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THE INFLUENCE OF SCIENTIFIC INDEPENDENCE TOWARDS STUDENTS' CONTENT ANALYSIS AND SCIENCE PROCESS SKILLS ON CELL METABOLISM TOPIC

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ABSTRACT

Students commonly judge that cell metabolism topic is arduous since they only listen to their teacher and memorizing concept without a deep comprehension. Other than that, a direct explanation could not enhance the students' science process skills. Thus, this research intended to analyze the differences of the content-analysis and science process skills between the students experiencing a learning that oriented to scientific independence (experimental class) and those joining a direct learning (control class). The materials taught in both classes were cell metabolism. This study employed the quantitative of the quasi-experimental method. The research object was the students learning Biology. The students joining a scientific independence-based class were able to answer questions requiring analytical thinking. The relationship of the students' scientific independence towards the content analysis and science process skills was seen on the test. Based upon the statistical data analysis, the correlation significance was 0,038<0,05. Therefore, it concluded that there was a very significant correlation between the students' scientific independence towards the content analysis and science process skills.

Keywords: independence, scientific, content analysis, science process skills

INTRODUCTION

Prior studies have found out the root of the problem underlying the fact that more than 50% students of two Madrasah Aliyah (high school level); MA Nudia and MA Darul Ulum in Semarang City, could not answer properly the biology questions requiring analytical thinking. On the run test, the students answered just in brief without attaching a detailed discussion. In fact, the cell metabolism topic is importantly understood since it is one of the topics of national and university entrance examination. Hence, they should comprehend the concept in order to be able to give satisfying answers. Once a student offers a detailed answer, it shows s/he understands the materials well; yet it did not happen. It revealed that they found it difficult to answer the questions of cell metabolism. Furthermore, this was worsened by the teachers who generally applied the direct learning method and gave assignments beyond the students' analysis skill development. The cell metabolism topic covers respiration and photosynthesis discussion which are complex and abstract concepts. The less comprehension a student has, the bigger the chance of a misconception happens (Andrews et al., 2012).

Moreover, in performing the scientific works, the students tended to be fully dependent on the teachers. These proved that during the

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classroom learning, the students were lack of independence and the teachers have not taught them to be.

The scientific independence covers the activity of experimenting, collecting data, and drawing up a conclusion. The teachers' unawareness to teach it resulted in the students' lack of understanding the way of using laboratory tools, practicum procedures, their self-safety, and maintaining laboratory tools. As a result, early data collection found that most students had the low-level skills in observing, proposing hypotheses, planning a program, interpreting data and graph, predicting and applying concepts, also, communicating. These findings were supported by the analysis results of the 2016 National Examination which stated that 48% of students of the two schools incorrectly answered the questions.

Based on the analysis of the previous study, one of the problematic concepts faced by XII IPA 4 was cell metabolism. The students found it difficult since it has complex basic competence including (1) the process and function of enzymes in cell metabolism, catabolism process and carbohydrate anabolism, also, the relation of carbohydrate and fat metabolism process. The following is the graphic illustrating the students' test results on several topics of XII IPA.

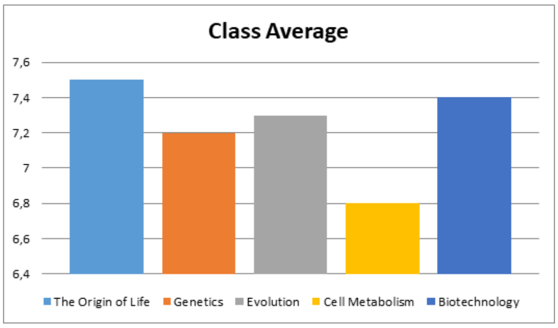

Figure 1. The Students' Test Results on Several Natural Science Topics

On the basis of the prior study's findings, the research problem of this study was; what are the differences of the students' content analysis and science process skills between those who joined the scientific independence-based learning and those who experienced the direct learning?

