic	Df	Significance
Score	Control	.076	34	.200*
	Experimental	.106	34	.200*

Based on normality output in Table 5, the significance value of procedural knowledge gain in experimental and control group is higher than 0.05, it can be said that procedural knowledge gain data of the experimental and control group are normally distributed.

Testing the homogeneity of procedural knowledge between control and experimental group were done by using Levene statistic with SPSS 17 Program with the significance level 0.05. After analyzing the data, the output can be seen in Table 8.

Table 8. Homogeneity of Procedural Knowledge Gain in Experimental and Control Group

Output	Levene Statistic	df1	df2	Significance
Gain Procedural Knowledge	0.041	1	66	0.840

Based on homogeneity output with Levene Statistic in Table 8, the significance level of procedural knowledge is 0.840. It showed that the significance level of procedural knowledge is higher than 0.05. It can be concluded that control and experimental group came from population that have the same variance, or both classes are homogeneous

Hypothesis testing was done after the data feasibility requirements completed and fulfilled by using Independent Sample T-Test with SPSS 17 Program. Data of conceptual and procedural knowledge were obtained then calculated by using t- test to see post test different average of the 2 groups.

The output of SPSS 17 program for Posttest score of students' conceptual knowledge taught by Scientific Inquiry model and conventional learning can be seen in Table 9.

Table 9. Hypothesis Testing of Students' Conceptual Knowledge Gain in Experimental and Control Group

		T-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Value	Equal variances assumed	.028	.11912	.03923
	Equal variances not assumed	.029	.11912	.03923

Based on Table 9, the significance value is 0.029 <0.05. it can be said that H0 is rejected or Ha is accepted in the significance level of 5% alpha. So, it can be concluded that the students' conceptual knowledge taught with Scientific Inquiry learning model is better than conventional learning.

The output of SPSS 17 program for Posttest score of students' conceptual knowledge taught by Scientific Inquiry model and conventional learning can be seen in Table 10.

Table 10. Hypothesis Testing of Students' Procedural Knowledge Gain in Experimental and Control Group

		T-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Value	Equal variances assumed	.001	.13824	.04404
	Equal variances not assumed	.001	.13824	.04404

Based on Table 10. The significance level is 0.001 <0.05, so it can be said that H0 is rejected and Ha is accepted with the level of 5% alpha. Students' procedural knowledge with Scientific Inquiry learning model is better than Conventional learning. It can be concluded that there

is an effect of Scientific Inquiry Model on students' conceptual and procedural knowledge. It can be seen from the significant result of students' procedural knowledge of Scientific Inquiry group compared to conventional learning group.

4. Discussion

4.1. The Mean Gain of Students' Conceptual Knowledge Taught by Scientific Inquiry Model was Better than Conventional Learning

The result of this research showed that the mean gain of students' conceptual knowledge taught by scientific inquiry model was better than conventional learning.

This better result occurred as scientific inquiry model forced students to solve problems. Applying Scientific Inquiry model developed deeper science concept understanding and formed students' scientific knowledge [7]. Students were expected to be responsible in conducting investigations in identifying problems, hypotheses, designing methods to prove hypotheses, analyzing them and giving conclusions.

According to the National Institutes of Health [12], the process of Scientific Inquiry model has four purposes. The first was to help students understand the basic aspects of scientific inquiry. Science was processed continuously, a process involved and produced hypotheses, gathered evidence, tested hypotheses and obtained conclusion based on evidence. Instead of involving one particular method, Scientific Inquiry was a flexible model. Different types of questions required different types of inquiry.

The results obtained in this research showed that there was a difference of conceptual knowledge in experimental group using Scientific Inquiry model and control group using conventional learning.

The findings of this study were in line with the research conducted [5,9], stated that there was a difference between scientific inquiry and conventional learning on students' learning outcomes. Students' learning outcomes taught by scientific inquiry were better than conventional learning. It showed that the findings of this research was in line with Hussain, but this reseach concerned specifically on learning outcomes measured or conceptual knowledge.

This was supported by [14] findings in an effort to enhance students' scientific process skills. This research used Conceptual Change to enhance students 'cognitive abilities and students' scientific process skills. These finding was in line in the application of Scientific Inquiry learning model was better than conventional learning. But the difference was the use of visual media to assist Scientific Inquiry model.

Some previous researches had been done on scientific inquiry. Dhaaka concluded that learning Biology concepts on students grade IX by using scientific inquiry was more effective than conventional learning [3]. It showed that scientific inquiry had implication in learning process. It was different with this research as it was not assisted by visual media.

Lederman said that explicit integration, reflective instruction about Nature of Sciences (NOS) and Scientific Inquiry (SI) in traditional knowledge content used as media to develop scientific literacy [8]. Inquiry had potential to encourage knowledge perception in wider context that affected students point of view about the world. It was in line with some previous researches but this research was more specific on conceptual and procedural knowledge.

Scientific Inquiry model was the learning model that developed scientific ways of thinking that help students in giving constructive explanation so students learned independently in investigating, solving problems and finding solutions. It was suitable with the nature of physics namely product, process, and scientific attitude. Some steps in getting knowledge were done through observations, formulating problem, hypothesis from experiment, concluding and finding theory and concepts.

The enhancement of students' conceptual knowledge by using scientific inquiry model caused the students to be more careful in analyzing problem, having ability to express ideas in groups and between groups. While in control group, as they had freedom asked teacher directly, the students prefer to ask directly and did not have an effective discussion with their group of friends.

4.2. The Mean Gain of Students' Procedural Knowledge Taught by Scientific Inquiry Model was Better than Conventional Learning

The findings of this study showed that the mean gain of students' procedural knowledge taught by scientific inquiry model was better than conventional learning.

Based on the analysis of procedural knowledge dimension, it was obtained knowledge and skills in certain aspects and algorithm, the knowledge about technique and method in certain aspects, knowledge to define when to use right procedure were different between scientific group and conventional group.

Scientific Inquiry model had effect on procedural knowledge. It involved students in finding solutions of the problems by doing investigation. In doing investigation, students' conceptual knowledge automatically trained so students' procedural knowledge of scientific group was better than conventional group.

Based on second hypothesis testing, it was obtained that scientific inquiry model had effect on students' procedural knowledge. The significant level obtained from t-test was 0.001. It showed the scientific inquiry had effect on students' procedural knowledge which the students' procedural knowledge became better.

It was in line with [13,18] conducted research on scientific inquiry. The difference was this research assisted by visual media and Rahayu's research assisted by pictorial riddle in the enhancement of students' learning outcomes but both of them measured procedural knowledge. Pratiwi stated that scientific inquiry had advantages in enhancing learning outcomes compared with conventional learning [11]. Moreover stated that the deeper conceptual knowledge, the deeper procedural knowledge to analyze phenomena [17].

Based on the results of several previous researchers, it can be seen that those researchers had not used gain in

seeking gain of students procedural knowledge while this research had used n-gain analysis to see the enhancement of n-gain students. The enhancement of students' procedural knowledge on Scientific Inquiry learning model was caused by students were more creative in learning process and having high curiosity presented authentic problems. While in the control group, as they had freedom to ask teacher directly, the students prefered to ask teacher directly and did not have an effective discussion friends in group.

5. Conclusion

The Mean Gain conceptual knowledge of students taught by the Scientific Inquiry learning model is better than students taught by conventional learning in physics learning.

The Mean Gain procedural knowledge taught by the Scientific Inquiry learning model is better than the students taught by conventional learning.

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