
Effects of open-ended laboratory approach to learners' academic performance

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Abstract

The challenge posed by today's educational system empowers teachers to create a learning environment that is highly interactive, engaging, and digitally exploratory to produce globally competitive and skillfully sound learners. In senior high school science classes, authentic assessment such as but not limited to laboratory activities is encouraged. This is governed by the Theory of Constructivism and Discovery-Based Learning which allow learners to relate past experiences to their present discoveries and observations and form meanings that will answer their questions. Nineteen respondents have purposively chosen to participate in the study from the government secondary school in Maasin City. Introducing the Open-ended Laboratory as an authentic teaching approach in learning topics in senior high Biology. Upon using the approach, results show a significant increase in the test results after pre-test and post-test scores were subjected to paired t-test. This result supports the claim that open-ended activities are efficient tools in improving the academic achievement of learners. Open-ended laboratory as an innovative teaching-learning approach does not only allow learners to be creative and personal about their ways of discovering things, it also endlessly opens their opportunities to fun and exciting collaborations.

Keywords: *Academic performance, Biology achievement, Laboratory-based learning, Open-ended laboratory, Performance-based*

Introduction

The implementation of K to 12 in Philippine schools' entails heightened and more in-depth learning competencies imbued with the standards set in the spiral progression (de Ramos-Samala, 2018). This is governed by the Theory of Constructivism that learners relate past experiences to their current situation and environmental interaction to form meaningful and useful concepts (Jumaat et al., 2017). However, students upon reaching Grade XI experience setbacks as they feel they are not equipped yet with the skills necessary for senior high school. This is evident in their academic performance inside the class where they got low scores and oftentimes lag in terms of coping up with the expected outcomes and performance

tasks (Gbollie & Keamu, 2017). They have been forced to self-review their prior knowledge to keep in phase with the class discussion and activities.

In Science classes, authentic assessment is encouraged in a spiral progression. Authentic assessments allow learners to perform tasks that are similar to the real world and thus evaluate how they apply what they previously learned by doing real-life learning activities (Villaroel et al., 2018). One common form of this type of assessment is laboratory experimentation which is governed by Discovery-Based Learning Theory. This means that learners can answer their questions through the observations they get from the experimentation (Chin & Osborne, 2008). As stipulated in the curriculum guide provided by the Department of

Education (2016), performance tasks for Grade 11 General Biology 1 class under Science, Technology, Engineering and Mathematics (STEM) strand include the incorporation of laboratory experimentation especially on the topics of biological molecules, cellular respiration and photosynthesis.

In Maasin City National High School, the only public secondary school in Maasin City Division offering STEM strand, students enrolled are expected to be equipped with the skills necessary for laboratory experimentation in Biology. Such experiences must already be gained in their guided laboratory experimentation in junior high school. However, after the conduct of our first laboratory experimentation on the factors affecting the amylase enzyme activity level using the traditional guided laboratory approach, results showed that only 40% (4 out of 10) is the passing rate for the oral presentation with an average grade of 87%, and 60% (6 out of 10) failing rate with an average grade of 65%. For the written laboratory report, the passing rate is only 20% (2 out of 10) with an average grade of 77.5% and 80% (8 out of 10) failing rate with an average grade of 60.5%. These results indicate that students might have limited skills in performing laboratory experiments even in a guided laboratory. Emphasis was given on the quality of their report content and critical thinking specifically the analysis of results and errors. This has been the major concern of Grade 11 STEM students in Maasin City National High School, Maasin City, Southern Leyte which serves as the guiding light in conducting this research.

The traditional guided laboratory has been heavily critiqued as being rote and inauthentic to the process of experimental science typically characterized by students completing an experiment just by following the laboratory manual (Wilcox & Lewandowski, 2016). This limits variability of learning experiences set by the pre-determined content goals and appreciation of the nature and importance of the topic application being undertaken. Introducing the open-ended laboratory for Grade 11 Biology class as an

experimentation approach in response to this challenge. This is a laboratory approach where learners develop or design their experiments related to the topics of the study using only the materials available in school or the locality. Designs could be adapted or modified based on existing designs. This will enhance their self-thinking and exploratory skills in scientific investigations since methods are specially designed to further explore physical phenomena increasing their level of understanding. The open-ended laboratory is usually used in the college and graduate science classes where in-depth laboratory analysis is deemed necessary.

This will be of immense importance since the results gathered can be used to highlight best practices in Science instruction and will serve as a framework in the improvement of laboratory experiment facilitation especially open-ended approach.