Hsu et al. (2009), Ozgelen (2012), Susilowati & Anam (2017) stated that the measurable aspect of content-analysis skills is the process of identifying problem performed by making use of the gained concepts in a certain problem in order to quickly finish the problem. Students' logic underlies their critical thinking of elaborating, detailing, and analyzing information used to comprehend new knowledge. The skill of analyzing information is the process of dividing and structuring information into smaller parts to recognize its pattern, connection, and various cause-effect of a complex scenario. Moreover, the students' thinking skill is very related to the learning devices employed during the scientific works (Boleng et al., 2018; Mapeala & Siew, 2015; Rabin, 2011; Yao et al., 2016).

The analysis of several published research on the strategies to develop students' analytical thinking revealed that it strongly correlates to the scientific works during the learning process. This means that if the students' scientific works have not been improved, it will contribute to the students' low content analysis skills. This research aimed at analyzing the differences in content analysis and science process skills between the students attending the scientific independence-based learning and those experiencing the direct learning. The science process skills are essentially developed to gain new knowledge and lead the students to independently discover facts and concepts (Seraphin et al., 2013; Michel & Neumann 2016; Susilowati & Anam, 2017).

Learning biology requires a systematic comprehension of biological processes (Seniwati, 2015). The biology learning process should be emphasized on performing practicum in order to lead students to build their own knowledge (Chang et al., 2011). Referring to Jackson et al. (2008), a practicum is done to encourage them in learning science since it provides an experimental process through science process skills. Nyoman et al. (2014) stated that practicum activities are important steps in discovering concepts.

A concept, according to Saylor & Alexander (1966) and Michel & Neumann (2016) is facts, data, perceptions, classifications, designs, and problem-solving emerging from human's experience and thought structured in ideas, principles, conclusions, plannings, and solutions. Concept mastery is essentially owned by a student to strengthen the existed concepts, or even discover new concepts. Students' concept mastery is not limited to getting to know a concept but connecting it to another in various difficult situations to solve problems.

Scientific work is a way of solving problems through a series of systematic and chronologic activity (Bang, 2017; Lodge, 2017). Students develop curiosity, honesty, creativity, perseverance, and accuracy in collecting, processing, communicating data, and drawing up conclusions during scientific experiments. By emphasizing learning on scientific works, they would be able to analytically communicate the discovered knowledge. Lestari et al. (2018) explained that analytical thinking is a process of solving a problem by applying the gained concepts. Furthermore, Azarpira et al. (2012) and Nuangchalerm & Thammasena, (2009) revealed that students' problem-solving skills could be examined by analyzing their answer to the examination questions. The questions developing high-level thinking skills could not be separated from science process skills which consist of observation, classification, prediction, measurement, drawing up conclusions, and communicating. The observation and measurement skills are the basis of thinking skills (Buchert, 2014; Mioduser & Betzer, 2008; Wouters et al., 2011). This research intended to analyze the differences between the content-analysis and science process skills between the students experiencing a learning-oriented to scientific independence (experimental class) and those joining a direct learning (control class).

METHODS

This study employed the quantitative of the quasi-experimental method. The quasi-experiment is suitable to analyze the cause and effect correlation by involving two groups; experimental and control. The research objects were the students learning Biology on cell metabolism topic in both the experimental and control group at Madrasah AliyahNudia Semarang. The independent variables were c The dependent variables were the students' content analysis and science process skills. The research design is presented in Table 2.

Table 1. The Research Design

Group	Pretest	Independent Variable	Posttest
E	Y1	X	Y2
K	Y1	-	Y2

The quasi-experimental design used the randomized group of pre- and post-test. The sample was chosen by employing the purposive sampling. Purposive sampling is a non-random sampling technique in which researchers determine particular characteristics that suit the research objectives so that the research problems are answered. This research chose 20 respondents consisting of 13 female and 7 male students. Suharsimi (2010) explained that the purposive sampling is suitable for taking sample based on the intention instead of strata, random, or cluster. In line with this, Sugiyono (2012) stated that the purposive sampling technique chooses the sample in regards to several considerations, which means that every object from the chosen population is intentionally taken in accordance with the objectives and considerations, which in this case were (1) similar teacher's characteristics; (2) relatively the same time allotment for teaching; and (3) students' low content analysis.

