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The Effects of Essay Tests and Learning Methods on Students' Chemistry Learning Outcomes

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ABSTRACT

This study aims to test the effects of essay tests and learning methods on students' chemistry learning outcomes. The sample of this study was drawn from grade 11 students at Jambi State Senior High Schools through a multi-stage random sampling technique. Within a factorial experimental design, the data were analyzed using the covariance analysis technique (ANCOVA) with Tukey's test. The experimental procedure was carried out using the requirement tests (e.g., normality and homogeneity). The results showed that Chemistry learning outcomes of the students, who were exposed to the use of higher contextual learning methods, were better than the control group, who were instructed with conventional learning methods. Also, the present study pointed to an interaction between the effects of formative tests and learning methods on chemistry learning outcomes when the influences of early skills were controlled. In light of these findings, the present study suggests that teachers use related teaching methods and essay tests to empower their students 'learning processes.

Keywords: Basic skills, chemistry learning outcomes, essay tests, learning methods.

INTRODUCTION

Using essay tests measures high-order abilities that are necessary to organize, elicit, express, and analyze ideas. These are advantages of essay tests that cannot be measured by objective forms/tests (A'yun, et al., 2015, Anderson, et al., 2001). Essay tests overcome the weaknesses of the objective measurements and their limited learning outcomes. Essay tests are suitable for measuring learning outcomes that are complex in nature (Bloom, et al., 1979, Budiada, 2011, Cortright et al., 2005).

Indicators of students' learning outcomes are less important at evaluation tools than the learning methods used by teachers. The success of the teaching is very much dependent on students' capabilities on transforming what has been learned (Danial, 2012). A lot of innovate learning methods, which is called the right teaching method, will better drive students' competencies. Teaching methods in science learning are either conventional teaching methods or context-based learning methods. Hence, the authors were interested in researching the

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following research question: The effects of the essay tests and learning methods on students' capabilities/abilities of chemistry learning outcomes when their initial abilities were controlled (Daniels, et al., 2009, Roberts, 1977).

Chemistry Learning Outcomes

Rosenshine, et al. (1996) explained that determining students' chemistry learning outcomes is not easy since many learning processes occur without observable responses. It means that learning process, which is latent, embraces several hidden forms. Thereby, learning process, which is invisible, often refers to a phenomenon or symptom. Unless a person demonstrates their learning abilities by doing something, we cannot know anything about his/her learning process or outcomes. If a person gains the ability as a result of his or her learning experience, it is called learning outcomes.

According to Yadav et al., (2011), learning is a result of the achieved learning process. Further, Gagne identified several learning categories, such as intellectual skills, cognitive strategies, verbal information, motor skills and attitudes. Some previous researchers have explained that teachers use the results of the tests to determine students' achievement levels. Students' scores usually express their learning outcomes after completing one lesson or program (Zimmerman, 2011, Wilson, et al., 2010). According to Bilgin, (2009), learning outcomes contain all skills and what is gained through learning processes or teachings in schools. Of course, they express scores and measured/tested results.

Chemistry, which incorporates scientific knowledge, e.g., facts, theories, principles, and laws, is the product of scientific findings and processes (Purba, 2002, Purwanto, 2003). Therefore, assessing chemistry learning needs to consider the characteristics of chemistry or chemical products/processes (Tien, et al., 2002. Because chemistry is needed in everyday life, students should have sufficient chemistry knowledge to associate them with daily life issues. The foregoing issues indicate that chemistry ought to change students' abilities of cognitive learning domain, e.g., changes in structure, arrangement, composition, order and mechanism. This process may include artificial and natural learning (Widiyatmoko, 2013).

Essay Test

In view of Wilson et al., (2010), a test is a systematic instrument or procedure that uses a particular numerical scale or classification for observing, and describing one or more characteristics of a student. Likewise, Supardi (2015) implies that tests are a systematic instrument or procedure for measuring certain behaviors. According to Sorby (2009), tests are a systematic procedure for observing and describing one's behavior in terms of scores or category systems.

Bloom, et al. (1979) classified learning outcomes into three areas: (a) cognitive domain, (b) affective domain, and (c) psychomotor domain. These areas depends on the measured educational or evaluation needs. This study's scope contains cognitive domain and relevant abilities. Andersson and Kratwohl (2001) divided cognitive processes into six categories: remembering, understanding, applying, analyzing, evaluating, and creating. Gormally et al. (2009) grouped learning outcomes under four functional types: formative tests, summative tests, diagnostic tests, and placement tests.