Objectives of the study

This study, therefore, attempted to investigate the effect of using open-ended Biology laboratory experimentation on the academic performance of Grade 11 STEM students of Maasin City National High School, Maasin City, Southern Leyte. Specifically, specifically, this study aimed at the following objectives.

1. To determine the diagnostic test result of the students before laboratory experimentation.
2. To determine the test result of the students in the laboratory experimentation with the open-ended approach.
3. To examine the significant difference in the pre-test and post- scores of the students with the open-ended approach.

Conceptual framework of the study

The variables evaluated in the study are illustrated in Figure 1. In the study, students' performance in their laboratory class was classified as the dependent variable, while the open-ended approach introduced to the

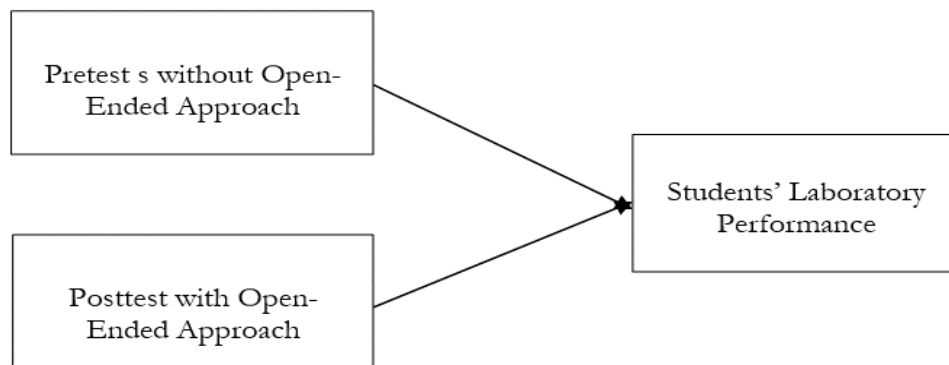


Figure 1. Conceptual Framework of the Study

students was defined as the independent variable. The variables were measured descriptively, and the significance of the difference in pretest and posttest performance of students in the laboratory for the groups exposed without open-ended approach and exposed with open-ended approach was examined using the paired comparison t-test.

Methodology

Research Design

This study used the Quasi-experimental one-group pretest-posttest research design since this will determine the significance of the difference between the performance of the group based on their pretest performance and posttest performance after the treatment was administered (Hong, Cabrera, & Beaudoin, 2020).

Research respondents and sampling

The respondents were the 19 Grade 11-Science, Technology, Engineering and Mathematics (STEM) students officially enrolled in the second semester in Maasin City National High School (MCNHS) who were selected through purposive sampling. The class is composed of eight males and 11 females with ages ranging from 16 to 18. The majority of the

students come from public high schools, particularly from MCNHS.

Research instrument

Teacher-made questionnaires on photosynthesis and cellular respiration were used to determine the pre-test scores of the students which were peer-reviewed and validated. These questionnaires covered the content standards and performance tasks under the topics to be undertaken in the laboratory experimentation with the learning competencies stipulated in the curriculum guide. The topics were photosynthesis and cellular respiration. The same questionnaires were used to determine their academic performance (post-test) upon exposing the students to the open-ended laboratory.

Procedure

Consent forms from the school head, parents, and students were secured before the study was conducted. This was to let every concerned be made aware of the ongoing research to allow maximum data gathering which was deemed necessary for the research which included the taking of the pictures while the experiment was going on. This also provided the researcher the right to keep all the data gathered which were treated with utmost confidentiality.

All the 19 Grade11- STEM students as respondents of this study took the pre-test to determine their prior knowledge on the topics to be covered. This was done in the second semester of SY 2017-2018. The results gathered were analyzed and interpreted. The students were then exposed and conducted open-ended laboratory experimentation. They had two rounds of this experiment. The first was on photosynthesis and the second was on cellular respiration. After conducting the open-ended laboratory for each round, the students presented their laboratory findings through written and oral presentations. Academic performance in Biology was then measured. This was done by giving the respondents post-test reflecting the learning competencies indicated in the curriculum guide after every round. Data gathered were analyzed and interpreted.

Data analysis

A paired two-tailed t-test was used to identify whether the average test results in the pre-test and post-test had a significant difference. The data obtained were imported into the IBM SPSS software package version 23 (Statistical Package for the Social Sciences, SPSS Inc., IBM Corporation) for the analyses.

