JOURNAL
OF BALTIC
SCIENCE
EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

THE EFFECTIVENESS OF EVIDENCE-BASED REASONING IN INQUIRY-BASED PHYSICS TEACHING TO INCREASE STUDENTS' SCIENTIFIC REASONING

Nia Erlina,
Endang Susantini,
Wasis,
Iwan Wicaksono,
Paken Pandiangan

Abstract. *Evidence-Based Reasoning (EBR) is a framework of inquiry-based teaching for developing scientific reasoning. This research aims to analyze the effectiveness of EBR in inquiry-based Physics teaching to improve students' scientific reasoning. Applying Slovin formula for sample determination, the research involved 139 upper-secondary school students with similar prior knowledge. This research used one group pre-test post-test design with replication. The effectiveness of teaching on improving scientific reasoning was analyzed by using Paired Sample T-test. ANOVA was used to analyze the consistency of the teaching effectiveness across in test group. The findings indicated that EBR effectively improved students' scientific reasoning in inquiry-based Physics teaching based on two main grounds. On the first, the significance was ensured by N-gain category of scientific reasoning component, which proved (a) control of variables reaching high category, (b) proportional thinking at moderate category; c) probabilistic thinking reaching moderate category, (d) hypothetical-deductive reasoning attaining low category; and (e) correlational thinking achieving low category. In addition, the level of scientific reasoning has attained the experience characterized by slightly imperfect answers. Students voiced positive response to EBR, which stated that it helped them engage in scientific reasoning in Physics learning. They also voiced the general opinion on EBR and inquiry-based learning in general.*

Keywords: *evidence-based reasoning, inquiry teaching, physics teaching, scientific reasoning.*

Nia Erlina, Endang Susantini, Wasis
State University of Surabaya, Indonesia
Iwan Wicaksono
University of Jember, Indonesia
Paken Pandiangan
Indonesia Open University, Indonesia

Introduction

The transfer of learning calls forth meaningful learning process relevant to the characteristics of subject being learnt. Physics encompasses characteristics pertinent to concepts and mathematics through scientific method. Inquiry has been the cornerstone of effective science learning to construct knowledge through scientific method and reasoning since the 1960s (Barz & Achimaş-Cadariu, 2017; Sudria, Redhana, Kirna, & Aini, 2018). Inquiry-based teaching has been applied by Education Minister Regulation of the Republic of Indonesia of 2016 as a standard of the teaching process through experiment, representation of experimental results in the form of a table, graph, and argument. The preparation of scientific argument is done orally and written to empower students' reasoning in that they are encouraged to ponder the characteristics of certain subjects, especially Physics on the topic of heat (Kant, Scheiter, & Oschatz, 2017). The learning process in Physics not only requires theoretical content of Physics in the form of fact, concept or principle but also calls for investigation, evidence collection, analyzes and evaluation on the understanding of Physics (Erlina & Wicaksono, 2016; Toplis, 2015). Mastering empirical Physics content requires evidence or fact and systematic reasoning result from investigation to encourage meaningful teaching Physics (Cepni, 2017; Erlina, Susantini, & Wasis, 2017; Susantini, Faizah, Prastiwi, & Suryanti, 2016).

Knowledge of Physics content has a strong relationship with scientific reasoning (Ewen, Schurter, & Gundersen, 2012; Moore & Rubbo, 2012). The fact shows that scientific reasoning is still relatively weak and hardly developed in learning Physics content. For example, students' investigation for answers is not accompanied by scientific reasoning (Kisiel, Rowe, Vartabedian, & Kopczak, 2012). In addition, high upper-secondary school students' in Surabaya results show that they are found to reach only the average score of 38.7 (low category) with respect to scientific reasoning ability. The results of similar research also indicate that scientific reasoning of high upper-secondary school students in Jember is still low, as marked by an average score of 27.22 (Erlina, Wasis, & Rosyid, 2016). Students have difficulties in defining experimental variables and interpreting as well as analyzing graphs or data. Students' low scientific reasoning is evinced by the fact that they are able to choose mathematical equations correctly, but there is still potential ambiguity when determining its meaning (Brookes & Etkina, 2015).

Low scientific reasoning results form several downsides. First, the development of scientific reasoning in learning is still poor. This poor development is characterized by a narrowed discussion of abstract ideas with minimum communication. Moreover, the demand of Science examination is still limited to low-level cognitive form of memorization and understanding, rather than testing analytical skills and high-level reasoning (Kind & Osborne, 2017; Piekny & Maehler, 2013). Another issue is related to scientific reasoning process and has not been involved in the laboratory experiment. Students spend more time collecting data or implementing procedures rather than discussing data analysis, interpreting data, and drawing conclusions (Dolan & Grady, 2010). The other shortcoming is concerned with the application of inquiry diverting from the philosophical foundation and theoretical study, which is still common among teachers when constructing students' knowledge. The advantages of constructing knowledge by inquiry include increasing students' reasoning in the ability of free thinking (Coiro, Castek, & Quinn, 2016). The resultant free thinking, in fact, diverts inquiry from achieving its actual goal. The implementation of inquiry is generally done directly, leading to the hypothesis testing stage rather than to the preparation of hypotheses (Dolan & Grady, 2010; Thoron & Myers, 2012).

Inquiry-based teaching provides an opportunity to build insights into facts in the surrounding environment (Vlaardingerbroek, Taylor, Bale, & Kennedy, 2017). Constructivist perspective as the underlying philosophical framework of inquiry finds the prior knowledge and students' role as a discoverer to predict and explain physical phenomena/concepts (Buell, Greenstein, & Wilstein, 2017; Edwards & le Grange, 2017). Students are required to collect relevant information and use it as a basis for formulating hypotheses, analyzing data, and linking fact and concept that underlie the process of drawing conclusions and problem solution (Chen, Wang, Dede, & Grotzer, 2017; Erlina, Jatmiko, & Wicaksono, 2015; Pandiangan, Sanjaya, Gusti, & Jatmiko, 2017). Inquiry teaching requires the instructional design that emphasizes the process of analytical thinking to seek and to find out the answer to a problem at hand (Akkuzu & Uyulgan, 2017; Erlina, Jatmiko, & Raharjo, 2016). The role of scientific reasoning is required to formulate the question and determine interpretation that is not supported by reliable evidence (Metz, 2017). The preparation of drawing conclusions from inquiry activities requires the identification of assumptions and critical as well as logical thinking skills (Lederman, Lederman, Bartos, Bartels, Meyer, & Schwartz, 2014). The scientific reasoning which is developed based on the basis of a dual-process theory produces rational, logical, and systematic thinking process to develop scientific reasoning (Amsel, Klaczynski, Johnston, Bench, Close, Sadler, & Walker, 2008). The implementation of inquiry-based teaching calls for analysis, interpretation, and application to improve the quality of logical reasoning, argument, and conclusion. Teaching activities provide students the opportunities to construct logical claims which are contained in Evidence-Based Reasoning (EBR) (Brown, Nagashima, Fu, Timms, & Wilson, 2010).

