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THE EFFECT OF INQURY BASED LEARNING ON THE PROCEDURAL KNOWLEDGE DIMENSION ABOUT ELECTRIC AND MAGNET CONCEPT

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ABSTRACT

The purpose of this study to determine the effect of the use of inquiry-based learning to the increased dimensions of procedural knowledge in electrical magnetic material. The study used a quasi-experimental research methods with research design is non-equivalent control group design and a sampel are selected with the random sampling method. The experimental group was taught by the method of inquiry-based learning and the control group was taught by conventional methods. Collecting data using the instrument of multiple-choice test that developed through this research with category of validity is valid, reliability with category of reliable, index of discrimination with category of low, and level of difficulty with category of medium. The results of the data analysis by using the formula N-Gain and t-test showed that an increase in the dimensions of procedural knowledge siginificantly for experimental class and less significant for control class. Based on the results of this study suggested to the teacher to always use the method of inquiry learning that an increase in procedural knowledge dimension, especially for topics related to experimental physics.

ABSTRAK

Tujuan penelitian ini untuk mengetahui pengaruh penerapan pembelajaran berbasis inkuiri terhadap peningkatan dimensi pengetahuan prosedural pada materi listrik magnet. Penelitian menggunakan metode penelitian eksperimen semu dengan desain penelitian *non-equivalent control group design* dan sampel dipilih dengan menggunakan metode random sampling. Kelompok eksperimen diajarkan dengan metode pembelajaran berbasiskan inkuiri dan kelompok kontrol diajarkan dengan metode ceramah. Pengumpulan data menggunakan instrumen tes pilihan ganda sebanyak yang dikembangkan melalui penelitian ini dengan validitas termasuk kategori valid, reliabilitas baik, indek daya pembeda dengan kategori kurang, dan tingkat kesukaran dengan kategori sedang. Hasil analisis data dengan menggunakan rumus *N-Gain* dan *uji-t* menunjukkan bahwa terjadi peningkatan dimensi pengetahuan prosedural secara signifikan pada kelas eksperimen dan kurang signifikan untuk kelas kontrol. Berdasakan hasil kajian ini disarankan kepada pengajar (Guru) untuk selalu menggunakan metode pembelajaran inkuiri agar terjadi peningkatan dimensi pengetahuan prosedural, terutama untuk topik-topik fisika yang terkait dengan percobaan.

Keywords: Dimesion of procedural; Experimental physics; Inquiry method

INTRODUCTION

Indonesia's participation in several events of the Trends in International Mathematics and Science Survey (TIMSS) has not shown satisfactory results. Indonesia ranked 32 out of 38 countries at the beginning of the year of its participation in TIMMS. Furthermore, Indonesia was ranked 36 out of 45 countries in 2003, ranked 35th out of 48 countries in 2007 and ranked 40th of 42 countries in 2011 (TIMSS, 2011). This low ranking includes cognitive, affective and skill domains.

The cognitive domains based on the

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framework of Anderson and Krathwohl (2001) include the dimensions of knowledge, namely; dimensions; (1) factual; (2) conceptual; (3) procedural; and (4) metacognitive. The dimensions of factual include knowledge of (i) terminology, and (ii) details and elements. The dimensions of conceptual include knowledge of (i) classification and categories, (ii) principles and generalizations, and (iii) theories, models, and structures. While the dimensions of procedural include knowledge of (i) specific skills and algorithms, (ii) techniques and methods, and (iii) criteria for the use of a procedure. Finally, the dimensions of metacognitive are knowledge of (i) strategy, (ii) cognitive operations, and (iii) about themselves.

According to Anderson and Krathwohl (2001) it can be summarized that the dimensions of procedural are more emphasized on the process, 'how' something can happen and how it can be solved by using certain steps in the solution. Several other experts further argue that the dimensions of procedural can be defined as a process of science activity that requires methods, steps to solve a rise problem to obtain meaningful conclusions at the experimental effort stage. This is in accordance with Hemado's (2013) opinion, which stated that, "Procedural knowledge is the acquisition of skills related to step-by-step actions in solving problem context". In line with the opinion expressed by Lanzer and Taatgen (2013) that "Procedural knowledge is critical to instruct action, yet being mostly tacit it is difficult to access".