Result and discussion

Academic performance of the students

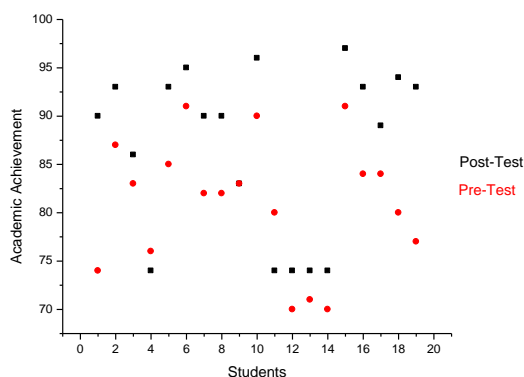


Figure 1. Academic performance (pre-test and post-test scores) of Grade 11 students using the Open-Ended Laboratory as an authentic teaching-learning strategy.

The academic achievement corresponds to the pre-test and post-test scores of the students during the assessment conducted by the researcher. Figure 1 presents the pre-test and post-test scores of the respondents. At the pre-test, results showed that most of the students have scores categorized as 'Satisfactory' (42%). There is also a considerable number of students whose scores are categorized as 'Did Not Meet Expectations' for having scores below 74 (21%). Only very few got scores ranging from 90-100 or 'Outstanding' (16%). Post-test scores showed that 89% of the students have increased their scores from Pre-test, that is 17 students out of 19. It can also be observed that the majority of the students have scores that are categorized as 'Outstanding' which comprised 58% of the entire class.

The significant difference in scores

Table 1 shows the computed p-value for t-test at 0.05 alpha (α) level using IBM- SPSS version 23. It can be seen that the computed p-value is 0.000 which is less than the alpha (α) value of 0.05.

It can be seen from Figure 1 that after administering the open-ended laboratory, there was a noticeable increase in the post-test scores of the students. This shows that the use of Open-ended Laboratory as a teaching-learning strategy in General Biology is an effective tool to increase the academic achievement of the students. This is congruent to the study of Bolong, Makinda & Saad (2014) which emphasized that the use of open-ended classes as an authentic approach has increased student grade performance and higher course outcome achievement.

Furthermore, Table 1 revealed that there is a significant difference in the pre-test and post-test scores or the academic achievement of the Grade 11 students when the Open-ended

Laboratory Approach was used in the class at a 5% level of significance. This implies that there is a positive increase in the academic achievement of the students in Biology when

the approach was used in a senior high school class. It is evident in this study that the use of an open-ended laboratory will improve the academic achievement of the students.

This result supports the study of Haron, Mohammad, Sam, Mustaffar, and Yatim (2013) which emphasized that open-ended experiments increased independent learning amongst students by giving them a platform to be more innovative and creative in designing and executing their experiments. Furthermore, the use of open-ended activities may have a positive

mastery of skills and competencies required for senior high school.

However, in administering the open-ended approach, many factors should be considered. Teachers should be able to differentiate the traditional approach (guided laboratory) from open-ended. In the open-ended, the researcher strongly recommends that students need to present their work plan for the teacher to pre-validate their chosen method and assure that the steps will lead them to achieve their objectives. After the experimentation, students present the findings of the study to

Table 1. Paired t-test on the academic achievement (pre-and post-test scores) of Grade 11 students using the Open-ended Laboratory Approach in a Biology class.

	Paired Differences					t	df	Sig. (2itailed)
	Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre- and post-test scores	5.89474	5.57668	1.27938	-8.58261	3.20686	4.607	18	0.000*

impact on students' epistemologies about the nature of experimental science and that affects the confidence when performing experiments (Wilcox and Lewandowski, 2016).

From the results and findings of this study, a conclusion can be made. There is a significant difference in the pre-test and post-test scores of the students using the open-ended approach at a 5% level of significance. Thus, the hypothesis is also rejected.

This study, therefore, supported works of literature that claimed the effectiveness of the open-ended laboratory approach as an authentic technique suitable for a modern senior high school learner. There is a significant increase in the academic achievement of the students upon using the open-ended laboratory learning approach.

An open-ended Laboratory has been an effective approach in teaching topics in Biology. It could also be implemented on other topics in Biology. It could also be applied to Grade 12 classes and other Science disciplines such as Physics and Chemistry to achieve

assure that they have learned the concepts from their experimentation. Although the teachers need to facilitate the activity, they have to make sure that students should be provided with the maximum opportunity to self-discovery and explore- thus, the very essence of the open-ended laboratory.

Conclusion and recommendations

From the findings of the study, it can be gleaned that the use of Open-ended Laboratory as a teaching-learning strategy in General Biology is an effective tool to increase the academic achievement of the students. Further, the researcher recommends using the Open-ended Laboratory Approach as a teaching-learning strategy to enhance the academic performance of the students in General Biology.

Declaration of no conflict of interest

The author declares that there is no conflict of interest.

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