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Research Article

Problem-Based Learning Approach: Effect On Achievement In Genetics Among Grade 12 Students

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ABSTRACT

The Philippine K-12 Science Education Framework stressed the importance of improving scientific knowledge through various pedagogies including the Problem-Based Learning Approach (PBLA). In this study, the effect of PBLA on achievement in Genetics among grade 12 Science, Technology, Engineering, and Mathematics (STEM) students was investigated. Two intact classes of 42 students each were compared using the non-equivalent pretest-posttest control group quasi-experimental design. One group used Conventional Teaching Approach (CTA) while the other employed the Problem-Based Learning Approach (PBLA). In PBLA, students were exposed to the following components of science instruction: overview of general concept; presentation of authentic problem; execution of PBL in groups; and Reflection. The data were collected using a validated and reliability tested researcher-made Achievement Test in Genetics (ATG). Videos and journal entries were used as additional data sources. Using the respective pretest mean score of and AGT as covariate, One-Way Analysis of Covariance was used in testing the effect of PBLA approach. The study concluded that PBLA is effective in improving students' achievement in Genetics ($\eta_p^2 = 0.64$). It is recommended that a longer investigation using PBLA may be done to ensure that the dosage of intervention is adequate. The protocols, instruments, and activities developed from this study may be used by other teachers should they opt to adapt PBLA in their respective classes.

Key words: *Problem-based learning approach, conventional teaching approach, achievement in genetics.*

1. Introduction

In the Philippines, the results in National Achievement Test (NAT) in science from year 2002 to present have been decreasing. The results are alarming in the educational system and found out the following as reasons of failing to hit the national target: Overloaded curriculum content, topics were not suited for student level and were not easy for students to comprehend, and teachers were not fully equipped and trained to handle some topics due to lack of comprehensive knowledge and strategies (Raymundo, 2008).

Specifically, in 2018, NAT results showed that for three-year straight, the national average mean percentage score (MPS) in both elementary and secondary continued its downward trajectory, considered as the weakest performance in the history of the standardized examination of the Department of Education. Science subjects such as biology, along with math and English, were recorded to have one of the lowest mastery level results (Albano, 2019).

The problem is not only evident in the Philippines but also in other countries. Example, in Nigeria, poor academic performance in biology was seen due to poor teaching methods adopted by

teachers at senior secondary level and are identified as one of the major contributing factors (Ahmed & Abimbola (2011).

In Turkey, study showed that genetics was found to be one of the most difficult topics in Biology (Miles & Shivlen, 2001; Cimer & Cimer, 2012).

According to Okoye & Okecha (2008), one of the foci in science education is the necessity to raise students' academic achievement. This is not only because a higher achievement specifically in science is the backbone for technical skills but also because higher achievement is given with high regard in a society which sets a high standard on academic achievement as the stepping stone for entrance into more prestigious professions or post graduate institutions.

Nonetheless, there is this emerging classroom pedagogy which captures science educators, curriculum designers, and planners called "Problem-Based Learning Approach (PBLA)". PBLA is a teaching method which uses complex real-world problems as the avenue to promote student learning of concepts and principles opposing the direct presentation of facts and concepts. In addition, PBLA can promote the development of problem-solving abilities, critical thinking skills, and communication skills. It can also provide opportunities for working in groups, finding and evaluating research materials, and life-long learning (Duch, Groh, & Allen, 2001). Due to its promising effects, the Philippine science education curriculum framework underscored PBLA as one of the approaches in developing and demonstrating scientific attitudes, values and skills to attain the goal of scientific literacy SEI-DOST & UP NISMED (2011).

PBLA promotes constructivism since the focus of instruction is the learners rather than the facts. This is a great strategy in teaching science subjects like Biology to improve academic achievement in Biology according to Strobel & Barneveld (200), Wright et al. (2012), Chang (2001), Robinson, Daily, Hughes, & Cotabash, (2014) and Hmelo-Silver (2004).

With this regard, this study will serve as a verification on the effectiveness of PBLA based from the context of science education in the Philippines.

Most importantly, this study highlights the effects of Problem-Based Learning Approach (PBLA) on the achievement in genetics of senior high school students.

2. Significance of the Study

The findings of this study are significant to science teachers, Senior High School Coordinators, District/Division Supervisors, School Administrators/Policy Makers and DepEd Curriculum Implementers, and research-inclined individuals. First, science teachers may adopt the PBLA procedures which could serve as a guide on how it could be done inside the classroom, how it could influence content delivery and how it could impact Scientific Reasoning Skills (SRS) and students' academic achievement towards science, in general. Also, it would provide an alternative learning strategy in line with the goals of Department of Education's K-12 curriculum. They may also use this strategy in training pre-service teachers as an additional pedagogical approach inside the classroom.