Based on this definition, it appears that the dimensions of procedural knowledge are contained in the syntax of inquiry-based learning. These dimensions of procedural knowledge in terms of problem identification skills, formulating research questions, designing investigations, and communicating results are reflected in inquiry-based learning (Krugly & Taylor, 2004; Selby, 2006). The advantages of inquiry study have been studied by some researchers and it gives a significant outcome to student achievement. Among them are mastery of concepts, critical thinking skills and scientific literacy can be improved through the implemantation of inquiry-based learning (Kurniawanti, Wartono, & Diantoro, 2014; Arief & Utari, 2015). Furthermore, the National Science Teachers Association (NTSA) concluded that learning by inquiry approach is capable of encouraging students to conduct investigation and gain knowledge (NTSA, 2004).

Some research results also show that inquiry-based learning can increase students' metacognitive (Kipnis & Hofstein, 2008), build student knowledge, reasoning and arguments (Wilson, CD, Taylor, JA, Kowalski, SM, & Carson, J., 2010; Nivalainen , Asikainen, & Hirvonen, 2013), enhancing conceptual understanding (Sarwi, Sutardi, & Prayitno, 2016), and the dimensions of procedural and conceptual knowledge can last longer if taught by inquiry approach (Kwon, Rasmussen & allen 2005). Moreover, inquiry-based teaching also has a strong analogy with Problem solving and Problem Based Learning approaches (Parr & Edwards, 2004).

Based on the opinion of the experts and their research results, then course-based learning inquiry can be extended its use to improve the procedural knowledge on the concept of physics, such as magnetic electricity. The structure of the magnetic case resolution is closely related to the dimensions of procedural knowledge (McCormick, 1997). Therefore, the purpose of the study was to determine the effect of the application of inquiry-based learning to the increasing dimensions of procedural knowledge on magnetic electrical materials.

In particular it is important to explore improvement of the procedural knowledge dimensions as well as exploring empirical information on indicators of achievement from the dimensions of procedural knowledge as the impact of inquiry-based learning. Improvement of the procedural knowledge is intended to the components of skills, rules, actions, and outcomes. The enhancement of the components of procedural knowledge can be determined after being compared between the treated group (experimental class) and the untreated group (control class). The comparisons between the two groups can be made or justified statistically if both groups have normally distributed and homogeneous data (Arikunto, 2009).

METHOD

The method and type of research used are quantitative and quasi experimental with non-equivalent Control Group Design research as shown in Table 1.

The research is done through two stages, namely the first stage of instrument development and the second stage is the implementation of research or implementation of research instruments that have been developed in the first stage. The development of research instruments begins with the definition of terms from theoretical and operational dimensions of procedural knowledge, the preparation of indicators, the writing of test items, the process of limited trials, testing the validity and reliability of the instruments.

Table 1. Research Design

Classes	Sampling	Pre test	Treatment	Post test
Exp	Non-random	Q1	Inquiry	Q3
Control	Non-random	Q2	Discourse	Q4

(Fraenkel, Wallen & Hyun. 2012)

Implementation phase of the instrument is done by using quasi experimental research method begins with sample selection, preparation of inquiry-based learning design for experimental class (28 students) and discourse-based learning design in control class (27 students). Implementation of research on experimental class is done by using syntax include; (i) formulating the problem, (ii) preparing the hypothesis, (iii) designing the experiment, (iv) conducting the experiment, (v) collecting and analyzing the data, and (vi) drawing conclusions. In the control group implementation of learning in accordance with the syntax of learning discourse method.

To measure the improvement of the procedural knowledge dimensions, an instrument called the Measurement Instrument for the Dimensions of Procedural Knowledge (MI-DPK) on magnetic electrical materials was developed. The MI-DPK test instrument consists of 20 multiple-choice items on magnetic material. Instrument validity test using product moment Pearson correlation equation and reliability test using Cronbach's Alpha (CA) equation (Arikunto 2009).

The limited test results of the instrument show that the average validity is 0.44 (valid), reliability is 0.76 (good), the difficulty level is 0.30 (medium), and the difference is 0.18 (low). After the validity test by the experts and limited trials, 13 valid items were obtained and used to measure the dimensions of students' procedural knowledge on magnetic electrical topics.