Given to the groups mentioned above, this study preferred formative tests, which are derived from the word "to form". Hastuti et al., (2017) and Purwaningsih et al., (2014) defined formative measurement/assessment as tests to determine students' learning processes. Formative tests are known as daily repetitions and/or in learning practices. Learning components and processes need to be planned for a single unit in any subject. Therefore, learning a unit calls for such components as: learning objectives, materials, methods, learning strategies, media, and evaluation. Evaluation scan be classified under two groups: essay-based learning tests and objective-form (double-choice) tests (Khalifa, et al., 2002, Kholifah, et al., 2014).

According to Pascarella, et al., (2004), an essay test consists of questions or instructions that require answers and relatively long descriptions. Tests are designed to not only measure learning outcomes but also ask students to answer questions by seeking, creating and arranging their knowledge. Participants have to compose their own words and sentences in formulating their answers and expressing their ideas/views in mind. Forms of questions or instructions ask students to explain, compare, interpret and find any difference. These questions require students to demonstrate their understanding of any concept or fact or phenomenon (Quitadamo, et al., 2007, Sadiman, et al., 2002, Smarabawa, et al., 2013). In brief, essay tests, which are forms of questions or instructions, ask students to formulate their words and sentences in formulating their answers. Hence, participants create, search and compile all elements required by the test.

Learning Methods

Gagne (1977) used a systematic method to achieve goals. Similarly, Gormally et al. (2009) argue that any method means a way to functionally reach a conclusion. Furthermore, Supardi (2015) defines the learning method as a way to organize teachers' subject matter knowledge. Hence, learning process occurs selectively and efficiently.

In a similar vein, Purwanto (2003) views the learning method as a presentation method used by the teachers. That is, teachers find problems in student learning and then make changes by systematically looking at students' first experiences, thoughts, feelings and subject-matter knowledge. Using appropriate learning methods not only find learning problems but also overcome them by considering the use of learning methods, learning materials and student characteristics. Thereby, learning method is a way to deliver teaching materials to students. Methods in teaching chemistry are principally oriented to the philosophy of education, learning objectives and students' learning ways. Therefore, this study used two approaches, e.g., contextual and conventional approaches for learning process (Çelik, et al., 2020, Rokhmat, et al., 2019).

The word 'contextual,' which comes from the word 'context', means "relationship, context, atmosphere and circumstances (context)". Contextual learning approach means acceptable, relevant, direct relationship(s) to follow any intent, meaning, and importance within context. According to Mulyani (2013), contextual learning approach helps teachers link their instructional materials to real-world situations. Further, it encourages students to make connections between their knowledge and daily lives. The contextual method is expected to be more meaningful for students in that learning process naturally engage students in activities and experiences. They acquire their own knowledge and skills by discovering themselves.

Quitadamo et al. (2007) explains that the contextual learning approach is basically an educational process that aims to help students see the meaning of the subject-matter knowledge. Thus, they learn by contextually connecting their subject-matter knowledge with their daily lives. These learning processes include personal, social and cultural dimensions. Such a learning environment includes eight main components: (a) making meaningful relationship(s), (b) doing meaningful work, (c) self-learning arrangements, (d) collaboration, (e) critical and creative thinking, (f) mature individuals, (g) achieving high standards, and (h) using authentic assessment(s). Contextual learning approach emphasizes the process of student engagement by designing the related instructional materials and relating them to real-life situations. Hence, it encourages students to apply their gained knowledge/experiences to their life situations or novel problems (Sanjaya, 2006). Contextual learning approach needs three important scaffolds: (a) it emphasizes the process of student engagement with instructional materials and orients learning process to the conventional experiences, (b) it encourages students to find the relationship(s) between instructional materials and real-life situations, and (c) it promotes students to apply their gained knowledge to their lives or novel problems by facilitating their understanding of the learned material and empowering their behaviors in everyday life. A contextual learning approach uses five important characteristics of knowledge in the learning process: (a) activating, (b) acquiring, (c) understanding, (d) applying, (e) reflecting. Its components are as follows: (i) constructivism (ii) inquiry (iii) asking questions (iv) learning community (v) modeling (vi) reflection and (vii) authentic assessment.

Contextual learning approach helps teachers link instructional materials to real-world situations and encourages students to make connections between their knowledge and skills. Further, they are able to transfer their gained knowledge into their daily lives. Thus, learning becomes more meaningful (Suyanti, 2010, Dewi, et al., 2019). This study handled contextual learning within chemistry learning that helps teachers associate chemistry learning with real-world situations to encourage their learning progresses and daily life experiences. Overall, this study saw it as social beings for achieving learning goals with high standards.

The conventional method does not differ from the aforementioned statements. That is, a teacher is very important to transmit his/her knowledge to students. So, it gives a very large and active role to the teacher, called teacher-centered learning process. In this study, the teacher explained all lesson sequences regarding the chemistry and provided a way out for his/her students. (S)he conducted discussions through his/her directives/guidance.