EBR is an inquiry-based framework which is able to generate scientific reasoning in experimental and predictive activities. EBR aims to support students' and teachers' understanding of the scientific reasoning process, examine and identify the development of scientific reasoning, and assess scientific reasoning in the formative and summative assesment. This framework shows two inputs in the form of premises and data processed through three different steps, comprising of analysis, interpretation, and application to create claims. Claims as outputs are based on a hypothetical-deductive reasoning process. The conclusion of hypothetical-deductive results in the form of scientific knowledge is constructed from the generalization of data, evidence, and rules (Brown, Nagashima, Fu, Timms, & Wilson, 2010). EBR uses generalization results as general knowledge that can develop specific knowledge and reasoning. In addition, EBR can develop scientific reasoning based on phenomena (Hardy, Kloetzer, Moeller, & Sodian, 2010). Cognitive psychology is divided into two main aspects to develop scientific reasoning, namely the investigative process of procedural knowledge and the inferential process of conceptual knowledge (Pelamonia & Corebima, 2015). These two main aspects can be actualized in an inquiry-based Physics teaching where an inquiry approach effectively can help students develop their ability to link scientific evidence and findings (Sutman, Schmuckler, & Woodfield, 2010). The consistent and logical linkage of evidence and scientific findings requires the implementation of EBR in inquiry-based Physics teaching to improve students' scientific reasoning.

EBR in inquiry-based Physics teaching has the advantages of providing two inputs of premise and data through three different reasoning processes (analysis, interpretation, and application) in the inquiry process. The process of reasoning encompasses: (1) analysis, which relates to collecting and linking observation results to produce and describe a statement as evidence; (2) interpretation, changing the evidence into a fairly general statement (linking evidence to the rule) before being applied in a new situation to make the evidence meaningful; and (3) application, describing the relationship rules that support certain things which are described by the premise. The scientific reasoning using EBR, especially in inquiry-based Physics teaching, can show how competent students are to perform the components of scientific reasoning, i.e. control of variables, proportional thinking, probabilistic thinking, correlational thinking and hypothetical-deductive reasoning (Ding, Wei, & Liu, 2016; Lawson, 2000; Piraksa, Srisawasdi, & Koul, 2014).

Research Problem

The present study was backgrounded by the fact that the students' scientific reasoning ability was hardly developed. The scientific reasoning ability under investigation was considered weak, regardless of the implementation of inquiry-based learning as stipulated in the curriculum (Erlina, Wasis, & Rosyid, 2016). The problem in this research was to analyze how effective EBR can improve students' scientific reasoning in inquiry-based Physics teaching. EBR was said to be effective when the teaching process statistically resulted in a significant increase in students' test scores before and after learning, which were atomized into the five components of scientific reasoning defined by the N-gain score.

Research Focus

The focus of this research was to analyze the effectiveness of EBR on inquiry-based Physics teaching on scientific reasoning with respect to the components of scientific reasoning. The analysis included the following questions: (1) are there significant (statistical) effects on scientific reasoning before and after the teaching process using EBR?; (2) what is the category of scientific reasoning achieved after the EBR application?; and (3) is there a difference in the increase of students' scientific reasoning in the 4 test groups?

Methodology of Research

General Background

The scope of this research was concerned with the application of EBR to improve students' scientific reasoning. The research focused on the formal operational stage using Physics subject concerning Heat in odd semester of Academic Year 2017/2018. Scientific reasoning was analyzed to determine whether there were different pre-test and post-test scores. N-gain calculation could be used to categorize students' scientific reasoning on the Physics subject whether they were in high, moderate, or low category in the 4 test groups. N-gain calculation could be used to categorize students' scientific reasoning whether they were in high, moderate, or low category in the 4 test group upper-secondary school 3 Jember, East Java.

Research Sample

The research involved 139 students from the population of 213 students in upper school who had moderate criteria based on the average scores achieved in the national exams. The number of the research samples were determined based on the Slovin formula with error margin of e = 5% i.e. [sample = population / 1 + (population × e^2)] (Sevilla, Ochave, Punsalan, Regala, & Uriarte, 1984). Students were divided into 4 test groups with the same basic concept and scientific reasoning characteristics i.e. C1 (36 students), C2 (35 students), C3 (35 students), and C4 (33 students).

Instrument and Procedures

This research was conducted using pre-test and post-test design with 4 replications (Fraenkel, Wallen, & Hyun, 2012). Scientific reasoning test which used pre-test was given before the treatment, and post-test was given after the EBR in inquiry-based Physics teaching was implemented. The implementation of EBR in the teaching process was related to syllabus, lesson plans, and student worksheets. The stages of EBR activities in inquiry-based Physics teaching consisted of analysis, interpretation, and applications. The EBR framework in inquiry-based Physics teaching is as follows.

Table 1. 7 Framework of EBR in inquiry-based teaching.

Activity		Scientific Reasoning	Result
1. Define a problem	Analysis		Premise Question
2. Develop a hypothesis		Control of variables	Hypothesis formulation Experiment variable Experiment result data
3. Search for evidence		Proportional thinking	Evidence-based on experiment Result data
		Probabilistic thinking	
4. Draw a conclusion	Interpretation	Hypothetical-deductive reasoning	Rules
			Deductive hypothesis
5. Test the adequacy of the conclusion	Application	Correlational thinking	Claim (relation premises and rules)
			Explanation claims

The evaluated scientific reasoning components consisted of (1) Control of Variables (CV), i.e. identifying independent variables and dependent variables; (2) Proportional Thinking (PPT), i.e. determining the relationship between variables using numbers, mathematical equations, tables, and graphs; (3) Probabilistic Thinking (PBT), i.e. predicting the resulting opportunity obtained when conducting replication; (4) Hypothetical-Deductive Reasoning (HDR), i.e compiling a hypothesis based on a general concept to a specific concept; and (5) Correlational Thinking (CT), i.e. creating mutual relationships (interrelated or unrelated) between variables (Piraksa, Srisawasdi, & Koul, 2014). Mastering concept in the pre-tests as a basic ability in scientific reasoning, referring to revised Bloom's taxonomy, consisted of remembering, understanding, applying, analyzing, evaluating, and creating (Lee & She, 2010; Williams, 2017).