Data were collected using MI-DPK tests prior to treatment (pretest) and after treatment (posttest), both for the control group and experimental group. In order to be able to recognize the increase in procedural knowledge, the MI-DPK test is based on three procedural knowledge indicators (Cauley, 1986), ie skills, rules, actions and goals of subject learning. Based on these indicators are compiled test items on magnetic electrical material with a composition of five items of the skills indicator, four items from the rules indicator, six items from the action indicator, and five items from the goals indicator. Data analysis in this research use t-test statistic equation and normalized G-factor (N-Gain) calculation (Cheng, 2004).

RESULTS AND DISSCUSSION

Data obtained in this research is quantitative data which is derived from the test results using MI-DPK. Data on pre-test results in the control class (27 students) and in the experimental class (28 students) were used to test normality and homogeneity.

The result of normality test of data using Liliefors Test showed that the control class data and experiment class were normally distributed with L_{calc} of 0.131 and 0.156 respectively. The data L_{table} is 0.163, it can be concluded that either the data from the control group or from the experimental group is normally distributed. Homogeneity test was done by using variance analysis and obtained for control group 139.96 and experimental group 220.97. Based on the two values of the variance, the value of F_{calc} = 1.58, while the value of F_{table} = 1.98 and this shows that the pre-test results are homogeneous. To know whether the increase is at a significant level of 0.95 or not, it is necessary to test the hypothesis.

The null hypothesis formulated is that there is an influence of the use of inquiry methods to the increasing dimensions of procedural knowledge of high school students in dynamic electrical topics". Hypothesis testing is based on the result of different test analysis between experimental class taught by inquiry method and control class which is taught by discourse method by using t-test formula. A summary of the results of the hypothesis test and decision test is shown in Table 2.

The impact of the implementation of inquiry methods in increasing dimensions of procedural knowledge can be obtained from the calculation of normalized N-Gain values. The N-Gain values for the experimental and control groups were 0.424 and 0.174, respectively. This means that the experimental group taught by inquiry method increases the dimension of procedural knowledge more significantly than the control group which taught by the discourse method. To assess the impact of inquiry-based learning, it is necessary to examine the increasing dimensions of procedural knowledge for each component.

Table 2. Results of pretest and posttest data analysis

Class	Data of	Average	t_{calc}	t_{table}	Decision
Experiment	Pretest	33.19	10.74	2.01	H_a accepted
	Postest	68.17			
Control	Pretest	33.54	4.67	2.01	H_a accepted
	Postest	48.46			
Experiment	N-Gain	0.42	4.03	2.01	H_a accepted
Control		0.17			

Procedural Knowledge on Skills Component

The procedural knowledge data per indicator for the experimental class is shown in Table 3 and for the control class shown in Table 4.

Table 3. Pretest and postest procedural knowledge data of the experiment group

Indicators	Pretest	Postest	N-Gain	Categories
Skills	1.6	2.5	0.38	moderate
Rules	1.0	3.3	2.19	high
Actions	1.2	2.7	0.52	moderate
Goals	1.2	2.9	0.93	high

Table 4. Pretest and postest procedural knowledge data of the control group

Indicators	Pretest	Postest	N-Gain	Categories
Skills	1.8	1.5	-0.14	low
Rules	1.3	2.0	1.00	high
Actions	1.4	1.9	0.19	low
Goals	0.9	2.6	0.81	high

The procedural knowledge indicator on the skill component is knowledge related to the selection of tools and materials needed to understand a concept. After applying inquiry learning on magnetic electrical topics, there was an increase in skill indicators by 0.38 with moderate category for experimental class and 0.14 with low category for control class. Improvements that occur in the experimental class were occurring since they are supported by one of the inquiry-based learning syntax that trains students in choosing the experimental tool or material. This result is in accordance with the data obtained by previous research, where there is an increase in students' ability to do experiments after applied guided inquiry method (Kurniawati, Wartono, & Diantoro, 2014, Damawati & Juanda, 2016).

Procedural Knowledge on Rules Component

Indicators of procedural knowledge on the components of rules related to the understanding and the ability to know the procedure of problem resolution appropriately and correctly. According to Anderson and Krathwohl (2001) the dimension of knowledge is also related to knowledge of skills and algorithms. Therefore, in this research there are four multiple choice problems about electric circuit developed related with procedure to know the increasing of knowledge dimension in rules component.