The normality and homogeneity test results determined group 1 as the experimental groups (E) which implemented the scientific independence-based learning with inquiry model and group 2 as the control group (K) which applied the direct learning. The test results indicated that the analyzed data were homogeneous, thus, a parametric test was possible to carry out. The students' ability in analyzing the material content of cell metabolism topic was assessed based upon the content analysis criteria adopted from Bloom and measured relying on their answers on the tests. There were 30 questions provided. The action verbs adopted for the tests were 'assess', 'compare', 'differentiate', 'sort', and 'determine'. The data collection technique of this research appears in Table 2.

Table 2. The Data Analysis Techniques

The Observed Aspects	Techniques	Instruments
Content analysis and science process skills	T - test	Questions
Learning improvement	N-gain	Questions
The correlation between content analysis and science process skills	Correlation	Questions
The students' response to scientific independence-based learning with inquiry model	Descriptive-qualitative analysis	Questionnaires
The teachers' performance on scientific independence-based learning with inquiry model	Descriptive-qualitative analysis	Questionnaires

The individual's mastery learning was measured using the following formula;

$$\frac{(1 \, x \, PS) + (1 \, x \, ES) + (2 \, x \, PrS) + (2 \, x \, PoS)}{6}$$

Where PS= Portfolio Score; ES= Exercise Score; PrS= Pre-test Score; PoS= Post-test Score. While in determining the classical mastery learning, the below formula was employed;

$$P = \frac{\sum ni}{\sum n} \times 100\%$$

Where P (classical mastery learning); ∑ni (the number of students passed the individual mastery learning) (nilai ≥ 75); and ∑n (total number of students).

The data of the students' science process skills were analyzed using the descriptive qualitative method. The given formula was employed to analyze the obtained score:

$$\text{Activity level} = \frac{\text{number of obtained score}}{\text{maximum number of score}} \text{ x } 100\%$$

The researchers adopted the Arikunto & Cepi's (2009) assessment criteria, which are as folows: (1)81% - 100% (very good); 61% - 80% (good); 41% - 60% (sufficient); 21% - 40% (poor); and <21% (bad).

The data of the students' answer on the shared questionnaires on the learning activities were examined descriptively. The percentage was calculated using the following equation:

$$P = \frac{f}{N} \times 100\%$$

Where; f = frequency; N = number of students; and P = percentage. In addition, the teachers' performance was evaluated by knowing the descriptive qualitative percentage computed using the below equation:

$$\text{Performance level} = \frac{\text{number of obtained score}}{\text{maximum number of score}} \text{ x } 100\ \%$$

RESULTS AND DISCUSSION

The learning outcomes obtained from both the experimental and control group were informed in Table 3.

Table 3. The Analysis of Students' Learning Outcomes from both the Experimental and Control Group

Group	Pre-test average	After learning: Post-test average	After learning: Classical mastery learning (%)	N-Gain average
Control	51	71	45 %	0,41
Experimental	52	82	90 %	0,64

Initially, the pre-test score average of the experimental and control class differed only by 1 number. However, after the different treatments were given, the gap enlarged to 11 number. The minimum of classical mastery learning on cell metabolism topic was ≥ 75. The number of students achieving the classical mastery learning in the experimental and control group appears in Figure 2.