The scores of students' scientific reasoning responses using three-tier-test items were described as follows. First, the students were able to choose the first option correctly. Also, the reason was perfectly correct on the second level. They were sure with the answer (score 4). At a lower level, the students were able to choose the first option correctly, but the reason was slightly imperfect on the second level. Also, they were sure with the answer (score 3). At score 2, the students were able to choose the first option correctly, yet the reason was incorrect on the second level. Moreover, the students were sure of the answer. At score 1, the students were sure with the incorrect alternative answer on the first level. Lastly, the students were sure with the wrong answer or the students were unsure of the answer (score 0) (Kirbulut & Geban, 2014).

Data Analysis

The students' answers indicating scientific reasoning were analyzed at each level, consisting of (1) expert, i.e. showing perfect answer marked by correct answer through a coherent argument; (2) experienced, i.e. showing slightly imperfect answers indicated by correct answer through incoherent argument; (3) competent, i.e. showing answers resulting from memorization; and (4) novice, i.e. showing answers lacking knowledge or indicating misconception in scientific reasoning. The score range for each level was as follows: (1) expert, marked by correct answer ranging from 75% to 100%; (2) experienced, marked by correct answer ranging from 50% to 75%; (3) competent, marked by correct answer ranging from 25% to 50%; and (4) novice, marked by correct answer ranging from 0% to 25% (Hagen & Creek, 2014). The increase in scientific reasoning was based on the N-gain (post-test score – pre-test score) / (100 – pre-test score) (Hake, 1998) based on the following criteria: (1) N-gain $\geq .70$ (high); (2) $.30 <$ N-gain $< .70$ (moderate); and (3) N-gain $\leq .30$ (low).

The effectiveness of EBR application on inquiry-based Physics teaching on improving scientific reasoning was determined by the scores achieved on the pre-test and post-tests. The difference was analyzed by using Paired Sample T-test. The Signed Rank Test or Wilcoxon Sign Test was used to check whether data normality or non-parametric data were evident. Furthermore, the consistency analysis on improving students' scientific reasoning used N-gain calculation of each test group, employing Analysis of Variance (ANOVA). The Kruskal-Wallis Test would be applied when normality or non-parametric data was ensured. Students' opinions about the application of EBR to scientific reasoning were analyzed descriptively and qualitatively by using the Guttman scale (Guttman, 1944). Students who answered Yes would get 1 and students who answered No would get 0.

Results of Research

This research presented the entire supporting data of the effectiveness of EBR in inquiry-based Physics teaching with respect to the following aspects: (1) mastering the prior concept; (2) pre-test and post-test of scientific reasoning; (3) N-gain scientific reasoning; (4) statistical analysis of scientific reasoning consistency; and (5) student response to teaching. Figure 1 shows the percentage of N-gain criteria of scientific reasoning components in 4 groups. The percentage of students with N-gain reaching high criteria on the control of variables component outnumbered those of the other components. Different results were evident in components of hypothetical-deductive reasoning and correlational thinking, i.e. the largest percentage of students' N-gain was achieved at low N-gain value. Table 2 shows the N-gain value of each component of students' scientific reasoning. N-gain on control of variables, proportional thinking, probabilistic thinking, hypothetical-deductive reasoning and correlational thinking was high, moderate, moderate, low, and low respectively.

High increase of variable control showed that most students had good answers. For example, when students worked on the equation about heat, $\Delta Q/\Delta t = k A (\Delta T/l)$, they were able to determine relevant variables to investigate the effect of steel length on the rate of heat transfer. An example of problem requiring proportional thinking was when students analyzed data from the experiment of heat transfer by conduction. Students were able to determine the comparison of temperature changes (ΔT)at test point 1 and test point 2, after test point 1 indicated a reduction in length. Students' answers with respect to probabilistic thinking demonstrated that they were able to determine temperature changes in metal reference point 2 when metal reference point 1 indicated a reduction in length. The students made mistakes in deductive hypothetical reasoning. Students were given scenarios related to heat transfer in several metals (copper, steel and aluminum) accompanied by the analysis results showing that the highest rate of heat transfer was evident in copper, compared to the other two metals. Students chose the wrong answer, that was reducing copper length, as they assumed that shorter metal would lead to higher rate of heat transfer. The components of correlational thinking between variables indicated low results.

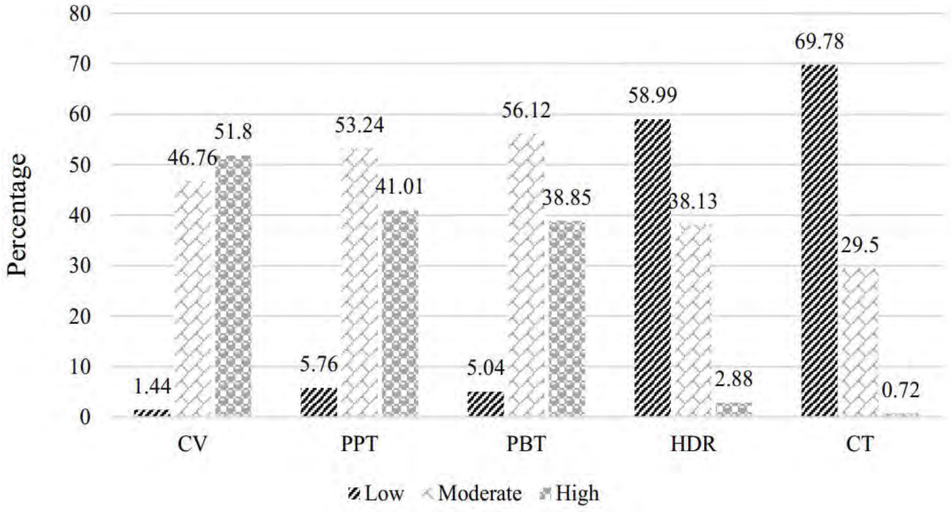

Figure 1. Percentage of n-gain criteria of scientific reasoning components in 4 groups.

Table 2. The average prior knowledge, post-test, and N-gain student scientific reasoning in 4 groups.