Second, senior high school coordinators and district/division supervisors are responsible in supporting and managing teachers especially in content delivery, they may recommend PBLA among teachers as an effective strategy in improving academic achievement in Biology. They may also train teachers during In-service Training (INSET) about how PBLA is done inside the classroom.

Third, school administrators/policy makers and DepEd curriculum implementers may wish to revisit the required competencies of the students and take into consideration strong emphasis on

academic performance. School administrators and policy makers can place due emphasis on Problem-Based Learning (PBL) by conducting relevant seminar-workshops, teacher trainings and other professional development activities that highlight the use of this strategy in teaching biology and other subject areas. Furthermore, teacher-training institutions in the Philippines may stress PBLA as a teaching strategy that will serve as an avenue for students to improve their scientific reasoning skills while being exposed to this instruction.

Lastly, this study can provide research-inclined individuals vital information and reference in conducting further studies about PBLA.

3. Review of Related Literature

History of Problem-Based Learning Approach

This world of technological advancement has set forth in this era which greatly gives emphasis on scientific skills needed for progress in the fields of inventions, engineering, science and technology. The acquisition of these skills could be harnessed well when students are submerged to real-life scenarios where they are tasked to solve problems integrated in the classroom instruction.

The technique of exposing learners in a problem-based situation started in dental and medical institutions to prepare medical students for their upcoming patients (Barrows, 1998). Specifically, PBL first started at Case Western Reserve University medical school in the United States in the 1950s, and McMaster University in Canada in the 1960s. PBL was established to improve the educational standards of medical schools by shifting a conventional programme to an integrated curriculum structured by "real-life" problems overpassing traditional discipline boundaries (Aspy, et al., 1993).

In 1960's, Problem-Based Learning (PBL) technique started to sprout in the secondary school system as well which had become a well-known strategy all throughout countries (Kenny et al. 2006).

Savery & Duffy (2001) defined PBL "as an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" (p. 12).

Alternative definition relevant for this study derives from Duch, Groh, and Allen (2001) who described the strategies and methodologies used in PBL where the exact skills developed, including "the ability to think critically, analyze and solve complex, real-world problems, to find, evaluate, and use appropriate learning resources; to work cooperatively, to demonstrate effective communication skills, and to use content knowledge and intellectual skills to become continual learners" (Duch et al., 2001).

Benefits of PBL in Academic Achievement

Academic achievement has always been considered as a barometer of students' performance in school and sometimes, an indicator of intelligence quotient. With the great demands of improving students' academic achievement, PBL has been seen to create a promising effect. Strobel and Van Barneveld (2009) found in their meta-analysis of PBL in higher education, overall these empirical observations found PBL to be effective for improving students' academic achievement, which includes knowledge retention, conceptual development, and attitudes, although attitudes were not clearly defined. In Wright et al. (2012) study, they compared problem-based learning to other forms of instruction to teach the geometry program Geometer's Sketchpad to students. They found that student achievement was the highest when implementing direct instruction versus problem-based, but students ranked book learning and problem-based learning as more effective than direct instruction for their own

learning. In the study of Chang (2001), it has been deemed that PBL was effective in improving students' learning in an online platform. Results from one study also affirmed with the claims of PBL and showed that those in the PBL group (n=67) were better able to apply their knowledge of scientific method and experimental design when presented with real-world problems as opposed to the control group (n=60) resulting to better academic achievement (Robinson, Daily, Hughes, & Cotabash, 2014). Further, Hmelo-Silver (2004) stated that PBL is advocated largely because it is said to lead to deep content learning and greater self-directed and problem-solving skills which could also be done with reflection every end of the task.

Moreover, PBL has been shown to have a positive impact on both performance on immediate post-assessments and on long-term retention of content. Two groups of 9th grade chemistry students were compared in a 2008 study in order to determine if PBL increased academic achievement. "Post-test mean scores…were found to be 81.8 in the experimental [PBL] and 62.4 in the control [traditional] group" (Tarhan et al., 2008, p. 293). A study of active learning (including PBL) found "increases in examination performance that would raise average grades by half a letter, and that failure rates under traditional lecturing increase by 55% over the rates observed under active learning" (Freeman et al., 2014, p. 8410). Also, Barneveld (2009) found that PBL was effective when it came to long-term retention and performance improvement therefore, preference should be given to instructional strategies that focus on students' performance in authentic situations and their long-term knowledge retention, and not on their performance on tests aimed at short-term retention of knowledge.