The data for this indicator is shown in Table 3 for the experimental class and Table 4 for the control class. The results of data analysis shows that after the students are taught by method of inquiry there is an increase of component of rules of 2.19 with high category of experimental class and 1.00 with high category of control class. There is a relatively high increase, compared to other indicators, because the three syntax of inquiry-based learning fits perfectly with the procedural rules, namely (i) the formulation of the problem, (ii) the preparation of the hypothesis, and (iii) designing or assembling experiments (McCormick, 1997; Cauley, 1986; Anderson & Krathwohl, 2001).

Increasing the procedural knowledge dimension of the rules component is also in accordance with the results of research conducted by Sarwi, Sutardi, and Prayitno (2016), where the application of guided inquiry method can improve procedural understanding in conducting experiments. The relevant research results is also demonstrated by Darmawati and Juanda (2016), where inquiry-based learning can improve reasoning ability. The reasoning abilities are the main factors for procedural understanding (Cauley, 1986).

Procedural Knowledge on Action Component

The action indicators on this knowledge dimension are related to the problem-solving ability appropriately and may indicate the relationships between methods and techniques (Cauley, 1986). Therefore, to measure the indicators, six multiple choices problems have been developed regarding the procedural actions in electrical circuitry. The data for the action indicator are shown in Table 3 of the experimental class and Table 4 for the control class. The results of data analysis showed that after applied inquiry based learning there was an increase of indicator score of 1.5 with moderate category for experimental class and 0.19 with low category for control class. An increase of 1.5 in the medium category, one reason is that there is only one stage of inquiry-based learning syntax which is related to procedural knowledge of action, collecting and analyzing data (Junike, Halim & Yusrizal, 2016).

Students' action in collecting and analyzing data needs to be supported by the ability to think hypothetically deductive, combinative and reflective thinking, as well as proportional thinking. The results of research by Derlina and Mihardi (2015) show that inquiry-based learning can improve the ability of reflective and reflective thinking in the medium category, while the ability to think proportionally in the high category.

Procedural Knowledge on Results Component

The indicators results components are related to understanding the sequence of actions taken to achieve the objectives (Cauley, 1986; Anderson & Krathwohl, 2001). Therefore, in the research five questions of multiple choices on electrical topic have developed to measure indicator of results component. The data for the indicators are shown in Table 3 for the experimental class and Table 4 for the control class.

The result of data analysis shows that the implementation of inquiry learning model has increased this indicator by 0.93 with high category for experimental class and 0.81 for control class. Despite an increase in the high category, it remains lower than the increase in the rule component indicator (2.19). One reason is that the syntax of inquiry learning associated with this indicator is only one stage, that is, the activity of making conclusions. This means that the time spent by students to carry out lesson-related learning activities with results indicators is quite short. Relevant research in accordance with the results of this study was conducted by Sarwi and Khanafiyah (2010), where the application of open inquiry methods can improve scientific work skills in the course of the wave. Scientific work skills are the main factors for understanding the sequence of actions in achieving the learning objectives.

CONCLUSION

Based on the results of this study obtained the conclusion that the implementation of inquiry-based learning in general affects the increasing dimensions of procedural knowledge. Four indicators of procedural knowledge dimensions, the highest increase is the indicator of rules component in the experimental class as well as in the control class. The most low-level indicators are skills component in the experimental class as well as in the control class.

The results of this study also inform that the dimensions of procedural knowledge, as one dimension of knowledge in the cognitive domain of Taxonomy Bloom revised edition, can be improved through the implementation of inquiry-based learning, especially open and guided inquiry types. The indicator of the rules component that achieves the optimal increase occurs because of continuous inquiry-based learning process support and simultaneous tracing of this component. It is means that there is a great opportunity to improve the output of other components by innovating on this inquiry model.

Based on the results obtained from this research it is propose to stakeholders or anyone who has the power to manage policies, to be encouraged to teachers and lecturers using inquiry methods to improve the dimensions of procedural knowledge. Using the same method may also be enhanced the dimensions of conceptual, factual and metacognitive knowledge. To prove this allegation, further research is needed.

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