Group	Cognitive Level	The Average of Prior Knowledge	Components of Scientific Reasoning	The Pre-Test Average of Scientific Reasoning	The Post-Test Average of Scientific Reasoning	N-gain
C1	Remembering Understanding Applying Analyzing Evaluating Creating	43.93 (< Standard)	CV	22.08 (Novice)	63.06 (Experienced)	.73
			PPT			.70
			PBT			.75
			HDR			.34
			CT			.21
C2		31.54 (< Standard)	CV	20.86 (Novice)	60.00 (Experienced)	.71
			PPT			.67
			PBT			.68
			HDR			.24
			CT			.19
C3		43.44 (< Standard)	CV	21.29 (Novice)	60.14 (Experienced)	.74
			PPT			.65
			PBT			.66
			HDR			.24
			CT			.21
C4		43.93 (< Standard)	CV	21.21 (Novice)	65.45 (Experienced)	.73
			PPT			.65
			PBT			.64
			HDR			.35
			CT			.22

Table 2 shows the average of mastering prior knowledge and scientific reasoning ability each student gained after various teaching strategies were implemented as a general inquiry routine in 4 groups. Students' mastery of the prior knowledge was categorized as low, which was still below the national passing standard, while the average score of the pre-test scientific reasoning was marked at a novice level. It indicated students' answers which lacked knowledge or tainted with the error in the concept of scientific reasoning. The average scores resulting from EBR implementation in inquiry-based Physics teaching in Table 2 show experienced level corresponding to scientific reasoning test results in each group. This category was characterized by the correct answer, although imperfect.

The statistical analysis of scientific reasoning is shown in Table 3. The effective teaching of scientific reasoning on each component of scientific reasoning across the groups showed the same result, as shown by all significant 2-tailed asymptotic results for the *p*-value < .05 applied to parametric tests. Table 3 concludes that EBR poses a significant effect on students' scientific reasoning with a significance level of 5%. A consistency analysis of EBR application was conducted when the students' N-gain scientific reasoning in 4 test groups indicated the normal distribution and homogenous. The ANOVA Test results on each component of scientific reasoning gained 2-tail asymptotic significance for *p* > .05. Table 4 concludes that there is no significant difference in the application of EBR in inquiry-based Physics teaching toward students' scientific reasoning in 4 groups, with a significance level of 5% on each component of scientific reasoning.

Table 3. **The result of statistic using paired sample t-test on students' scientific reasoning.**

Group	Scientific Reasoning Components	Mean	*N*	*t*	*df*	*SD*	*p*
C1	CV	2.36	36	19.59	35	.72	< .0001
	PPT	1.93	36	14.26	35	.74	< .0001
	PBT	2.03	36	18.60	35	.65	< .0001
	HDR	.93	36	7.32	35	.67	< .0001
	CT	.78	36	7.32	35	.64	< .0001
C2	CV	2.26	35	18.01	34	.74	< .0001
	PPT	1.94	35	15.85	34	.72	< .0001
	PBT	2.11	35	18.50	34	.68	< .0001
	HDR	.86	35	6.92	34	.73	< .0001
	CT	.71	35	6.33	34	.67	< .0001
C3	CV	2.14	35	18.74	34	.66	< .0001
	PPT	1.89	35	16.50	34	.68	< .0001
	PBT	2.09	35	16.41	34	.77	< .0001
	HDR	.89	35	7.07	34	.68	< .0001
	CT	.78	35	7.75	34	.65	< .0001
C4	CV	2.33	33	17.25	32	.78	< .0001
	PPT	1.98	33	12.68	32	.79	< .0001
	PBT	2.10	33	15.61	32	.78	< .0001
	HDR	.82	33	6.13	32	.76	< .0001
	CT	.68	33	6.16	32	.70	< .0001

The statistical tests results on the consistency of EBR applications in inquiry-based Physics teaching across groups are as follows.

Table 4. **The result of ANOVA statistic test on the students' scientific reasoning components in 4 testing groups.**

Scientific Reasoning Components	Sum of Squares	*df*	*F*	*p*
CV	6.300	138	2.007	.069
PPT	7.686		1.386	.217
PBT	5.715		1.619	.135
HDR	8.741		1.647	.128
CT	4.129		1.389	.215

The results of student responses to the EBR process are shown in Table 5. Students voiced positive responses to the learning with which they were engaged. Table 5 provides information on scientific reasoning that was not fully mastered by students, namely to develop a deductive hypothesis based on general theory and to determine the interrelationship between variables. Data of student response on scientific reasoning activities were also supported by responses to the EBR process and inquiry-based learning in general. Only some students were able to describe premise presentation, make a logical connection, confirm knowledge, ask the question, and communicate data.

Table 5. Student responses on EBR application.

Criteria	The Percentage of Students Who Answered 'Yes' (%)				Average
	C1	C2	C3	C4	
Teaching activities can help students engage in scientific reasoning:					
a. Control independent and dependent variables	97.22	100	97.14	100	98.59
b. Relationship among mathematical equation, table, and graph	100	100	97.14	100	99.29
c. Prediction of opportunity in replication	100	97.14	94.29	100	97.86
d. Deductive hyphothesis based on general theory	83.33	71.43	80	84.85	79.90
e. Reciprocal relationship (related or unrelated)	72.22	68.57	62.86	72.73	69.09
Teaching activities can help students describe the EBR:					
Analysis					
a. Presentation of the premise takes the attention to learn	72.22	65.71	60	84.85	70.70
b. Data collection based on hands on and minds on	100	100	100	100	100
c. Probing empirical evidence	100	100	97.14	96.97	98.53
Interpretation					
d. Rules bridges data relationship with Physics concepts	97.22	100	97.14	96.97	97.83
Application					
e. Claims make logical connection between premise and rule	80.56	71.43	68.57	75.76	74.08
f. Confirm the knowledge progress	63.89	65.71	60	100	72.40
Teaching activities can help students describe inquiry-based learning in general:					
a. Observation	100	100	97.14	100	99.29
b. Asking and answering question	77.78	71.43	68.57	81.82	74.90
c. Searching information	97.22	94.29	100	100	97.88
d. Collecting data	100	100	100	100	100
e. Analyzing data	100	91.43	97.14	100	97.14
f. Communicating data	77.78	60	62.86	72.73	68.34
g. Constructing knowledge based on experience	100	97.14	100	100	99.29

**C : Testing Groups*

Table 5 concludes that more than 50% of students confirm learning using EBR in inquiry-based Physics teaching helps them to engage in scientific reasoning, to describe the EBR learning, and to describe inquiry-based learning in general.