On the other hand, in the study of Sindelar (2002), although PBL encourages student engagement, it does not create a significant increase on the academic achievement of high school students in science. This gives idea on the researcher as a verification based from the context of science education in the Philippines. Drake and Long (2009) also did not find any significant difference in performance; nonetheless, the PBL group did perform slightly better than the control group from pre- to post-test.

4. Objectives of the Study

This study was aimed to determine the effect of Problem-Based Learning Approach (PBLA) on the achievement in genetics among grade 12 students at Odiongan National High School. Specifically, this study answered the question: Does the class exposed to PBLA have significant higher post-test mean scores in Achievement Test in Genetics than those exposed to CTA using their pre-test scores as covariate?

5. Hypothesis of the Study

The post-test mean score in Achievement Test in Genetics (ATG) of the class that was exposed to PBLA is not significantly higher from that of the class exposed to CTA using their pre-test scores as covariate. Mean, SD and ANCOVA was used in this hypothesis.

6. Materials and Methods

6.1 Research Design

The design used in this study was non-equivalent pretest-posttest control group quasi-experimental design. The participants were from two intact classes in a natural school setting where the random assignment is not possible, and the distraction of class structure was avoided to the minimum. This design was suggested to be the best option for school-based research where class were formed at the start of the year and it was not practical nor feasible to assign the students randomly to treatments, as discussed in the work of Ross and Morisson (2004).

6.2 Population and Sample

Samples used for the study were 84 grade-12 students of Odiongan National High School. Students from two intact classes (42 students each) were completely enumerated to participate in the study. The classes came from the Academic Track, specifically, the Science, Technology, Engineering and Mathematics (STEM) strand.

6.3 Research Instrument

This study used an instrument known as Achievement Test in Genetics (ATG). This is a 30-item researcher made test which was administered as pre-test and post-test. It was developed by considering the unit topics in curriculum guide. The unit topic was Genetics with subtopics such as Mendel's Law of Inheritance, Sex Linkages, Central Dogma and Recombinant DNA were the topics included in the discussion. To ensure the content validity of the competencies in Biology, a table of specifications was made before the actual crafting of the test (See Appendix D). The test was validated by three (3) Science Master Teachers of Odiongan National High School who have master's degree in education major in science and are teaching pure sciences in more than five years. To test the reliability of the instrument, pilot testing was conducted to 1st year engineering students of Romblon State University-Main Campus. They were the samples for pilot testing because it was expected that they were from the STEM strand had already undergone the subject General Biology 2. From the results of the pilot test, a Cronbach's alpha value of 0.721 was generated establishing the acceptability and reliability of the instrument.

6.4 The Intervention

The intervention is termed Problem-Based Learning Approach (PBLA). In PBLA, students were given opportunities to explore their own learning by solving authentic problems. In the context of the experiment, PBLA started with the overview of general concepts for PBL. This portion includes the discussion of the major concepts needed for PBL execution. It was followed by the presentation of the problem where authentic problems were presented among students with guide questions that they need to answer. After that, execution of PBL in groups followed. In this part, students in groups of 4-5 members followed the following steps: Understanding the Problem (Meeting the problem, Exploration (Gathering of information, sharing of information, and generating possible solutions), Resolving the problem Output making and Presentation (The process of making & presenting the performance tasks). The last part of the PBL process is the Reflection. On this part, students are required to write on their journals their learnings, feelings and other concerns relevant to the daily topics.

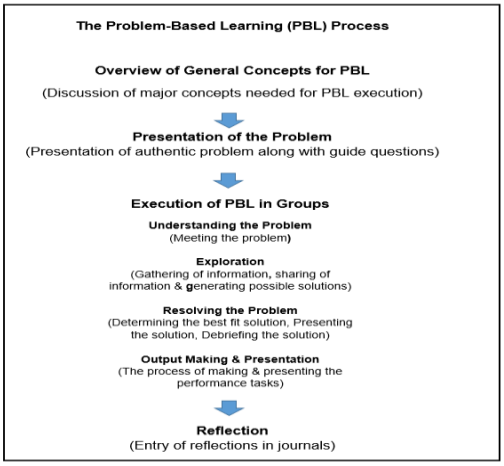

Figure 1: The PBL Process

6.5 Data Analysis

Means and standard deviations were used in describing the data. Findings from these analyses were used to calculate the effects of PBLA on achievement in Genetics of the students. In establishing the comparability of the CTA and PBLA groups, the pre-test scores ATG were analysed using T-test for independent samples. One-Way Analysis of Covariance (ANCOVA I) was used to compare the post-test mean scores in ATG between the PBLA and CTA classes, using ATG mean pre-test scores as covariates, respectively.