Initial ability

Before beginning any teaching activity, teachers need to know their students' initial abilities (named preparedness). Thereby, they prepare their teaching messages and relate to their students' learning styles. Also, they can predict learning outcomes of each student when students complete their learning processes. Teachers need to empathize students' performances of learning processes. Initial ability as a must-have competency influences learning a new lesson or advanced learning (Bloom, 1996) Gafur (1989) defines initial ability as relevant knowledge and skills. Relevant curricula purpose to equip students with these knowledge and skills by taking their initial abilities into account.

Teachers' instructional potentials are important for handling different characteristics within their classes. Characteristics of Natural Sciences (especially chemistry at high school) are quantitative regularity. Initial ability acts as a cognitive readiness to accept new teaching material(s) during learning process. Such a readiness results in transforming skills at cognitive domains to new knowledge and skills (Dembo, et al., 1981, Effendi-Hasibuan, et al., 2019).

To sum up, this study explored whether there is any difference between experimental (contextual learning approach) and control (conventional learning method) groups' chemistry learning outcomes when the influence of initial ability is controlled. Further, it discovered how the use of formative tests (i.e., essay tests) impacted their chemistry learning outcomes when initial ability is controlled. Finally, the current study investigated whether there was an interaction between the effects of formative tests and learning methods on chemistry learning outcomes, when the initial ability is controlled. This study aims to test the effects of essay tests and learning methods on students' capabilities of chemical learning outcomes by controlling students' initial abilities.

METHODS

This research used an experimental research method with factor design (Kholifah, et al., 2014). Its independent variables were essay tests, and learning methods, while its dependent variable was chemistry learning outcomes (Y). Prior to the teaching intervention, pre-tests were administered to the experimental and control groups. Therefore, their initial abilities of Chemistry (X) acted as a covariance variable (see Table 1).

Table 1. *Factorial experiment design (2×2)*

Shape of Formative test / Learning Methods	Essay Formative Test (A)
Contextual (B_1)	$[X, Y]_{11k}$ $k = 1, 2, \dots, n_{11}$ (AB_1)
Conventional (B_2)	$[X, Y]_{12k}$ $k = 1, 2, \dots, n_{12}$ (AB_2)

X = Score of initial ability, Y = Score of chemistry learning outcomes, K = Group (sample per cell)

a) Population and Sample

Target population of this study was all students at Senior High Schools in the city of Jambi. The sample of the research consisted of two Grade XI classes (e.g., Grade XI IPA3 and Grade XI IPA4) drawn from IPA SMA Negeri 1. The sample was selected by using a multistage cluster random sampling technique. Given principles suggested by Dochy et al. (2003), the researchers determined two schools, which had some similar characteristics, such as physical conditions, facilities, school categories, nationally. Later, they randomly selected two classes with similar characteristics (e.g., 16 students for the experimental group—exposed to essentially formative tests-- and 16 students for the control group—exposed to a double formative test). Experiment and control groups followed contextual and conventional learning methods respectively. Eventually, they randomly assigned the experimental and control groups, i.e., Class XI IPA3 class as the experimental group, and Class XI IPA4 as the control group (see Table 2).

Table 2. *A summary of the experimental research design*

Learning Methods (B)	Essay Formative Test (A1)	Total
Contextual (B1)	XI IPA_3	16
Conventional (B2)	XI IPA_4	16
	Total	32

b) Data analysis

The researchers employed covariance analysis (ANCOVA) to test the effects of the main factor and interaction factor on students' chemistry learning outcomes by controlling their initial abilities. Further, they used independent samples T-test to determine whether there was any significant difference between the experimental and control groups' mean scores of chemistry learning outcomes when their initial abilities were controlled. That is, two factors (e.g., learning methods and formative tests) might act as the major effect and significant interaction effect(s).

FINDINGS

a) Descriptive Statistics

Table 3 presents descriptive statistics of chemical learning outcomes in regard to learning methods (e.g., conventional learning methods, and contextual learning approach).

Table 3. Descriptive Statistics of Chemical Learning Outcomes

Learning Methods	Descriptive Parameters	Essay Formative Test (A)	
		X	Y
Contextual (B_1)	n	16	16
	$\overline{X}$	69.75	61.94
	M_o	72	57.59
	M_e	69.75	59.93
	SD	12.51	11.37
	Max	90	77
	Min	50	36
Contextual l (B_2)	n	16	16
	$\overline{X}$	64.13	49
	M_o	65.50	41.5
	M_e	65.50	47.5
	SD	13.89	9.78
	Max	85	73
	Min	40	36
Total	n	32	32
	$\overline{X}$	66.50	55.19
	M_o	63.5	54.75
	M_e	65.34	54.50
	SD	13.91	12.37
	Max	90	77
	Min	40	36

A: Students at Group A, who were exposed to essay formative test, B1: Students at Group A, who were taught by contextual learning methods, B2: Students at Group A, who were taught by conventional learning methods, n: Number of samples, X: Students' initial scores, Y: Students' scores of chemistry learning outcomes

b) Hypothesis Testing

Table 4 summarizes the results of ANCOVA.