Discussion

Information from Table 2 shows the students' average prior knowledge in 4 groups before the implementation of EBR in Physics teaching. The mastery of concept was categorized as low, which was still below the national passing standard. The low mastery of students' concepts was influenced by less meaningful learning process even though the inquiry-based teaching process became an obligation (Wicaksono, Madlazim, & Wasis, 2017). Students actively searched information pertinent to Physics only to accomplish low-level cognitive thinking questions in the form of rote definition, recalling the Physics formulas, applying Physics formulas with simple mathematical operations, and reading single graphs. In addition, the number of students' cognitive performance reaching high level in Physics learning examination was still low. The types of problem in the examination did not contain high-level questions, even though students mastered Mathematics skills needed to solve problems in Physics. The mathematical skills that students mastered did not help them to apply concepts to certain context in Physics (Motlhabane, 2017). In addition to the low achievement, the information that students gained to support their work on Physics resulted from free learning resources without a facilitator. Freedom of information generated a collection of irrelevant information that became the trigger for student misconceptions (Erman, 2017). Low thinking claim process along with unclear information was the factor causing students' low meaningfulness in learning, so it influenced the mastery of Physics concept. Constructivist learning theory suggests that teachers should encourage and direct students' attention to important concepts to learn and to connect new material with known things (prior knowledge) as they interact with the environment (Moreno, 2010). The theory contributes to the need for the involvement of students' thinking skills to construct knowledge by involving data, evidence, and rules. As such, learning leads to meaningful understanding (Brown, Nagashima, Fu, Timms, & Wilson, 2010).

The pre-test result of students' indicated the average students scientific reasoning reaching novice level. It indicated that the answers were characterized by the lack of knowledge or misconceptions in doing scientific reasoning. The low scientific reasoning was caused by the application of inquiry teaching, which diverted from the philosophy of inquiry. However, this erroneous reasoning has become the provision of curriculum competence. Teachers do not emphasize hands-on and minds-on activities in inquiry-based Physics teaching so that students are less involved doing analysis, interpretation and elaborating theoretical and mathematical Physics concepts. Another impact was that the ability of scientific thinking became underdeveloped, though the inquiry-based teaching is applied because students were not trained for analyzing, synthesizing, and creating (Azar, 2005; Cepni, 2017). Students experienced difficulty in performing high-level thinking and practicing reasoning patterns. As a corollary, this limitation led to the failure of achieving scientific reasoning in inquiry teaching implemented. Piaget's cognitive development model states that students have different stages of development prior to reaching the stage of formal operational reasoning, which is scientific reasoning. Piaget's theory contributes to optimizing the stage of student development through scientific reasoning inquiry process because scientific reasoning is the end of the developmental ability and the characteristic of intellectual maturity that can be trained (Piaget, Inhelder, & Piaget, 2013).

The implementation of EBR in inquiry-based Physics teaching resulted in the experienced level as shown by the average scores of the scientific reasoning test results in each group. It showed the category of slightly imperfect answer with the correct choice of the answer through incoherent arguments. The result of learning scientific reasoning at experienced level was characterized by the ability to build general concepts or support arguments theoretically, and the experiment results were obtained from through hands-on and minds-on activities. The hands-on activity allowed students to collect data through experiment and laboratory activities, so it motivated students' motor sensory to concretize their alternative concepts (Tajudin & Chinnappan, 2016). EBR teaching activated students' abstract thinking abilities in inquiry learning as minds on activity by making logical connections between premises and rules. When analysis focused on the students' responses, all students reported that they were able to engage in probing relevant information and evidence when conducting inquiry, but some students were still having difficulty doing the correlational thinking. The stages of EBR in inquiry-based Physics teaching were in line with the search for relevant information where students knew the relevance of the evidence and theory or concept. As a result, a problem can be solved easily (Slavin, 2009). Evidence-based teaching is in line with constructivist learning. Constructivist philosophy gives students the flexibility to think through inquiry activities as new experiences which are internalized through previous or existing experience (Akpan & Beard, 2016).

Table 2 shows the N-gain of each component of students' scientific reasoning. The N-gain of variable control's component reached high category. Students who achieved high category achieved a greater percentage than the number of students in the category of moderate and low. It is shown in Figure 1, most students were able to choose the alternative choice on the first level correctly, the reason was perfectly correct on the second level, and they were confident with the answer. When students were given the heat concept in mathematical equations, they were able to determine the variables to investigate the effect of steel length on the rate of heat transfer. Students also presented scientific explanation concerning the fact that the variation in metal length was obtained by determining the test point of the heat source. Therefore, the rate of heat transfer could be known. Control of variable is a basic ability of the learning process in school and science literacy, but it will not develop without instruction (Schwichow, Croker, Zimmerman, Höffler, & Härtig, 2016). Most students were capable of controlling variables because EBR teaching presented a premise that expressed an initial statement. For example, this metal rod has a short size. The presentation of initial statement was relevant to the research results which indicated that the expression of statement is useful to draw students' attention in the learning process (Wecker, 2013). This research showed that the initial statement of the premise was able to stimulate students to recall the magnitudes of Physics concepts because it was in line with the theory of information processing. Information processing theory suggests that the ways of presenting information can influence the ways by which students process information (Joyce, Weil, & Cahoun, 2009).

The implementation of EBR in inquiry-based Physics teaching resulted in N-gain of proportional and probabilistic thinking components in moderate category. Table 2 and Figure 1 show that the N-gain of component of proportional thinking in moderate category, which was also marked by the most percentage of N-gain. The results of scientific reasoning test generally showed that the first level of choice alternative was correct. The reason on the second level was slightly imperfect, and the students were sure with the answer. Students were able to determine the temperature change on the metal at reference point 2 when the metal at reference point 1 had a long reduction, but they still had difficulty in delivering the argument behind their answer clearly. Proportional reasoning illustrates important concept and thinking required to understand level, ratio, and proportionalities, including scale (Norton, 2005; Nunokawa, 2012). The N-gain corresponding to the proportional thinking skill in moderate category was supported by the research result indicating that the involvement of experimental activity resulted in a consensus-proportional thinking skill (Schwarz & Linchevski, 2007). N-gain with moderate category was also achieved in the proportional thinking component. Only a few students on the proportional thinking component attained high N-gain. Students with high N-gain supported the answer concerning the heat transfer rate of copper material, which was greater than that of steel material. Students provided answer coupled with scientific arguments in the form of mathematical calculations supplemented by conceptual support about the effect of thermal conductivity of the material. The students' answers showed that EBR teaching developed students' abstract thinking skill. The proportional thinking skill was students' mental characteristic in cognitive competence dealing with abstract operation and hypotheses testing (Moreno, 2010). In addition, EBR facilitates students to make proportional and probabilistic prediction by posing question as elaboration of premise. Posing question draws students' attention to focused questions, effectively supporting sustained reasoning (Lustick, 2010).