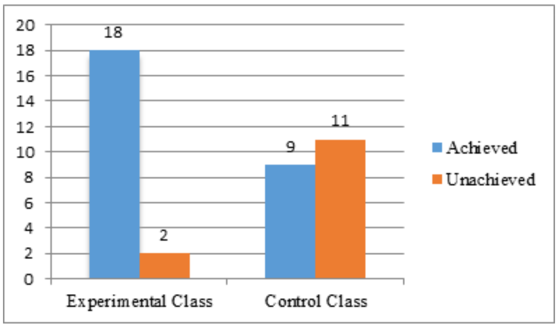

Figure 2. The Number of Students who Achieved and Unachieved the Classical Mastery Learning

In this study, the classical mastery learning was obtained from the assessment results of the portfolio, worksheet, and post-test score. There were 20 students in the experimental class. There were 18 students achieved the mastery learning while the other 2 did not. On the other side, only 9 students achieved the mastery learning in the control class. In measuring how big the students' improvement was in analyzing content, an N-gain test was performed. The test results in the control class showed that 8 students categorized as low, 11 students categorized as intermediate, and 1 student categorized as high. Meanwhile, the experimental class had 15 students in the intermediate category and 5 students in the high category.

Each student's science process skills were evaluated through his/her scientific works during the learning process and the portfolio. The assessment of students' science process skills in the experimental class is presented in Figure 3.

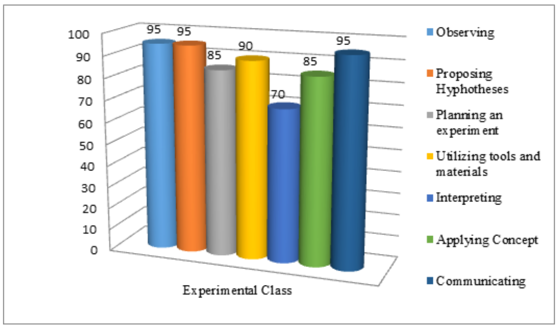

Figure 3. The Students' Science Process Skills in the Experimental Class

Referring to Figure 2, the percentage of the science process skill aspects obtained by the students in the experimental class was 95% for the observing, 95% for the proposing hypotheses, 85% for utilizing tools and materials during the experiment, 70% for analyzing the experiment results, and 80% for communicating the experiment results. These results indicated that the students already possessed scientific independence. Moreover, they responded positively to the learning implemented in this research.

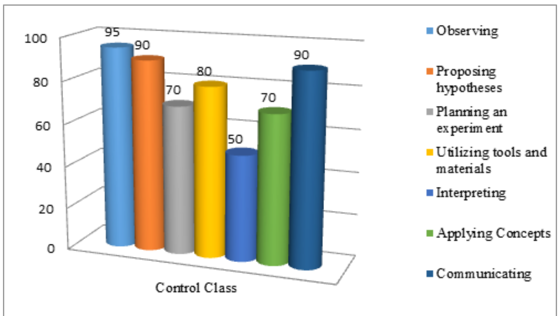

Figure 4. The Students' Science Process Skills in the Control Class

The results of the correlation analysis of the students' content analysis skillsand process skills are listed in Table 4.

Table 4. The Correlation Coefficient of the Students' Independence with Content Analysis and Process Skills

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.333[a]	6	.038
Likelihood Ratio	16.912	6	.010
Linear-by-Linear Association	2.424	1	.119
N of Valid Cases	20		

a. 14 cells (100.0%) have expected count less than 5. The minimum expected count is .40.

The *chi-square* analysis obtained a *chi-square* value of 13,333 with a significance of 0.038 since the significance value was 0.038 < 0.05, then a significant relationship between the students' independence with the content analysis skills existed.

In this study, The students' analytical thinking skills were witnessed to improve during the practicum activities; therefore, they were capable of understanding the cell metabolism topic. This is in line with Abrahams & Millar (2008) that students could develop their thinking skills through scientific works. Moreover, Bancong & Song (2018) stated that experimental learning applied in Indonesia fully intends to improve the analytical thinking skills. In addition, Schuster et al. (2018) elucidated that efficient science learning will be achieved if students master the concepts. However, previous studies revealed that the students found it difficult to learn cell metabolism materials. Thus, this study measured the students' concept mastery by examining their mastery learning.