Table 4. The results of ANCOVA

No	Variance sources	JK			JK Residu	db	RJK Residu	F_h	F_{table}	
		X	Y	XY					α = 0.05	α = 0.01
1	Between column (A)	25.00	441.00	105	412.08	1	412.06	3.51		
2	Between row (B)	189.06	588.06	333.44	492.82	1	492.82	4.20	2.76	4.14
3	Interaction A x B	100.00	637.56	690.94	412.92	1	412.92	3.52		
4	Insert	11959.38	7151.13	1632.19	6928.34	59	117.43			
5	Total	9573.44	8817.75	1743.13	10423.19	64	100.00			

DISCUSSION and CONCLUSION

Relationship between Contextual Learning Approach and Conventional Learning Method

The results indicated that mean scores of the experimental (using contextual learning approach) and control (using conventional methods) groups' chemistry learning outcomes were 69.75 and 64.13 respectively. This means that the experimental (with contextual learning approach) group's chemistry learning outcomes owere higher than those of the control group (with conventional learning methods) when their initial abilities were controlled.

As seen from Table 4, the value of F_{count} = 4.20 is higher than that of F_{table} (0.05, 1.59) = 2.76. (F_{count} = 4.20> F_{table} = 2.76 at α = 0.05). The results showed that there was a significant difference between the experimental (with contextual learning approach) and control (with conventional learning methods) groups' chemistry learning outcomes when after their initial abilities were controlled.

The results of the variance test showed that the value of tcount (2.24) is higher than that of ttable (1.67) (t_{count} = 2.24> t_{table} = 1.67 on the significant level α = 0.05). Thus, the results rejected H0. This means that there was a significant difference between the experimental and control groups' chemistry learning outcomes when their initial abilities were controlled.

The Effect of Conventional Learning Methods on Students' Chemistry Learning Outcomes When Student Initial Abilities were Controlled

The mean scores of the experimental (who were exposed tp essay formative test and contextual learning approach) and control (who were instructed with conventional learning methods) groups were 61.94 and 49.00 respectively. This means that chemistry learning outcomes of the experimental group's (with formative essay test and contextual learning approach) methods were higher than those of the control group (with conventional methods) when their initial abilities were controlled.

As seen from Table 4, the value of t_{count} (3.29) is higher than that of t_{table} (1.693) (t_{count} = 3.29> t_{table} = 1.693 at α = 0.05). This means that there was a significant difference betweeb the experimental (with essay formative test and contextual learning approach) and control (conventional learning methods) groups' chemistry learning outcomes when their initial abilities were controlled.

Interaction Effect between Formative Forms and Learning Methods when the Initial Ability was considered as a Covariance

As can be seen from Table 4, the value of F_{count} (3.52) is higher than that of F_{table} (2.76) (F_{count} = 3.52> F_{table} = 2.76 at α = 0.05). These results indicated an interaction effect between formative tests and learning methods when their initial abilities were controlled for their chemistry learning outcomes. This means that the effect of the Formative form) was higher at chemistry learning outcomes than the learning methods when their initial abilities were controlled.

Conclusion

Because the experimental (with contextual learning approach) group's chemistry learning outcomes were better than those of the control group (with conventional learning methods) when their initial abilities were controlled, it can be concluded that the use of the contextual learning approach results in better chemistry learning outcomes than the conventional learning methods. Similarly, since the experimental group (with essay formative test and contextual learning approach) performed better at chemistry learning outcomes than the conventional learning method when their initial abilities were controlled, it can be deduced that essay tests and contextual learning approach improve the chemistry learning outcomes. An interaction effect between formative tests and learning methods (when the initial ability was used as a covariance) means that two factors (formative tests and learning methods) determine students' chemistry learning outcomes. However, producing maximal chemistry learning outcomes needs the adjusted conditions and situations between formative tests. This research suggests that chemistry learning outcomes should be improved by using appropriate learning methods. Further studies should deploy formative tests or essays to elicit students' learning potentials/capabilities and to measure complex learning outcomes and high-order cognitive levels/skills. Because higher-order thinking skills are very important in societal life, chemistry learning should equip students with making alternative choices and using the most useful ones.

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