The implementation of EBR in inquiry-based Physics teaching resulted in N-gain in the component of hypothetical-deductive reasoning and correlational thinking in low category. N-gain at low level was evident on the hypothetical-deductive reasoning component as shown in Table 2. Figure 1 also shows that student percentage based on N-gain was dominated by low category. Most students were not able to choose the choice alternative on the first level correctly, and they came up with incorrect reasons on the second level. Also, they were confident about the answer. Students' answers were found incorrect when students learnt the phenomenon of heat transfer in some metals (copper, steel and aluminum), from which they learnt that the rate of heat transfer in copper was the greatest compared to the other two metals. Students chose the wrong answer by reducing the length of copper. It happened because the shorter metal produced a faster rate of heat transfer (Jatmiko, Prahani, Supardi, Wicaksono, Erlina, Pandiangan, & Althaf, 2018). Students gave illogical argument to what was in question. The student worksheet from the learning process showed that they had not been able to comprehend the comparison of data in the table of experiment result. As a corollary, they only referred to a single experiment. Students who were able to compare scores or scales did not relate the concepts of the material learned upon explaining the alternative choice of selected answers. This led to students' weak hypothetical-deductive reasoning. The relevant research results explain that the process of interpretation linking evidence with scientific or intuitive rules is susceptible to misconception (Hardy, Kloetzer, Moeller, & Sodian, 2010). The result of N-gain corresponding to hypothetical-deductive reasoning skill also applied to the correlational thinking component with N-gain in low category. The N-gain in low category was supported by the dominant percentage of students attaining the N-gain low category on the correlational thinking component. Students were not able to choose the alternative choice at the first level correctly; they formulated wrong reason on the question at the second level, and they were sure with the answer. Students' ability to analyze the relationship between variables on the results of experiment data regarding heat transfer by conduction indicated low result. The student replied that metal length corresponded to the thermal conductivity of metal in that metal length influenced the rate of heat transfer. The answers indicated that students' ability to analyze data was still weak, so they were unable to show correlation well (Jatmiko, Widodo, Martini, Budiyanto, Wicaksono, & Pandiangan, 2016). In addition, the students were unable to gather relevant evidence with reinforced reasoning corroborated by evidence. This resulted in unreliable reasoning due to lack of relevant evidence.

EBR posed a significance on the students' scientific reasoning components in the 4 groups, showed similar results with a significance level of 5%. There was no significant difference in the application of EBR to students' correlational thinking in 4 test groups with a significance level of 5%. Table 3 and 4 show consistency of students' scientific reasoning taught using EBR. The conclusions on Table 3 and 4 prove that students need systematic intervention to stimulate thinking skills during learning (Erman, 2010). Student response informed that EBR activities in inquiry-based Physics teaching could help them engage in scientific reasoning, and teaching activities could help them describe the EBR. In addition, they felt that learning activities could help them describe inquiry-based learning in general. Student responses also supported that the finding of empirical evidence but hypothetical-deductive reasoning results showed N-gain in low level. This situation resulted from the fact that the students were not convinced with the truth. Therefore, the teacher must identify misconceptions in their prior knowledge or concept before teaching basic concepts, identify reference from textbooks, and facilitate effective communication. This will make sure the information received by students is complete and correct (Erman, 2017; Lehrer & Schauble, 2006). Student responses to the application process showed the related interrelationship about making logical connections between premise and small value rule. These results were consistent with earlier indication showing that only 18% of students composed an explanation with claim, evidence support, and reasoning. EBR allowed students to construct claim based on logical premise and rule, but the student's response in confirming the progress of knowledge was weak. Nevertheless, over 50% of students responded positively to the effectiveness of EBR in improving scientific reasoning.

Conclusions

The research results of and discussion on the effectiveness of EBR in improving students' scientific reasoning in Physics teaching draw several conclusions. First, the implementation of EBR results is the significant improvement on students' scientific reasoning in Physics teaching, which is evinced by 2-tailed asymptotic significance for $p < .0001$. Also, the students' scientific reasoning in Physics learning after the EBR application is found at the high category (control of variables), moderate (proportional and correlational thinking), and low (hypothetical-deductive reasoning and correlational thinking). Lastly, no significant difference is evident in the increase associated with each component of students' scientific reasoning in Physics teaching in 4 groups, as indicated by 2-tail asymptotic significance for $p < .05$. This research has implied that EBR effectively increased the components of scientific reasoning in inquiry-based Physics teaching, which comprises control of variables, proportional thinking, and correlational thinking. Students' motivation also needs to be accrued at the outset of learning in order to draw their attention to the premise presentation. EBR needs to emphasize the clarification process on the interpretation of the learned concepts and the result of empirical verification. Precise clarification needs to be carried out before the application, therefore resulting an accurate claim. The resultant claim will be even more exemplary when instruction coupled with logical explanation is operative.

Acknowledgment

The authors would like to thank the Government of the Republic of Indonesia through the Ministry of Finance, especially LPDP [Project Number = 20170961080036], for the funds granted to complete this research. The authors also express their gratitude to Public Senior High Schoool 3 of Jember, which has supported the EBR implementation in inquiry-based Physics teaching.

References

Akkuzu, N., & Uyulgan, M. A. (2017). Step by step learning using the I diagram in the systematic qualitative analyses of cations within a guided inquiry learning approach. *Chemistry Education Research and Practice*, *18* (4), 641-658.

Akpan, J. P., & Beard, L. A. (2016). Using constructivist teaching strategies to enhance academic outcomes of students with special needs. *Universal Journal of Educational Research*, *4* (2), 392-398.

Amsel, E., Klaczynski, P. A., Johnston, A., Bench, S., Close, J., Sadler, E., & Walker, R. (2008). A dual-process account of the development of scientific reasoning: The nature and development of metacognitive intercession skills. *Cognitive Development*, *23* (4), 452-471.

Azar, A. (2005). Analysis of Turkish high-school physics-examination questions and university entrance exams questions according to Bloom's taxonomy. *Türk Fen Eğitimi Dergisi*, *2* (2), 144-150.

Barz, D. L., & Achimaş-Cadariu, A. (2017). Development of a skills-based instrument to measure scientific reasoning in medicine across different levels of expertise. *Journal of Baltic Science Education*, *16* (3), 289-299.

Brookes, D. T., & Etkina, E. (2015). The importance of language in students' reasoning about heat in thermodynamic processes. *International Journal of Science Education*, *37* (5), 759-779.