7. Results

Research question: Does the class exposed to PBLA have significant higher post-test mean scores in Achievement Test in Genetics than those exposed to CTA using their pre-test scores as covariate?

Table 1 Comparison of Student's Achievement in Genetics between PBLA and CTA

Descriptive Analysis of Pre-Test and Post-Test Scores in Achievement Test In Genetics

	Group	***N***	***Mean***	***Std. Deviation***
Pre-Test	PBL	42	12.14	3.89
	CTA	42	13.52	4.14
	Total	84	12.83	4.02
Post-Test	PBL	42	24.21	1.02
	CTA	42	19.02	2.70
	Total	84	21.62	1.86

Students from the CTA class (M = 13.52, SD = 4.14) obtained slightly lower pretest mean score than those from the PBLA group (M = 12.14, SD = 3.89) with a mean difference of 1.38. A t-test for two independent samples established that this difference in means between the two groups was not significant, $t(82) = 1.48$, $p = 0.14$, hence their comparability (See Appendix J). As to the post-test scores in SRST, PBLA class (M = 24.21, SD = 1.02) obtained a higher mean score than the CTA class (M = 19.02, SD = 2.70) with a difference of 5.19.

Table 2. ANCOVA Tests of Between-Subjects Effects in Achievement Test in Genetics

Dependent Variable	*Source*	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	η_p^2
Post-test	Corrected Model	531.38[a]	2	265.69	71.1	.001	.65
	Intercept	2909.46	1	2909.46	778.6	.001	.90
	Pre-test	16.25	1	16.25	4.4	.040	.07
	Group	531.22	1	531.22	142.2	.001	.65
	Error	295.22	79	3.74			
	Total	39683.0	82				
	Corrected Total	826.60	81				

a. R Squared = .643 (Adjusted R Squared = .634)

A one-way between-groups analysis of covariance was conducted to compare the effectiveness of PBLA and CTA in improving students' achievement in Genetics. Participants' scores on the pre-test of ATG were used as covariate in this analysis. After adjusting for ATG pre-test scores, there was a significant difference between PBLA and CTA on ATG posttest scores, $F(1,81) = 142.15$, $p = 0.001$,

partial eta squared = 0.65, a large Cohen's f effect size (Cohen,1998; Miles & Shevlin, 2001). Therefore, the null hypothesis is rejected.

7.1 Discussion

With the use of the PBL, it has been reported by the literature that it is really effective in improving students' academic performance. It provides authentic experiences that encourage dynamic learning, support knowledge building, and naturally assimilate school learning and real life, as well as integrating disciplines which result to enhancement in academic achievement (Smith 1999). The investigation has reflected a positive impact on students' learning. The eagerness of students to accomplish and answer the given problems were very evident. Aside from that, during the students' presentation of answers in the PBL execution phase, students become more attentive and they seem to enjoy the topics in Genetics which then resulted to promising scores in the Achievement Test in Genetics. Some of the students' reflections expressing their feelings and observations toward PBL execution in several topics of genetics are presented as follows:

"Our topic was all about laws of inheritance. The problems given gave us greater understanding regarding the topic because we were able to apply the laws of inheritance in real-life problems and it feels really satisfying" (Student A).

"…the situation helped us learn in a way that it gives hints and clues regarding the topic and it is up to us to make use of these clues to answer the questions given" (Student B).

"…answering problems made our biology class lively and not the usual boring one where one could fall asleep" (Student C).

The results of this study support the same claims on the studies of Hmelo-Silver (2004), Strobel et al. (2009), Wright et al. (2012), Chang (2001), Robinson, Daily, Hughes, & Cotabash (2014) which concluded that PBL was really effective in improving students' academic achievement. This is one of the answers to the great demands of improving students' academic achievement where PBL has been seen to create a promising effect. Further, this study is anchored on the results of the research conducted by Tarhan, Aya-Kayali, Ozturk Urek, & Acar (2006) which revealed that experimental group under the PBLA resulted to a higher mean score compared to the control group which was exposed to traditional teaching.