Roberts (2016) explained that valid and reliable questions would achieve the target level of comprehension. As stated above, this research analyzed the content, hence, the test validity became the major issue to obtain the apparent data of the students' content analysis. The students' content analysis skills were known by their answers to the tests. Prior to that, the test of validity, reliability, differentiators, and difficulty level have been examined. There were 30 valid questions of 35, which means that those 30 questions could properly assess the intended aspects and reveal the data of the studied variable. The valid questions contained the cell metabolism materials in accordance with the basic competence and indicators.

It found that the level of content analysis from the two groups was different, based on the post-test results of both the experimental and control group. The post-test results analysis showed that the students of the experimental groups have better content analysis skills compared to those in the control group. The content analysis skills were determined by the number of students achieving the classical mastery learning. Besides, there was also a different response outcome proposed by the students and teacher. 90% of the students in the experimental class declared that they were able to study the cell metabolism topic, while only 60% of the students in the control class declared that they were able to study the cell metabolism topic.

Rees et al. (2013), Hairida (2016), and Buck et al. (2008) said that inquiry learning could improve students' science process skills. Similarly, it revealed in this study that the students'science process skills differed from those learning using the inquiry model and those studying using the direct learning model. The experimental class oriented not only to apply scientific methods but also scientific independence. Experience gained by the students through self-made worksheets has resulted in their ability in utilizing tools and materials, and scientific independence. Meanwhile, the students' dependency on the teacher found in the control class had strengthened that it would only alienate them to scientific independence.

There was a positive correlation between the content analysis and science process skills, as seen from the result of the regression correlation where Sig. = 0.038or > 0,05, therefore, it said that the better the content analysis skills, the higher the science process skills. Therefore, it has been proven that content mastery is the key to favorable science process skills (Zion, 2008), as stated also by Awalliyah et al. (2015) that a student's high science process skills are determined by his/her level of concept mastery. Moreover, Noviani et al. (2017) explained that students' ability in answering questions relies on their critical thinking skills developed through scientific works during the learning process.

After the learning, the students in both groups were asked to give feedback on the applied strategies. The responses were collected by choosing the provided choices on closed questionnaires. The students in the experimental class mostly stated that they were able to learn the materials easily, which contrasted a bit with the control class. Furthermore, the students in the control class said that they were unable to arrange the self-made worksheet. This was caused by the different level of concept mastery in both groups. The findings are parallel with Misbah et al. (2018) elucidated that the students' performance during the practicum process strongly relies on their understanding of the worksheet. The students of the experimental group's responses had a significant impact on their achievement seen the analysis of test score, content analysis skills, and science process skills. Other than that, the teacher's performance was also evaluated.

The same teacher taught in both the experimental and control group but applied different learning strategies. This research had been carried out for a semester or six-month learning. The uncovered differences were in proposing hypotheses, directing the students to use the lab tools and materials, and supervising the students in interpreting the scientific work outcomes. The observers explained that these differences occurred since the teacher required a longer time in the control class and the students lacked these three aspects. Generally, the teacher scored well in both groups. A well-performed teacher has to overcome the students' learning problems (Japkowicz & Matwin, 2017). Nevertheless, in the experimental group, the teacher sometimes too much assisted the students while the learning orientation was scientific independence. This was probably because the teacher was used to provide any learning need (Koskinen et al. 2018).

CONCLUSION

The students' content analysis and science process skills of the experimental group (scientific independence-based learning with inquiry model) and control group (direct learning model) differed quite remarkably. The differences found in their test scores and answers to the questions requiring content analysis skills. Other than that, the students in the experimental group were more skillful in performing scientific works. In addition, there was a correlation between the content analysis and science process skills based on the correlation where Sig. = 0,038 or < 0,05. The better the content analysis skills, the higher the science process skills.

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