Brown, N. J., Nagashima, S. O., Fu, A., Timms, M., & Wilson, M. (2010). A framework for analyzing scientific reasoning in assessments. *Educational Assessment*, *15* (3), 142-174.

Buell, C. A., Greenstein, S., & Wilstein, Z. (2017). Constructing an inquiry orientation from a learning theory perspective: Democratizing access through task design. *PRIMUS*, *27* (1), 75-95.

Cepni, S. (2017). National and international advances in Physics education in the last three years: a thematic review. *Journal of Turkish Science Education*, *14* (3), 87-108.

Chen, J., Wang, M., Dede, C., & Grotzer, T. A. (2017). Design of a three-dimensional cognitive mapping approach to support inquiry learning. *Journal of Educational Technology & Society*, *20* (4), 191-204.

Coiro, J., Castek, J., & Quinn, D. J. (2016). Personal inquiry and online research. *The Reading Teacher, 69* (5), 483-492.

Ding, L., Wei, X., & Liu, X. (2016). Variations in university students' scientific reasoning skills across majors, years, and types of institutions. *Research in Science Education, 46* (5), 613-632.

Dolan, E., & Grady, J. (2010). Recognizing students' scientific reasoning: A tool for categorizing complexity of reasoning during teaching by inquiry. *Journal of Science Teacher Education, 21* (1), 31-55.

Edwards, N., & le Grange, L. (2017). The use of inquiry-based science teaching to promote students' conceptual understanding of direct current electricity. *Suid-Afrikaanse Tydskrif Vir Natuurwetenskap en Tegnologie*, *36* (1), 1-10.

Erlina, N., Jatmiko, B., & Raharjo, R. (2016). Pengembangan perangkat pembelajaran fisika menggunakan model learning cycle 7E untuk meningkatkan keterampilan penyelesaian masalah [Development of physical learning tool using model learning cycle 7E to improve problem solving skill]. *Jurnal Penelitian Pendidikan Sains, 5* (2), 1032-1038.

Erlina, N., Jatmiko, B., & Wicaksono, I. (2015). Problem solving skills in learning Physics. In: *Proceeding International Conference: Trending Issues of School Education in Advanced Countries and Indonesia* (pp. 427-445). Surabaya: State University of Surabaya.

Erlina, N., Susantini, E., & Wasis. (2017). Efektivitas model pembelajaran learning cycle 5E terhadap peningkatan keterampilan penalaran ilmiah [The effectiveness of learning model cycle 5E to improving scientific reasoning skills]. *Prosiding Seminar Nasional Pendidikan Sains PPs Unesa 2017* (pp. 200-208). Surabaya: State University of Surabaya.

Erlina, N., Wasis, & Rosyid. (2016). Pengembangan dan penerapan three-tier test untuk mengukur keterampilan penalaran ilmiah siswa SMA [Development and application of three-tier test to measure scientific reasoning skills high school students]. *Prosiding Seminar Nasional Pendidikan 2016* (pp. 214-222). Jember: Universitas Jember.

Erlina, N., & Wicaksono, I. (2016). Penalaran ilmiah dalam pembelajaran fisika [Scientific reasoning in Physics learning]. *Prosiding Seminar Nasional 2016* (pp. 473-480). Surabaya: State University of Surabaya.

Erman, E. (2010). Intervensi kognitif dalam pembelajaran ipa untuk memacu perkembangan kemampuan berpikir abstrak siswa SD [Cognitive intervention in science learning to enhance abstract ability development of elementary students]. *Jurnal Pendidikan dan Pembelajaran*, *15* (1), 270-277.

Erman, E. (2017). Factors contributing to students' misconceptions in learning covalent bonds. *Journal of Research in Science Teaching, 54* (4), 520-537.

Ewen, D., Schurter, N., & Gundersen, P. (2012). *Applied Physics (10 th ed)*. Upper Saddle River: Prentice Hall.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education*. New York: McGraw-Hill Companies.

Guttman, L. A. (1944). A basis for scaling qualitative data. *American Sociological Review, 9* (1), 139- 150.

Hagen, S. W., & Creek, B. (2014). *Standardization of industry expectations for oil and gas*. Texas: International Association of Drilling Contractors.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics tests data for introductory physics courses. *American Journal of Physics*, *66* (1), 64-74.

Hardy, I., Kloetzer, B., Moeller, K., & Sodian, B. (2010). The analysis of classroom discourse: Elementary school science curricula advancing reasoning with evidence. *Educational Assessment, 15* (3), 197-221.

Jatmiko, B., Prahani, B. K., Supardi, Z. A., Wicaksono, I., Erlina, N., Pandiangan, P., & Althaf, R. (2018). The comparison of ORIPA teaching model and problem based learning model effectiveness to improve critical thinking skills of pre-service physics teachers. *Journal of Baltic Science Education*, *17* (2), 300-319.

Jatmiko, B., Widodo, W., Martini, Budiyanto, M., Wicaksono, I., & Pandiangan, P. (2016). Effectiveness of the INQF-based learning on a general physics for improving student's learning outcomes. *Journal of Baltic Science Education, 15* (4), 441-415.

Joyce, B., Weil, M., & Cahoun, E. (2009). *Models of teaching*. USA: Pearson Education.

Kant, J. M., Scheiter, K., & Oschatz, K. (2017). How to sequence video modeling examples and inquiry tasks to foster scientific reasoning. *Learning and Instructio*n, *52* (1), 46-58.

Kind, P., & Osborne, J. (2017). Styles of scientific reasoning: A cultural rationale for science education. *Science Education, 101* (1), 8-31.

Kirbulut, Z. D., & Geban, O. (2014). Using three-tier diagnostic test to assess students' misconceptions of states of matter. *Eurasia Journal of Mathematics, Science & Technology Education*, *10* (5), 509-521.

Kisiel, J., Rowe, S., Vartabedian, M. A., & Kopczak, C. (2012). Evidence for family engagement in scientific reasoning at interactive animal exhibits. *Science Education*, *96* (6), 1047-1070.

Lawson, A. E. (2000). The generality of hypothetico-deductive reasoning: Making scientific thinking explicit. *The American Biology Teacher*, *62* (7), 482-495.

Lederman, J. S., Lederman, N. G., Bartos, S. A., Bartels, S. L., Meyer, A. A., & Schwartz, R. S. (2014). Meaningful assessment of learners' understandings about scientific inquiry: The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching*, *1* (51), 65-83.

Lee, C. Q., & She, H. C. (2010). Facilitating students' conceptual change and scientific reasoning involving the unit of combustion. *Research in Science Education*, *40* (4), 479-504.

Lehrer, R., & Schauble, L. (2006). *Handbook of child psychology: Scientific thinking and science literacy*. USA: John Wiley & Sons.

Lustick, D. (2010). The priority of the question: Focus questions for sustained reasoning in science. *Journal of Science Teacher Education*, *21* (5), 495-511.

Metz, S. (2017). Evidence-based reasoning. *Science Teacher*, *84* (6), 6-13.

Moore, J. C., & Rubbo, L. J. (2012). Scientific reasoning abilities of non-science majors in physics-based courses. *Physical Review Special Topics-Physics Education Research*, *8* (1), 1-8.

Moreno, R. (2010). *Educational psychology*. New York: Jhon Wiley & Sonc.

Motlhabane, A. (2017). Unpacking the south african physics-examination questions according to Blooms' revised taxonomy. *Journal of Baltic Science Education*, *16* (6), 919-931

Norton, S. J. (2005). The construction of proportional reasoning. *International Group for the Psychology of Mathematics Education*, *4* (1), 17-24.

Nunokawa, K. (2012). Multi-relation strategy in students' use of a representation for proportional reasoning. *Eurasia Journal of Mathematics, Science & Technology Education*, *8* (4), 233-248.

Pandiangan, P., Sanjaya, M., Gusti, I., & Jatmiko, B. (2017). The validity and effectiveness of physics independent learning model to improve physics problem solving and self-directed learning skills of students in open and distance education systems. *Journal of Baltic Science Education*, *16* (5), 651-665.

Pelamonia, J., & Corebima, A. D. (2015). Cognitive basis and semantic structure of phenomenological reasoning on science among lower secondary school students: A case of Indonesia. *Journal of Baltic Science Education*, *14* (4), 474-486.

Piaget, J., Inhelder, B., & Piaget, J. (2013). *The growth of logical thinking from childhood to adolescence: An essay on the construction of formal operational structures*. London: Routledge.

Piekny, J., & Maehler, C. (2013). Scientific reasoning in early and middle childhood: The development of domainŋgeneral evidence evaluation, experimentation, and hypothesis generation skills. *British Journal of Developmental Psychology*, *31* (2), 153-179.

Piraksa, C., Srisawasdi, N., & Koul, R. (2014). Effect of gender on student's scientific reasoning ability: A case study in Thailand. *Procedia Social and Behavioral Sciences*, *116 (*5), 486-491.

Schwarz, B. B., & Linchevski, L. (2007). The role of task design and argumentation in cognitive. *Learning and Instruction*, *17* (5), 510-531.

Schwichow, M., Croker, S., Zimmerman, C., Höffler, T., & Härtig, H. (2016). Teaching the control of variables strategy: A meta-analysis. *Developmental Review*, *39* (1), 37-63.

Sevilla, C. G., Ochave, J. A., Punsalan, T. G., Regala, B. P., & Uriarte, G. G. (1984). *An introduction to research methods*. Quezon City: Rex Printing.

Slavin, R. E. (2009). *Educational psychology: Theory and practice 9 th ed.* New Jersey: Pearson Education.

Sudria, I. B. N., Redhana, I. W., Kirna, I., & Aini, D. (2018). Effect of Kolb's learning styles under inductive guided-inquiry learning on learning outcomes. *International Journal of Instruction*, *11* (1), 89-102.

Susantini, E., Faizah, U., Prastiwi, M. S., & Suryanti. (2016). Developing Educational Video to Improve the Use of Scientific Approach in Cooperative Learning. *Journal of Baltic Science Education*, *15* (6), 725-737.

Sutman, F. X., Schmuckler, J. S., & Woodfield, J. D. (2010). *The science quest: Using inquiry/discovery to enhance student learning, grades 7-12*. San Francisco: John Wiley & Sons.

Tajudin, N. a. M., & Chinnappan, M. (2016). The link between higher order thinking skills, representation, and concepts in enhancing timss tasks. *International Journal of Instruction*, *9* (2), 199-214.

Thoron, A. C., & Myers, B. E. (2012). Effects of inquiry-based agriscience instruction on student scientific reasoning. *Journal of Agricultural Education*, *53* (4), 156–170.

Toplis, R. (2015). *Learning to teach science in the secondary school: A companion to school experience*. New York: Routledge.

Vlaardingerbroek, B., Taylor, N., Bale, C., & Kennedy, J. (2017). Linking the experiential, affective and cognitive domains in biology education: a case study-microscopy. *Journal of Biological Education*, *51* (2), 144-150.

Wecker, C. (2013). How to support prescriptive statements by empirical research: Some missing parts. *Educational Psychology Review*, *25* (1), 1-18.

Wicaksono, I., Madlazim, & Wasis. (2017). The effectiveness of virtual science teaching model (VS-TM) to improve student's scientific creativity and concept mastery on senior high school physics subject. *Journal of Baltic Science Education, 16* (4), 549-561.

Williams, A. E. (2017). Promoting meaningfulness by coupling Bloom's taxonomy with adult education theory: introducing an applied and interdisciplinary student writing exercise. *Transformative Dialogues: Teaching & Learning Journal*, *10* (3), 1-11.

Received: *July 10, 2018* Accepted: *November 05, 2018*

Nia Erlina
M.Ed, Researcher, Universitas Negeri Surabaya (State University of Surabaya), Jalan Ketintang, Surabaya 60231, Indonesia.
E-mail: niaerlina@mhs.unesa.ac.id
Website: http://www.unesa.ac.id/

Endang Susantini
Professor, Researcher, Universitas Negeri Surabaya (State University of Surabaya), Jalan Ketintang, Surabaya 60231, Indonesia.
E-mail: endangsusantini@unesa.ac.id
Website: http://www.unesa.ac.id/

Wasis
Ph.D, Researcher, Universitas Negeri Surabaya (The State University of Surabaya), Jalan Ketintang, Surabaya 60231, Indonesia.
E-mail: wasis@unesa.ac.id
Website: http://www.unesa.ac.id/

Iwan Wicaksono
(Corresponding author)
Ph.D, Researcher, Universitas Jember (University of Jember), Jember, Jalan Kalimantan, 68118, Indonesia.
E-mail: iwanwicaksono.fkip@unej.ac.id
Website: http://www.unej.ac.id/

Paken Pandiangan
Ph.D, Researcher, Universitas Terbuka Indonesia (Indonesia Open University), Jakarta, Jalan Cabe Raya, Jakarta 15418, Indonesia.
E-mail: pakenp@ecampus.ut.ac.id
Website: http://www.ut.ac.id/