8. Conclusions and Recommendations

Based on the findings of the study, it was concluded that the Problem-Based Learning Approach (PBLA) is a very effective method in improving academic achievement in genetics of grade 12 students.

In view of the findings and conclusions of the study, the following recommendations were made. For the school administrators/policy makers and curriculum implementers particularly those who are in-charge of instruction, the literature reviewed and the empirical results generated from this investigation can be presented as evidences and a springboard for considering it as among the researchable areas in the agenda for quality instruction. They may include PBLA and the results of this study on their annual/quarterly trainings and seminar workshops related to new trends of pedagogical approaches. Also, since this investigation covers only one unit, the adequacy of the dosage of intervention cannot be fully ascertained. Thus, a similar semester-long experiment in junior or in senior high school or a yearlong investigation is recommended, using the same procedures as necessary.

REFERENCES

Ahmed, M. A., & Abimbola, I. O. (2011). Influence of teaching experience and school location on biology teachers' rating of the difficult levels of nutrition concepts in Ilorin, Nigeria. *JOSTMED, 7*(2), 52-61.

Albano, E. (2019). Grade 6 NAT scores at 'low mastery level. *The Manila Times.* Retrieved from http://www.manilatimes.net/2019/09/26/campus-press/grade-6-nat-scores-at-low-mastery-level/621772amp/

Aspy, D. N., Aspy, C. B. and Quimby, P.M. "What doctors can teach teachers about problem-basedlearning". *Educational Leadership*, 50: 22-24, (1993).

Barneveld, A. V. (2009). When is PBL More Effective? A Meta-synthesis of Meta-analyses Comparing PBL to Conventional Classrooms. Interdisciplinary *Journal of Problem-Based Learning, 3*(1).

Barrows, H. (1998). The essentials of problem-based learning. *Journal of Dental Education*, 62(9), 630-633.

Chang, C. (2001). Comparing the impacts of a problem-based computer-assisted instruction and the direct-interactive teaching method on student science achievement. *Journal of Science Education and Technology, 10*(2), 147-153.

Cimer S.O., & Cimer, A. (2012). Issues around incorporating reflection in teacher education in Turkey. *Journal of Turkish Science Education, 9*(1), 17-30

Cohen, J (1998). Statistical power analysis for behavioural sciences (2nd ed.). Hillsdale, NJ: Erlbaum.

Drake, K. N., & Long, D. (2009). Rebecca's in the dark: A comparative study of problem-based learning and direct instruction/experiential learning in two 4th-grade classrooms. *Journal of Elementary Science Education, 21*(1), 1–16.

Duch, B. J., Groh, S. E., & Allen, D. E. (2001). The power of problem-based learning: A practical "how to" for teaching undergraduate courses in any discipline. Sterling, VA: Stylus.

Freeman, S., Eddy, S. T., Mcdonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410-8415.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*, 235–266.

Kenny, R., Bullen, M., & Loftus, J. (2006). A pilot study of problem-based formulation and resolution in an online problem-based learning course. *The International review of Research in Open and Distributed Learning, 7*(3).

Miles, J. & Shevlin, M. (2001). Applying Regression and Correlation: A guide for students and Researchers. Sage: London.

Raymundo, A. K. (2008). Biology Education: Gaps, Issues, and Concerns. Proceedings of the Roundtable Discussion on Biology Education. National Academy of Science and Technology (NAST) Philippines, Manila

Robinson, A., Dailey, D., Hughes, G., & Cotabish, A. (2014). The effects of a science-focused stem intervention on gifted elementary students' science knowledge and skills. *Journal of Advanced Academics, 25*(3), 189-213. DOI: 10.1177/1932202X1453379

Ross, S. M., & Morrison, G. R. (2004). Experimental research methods. *Handbook of research on educational communications and technology, 2,* 1021-43.

Savery, J. R., & Duffy, T. M. (2001, June). Problem based learning: An instructional model and its constructivist framework (Rep. No. 16-10).

SEI-DOST & UP NISMED (2011). *Science framework for philippine basic education.* Manila: SEI-DOST & UP NISMED.

Sindelar, T. M. (2010). *The effectiveness of problem-based learning in the high school science classroom* (Doctoral dissertation, Wichita State University).

Smith, C. A. (1999). Problem-based learning. *Biochemical Education, 27*(3), 157-169.

Strobel, J., & van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-Based Learning, 3*(1), 44–58.

Tarhan, L., Ayar-Kayali H., Ozturk Urek R., & Acar B. (2008). Problem-based learning in 9th grade chemistry class: 'intermolecular forces*.' Research in Science Education, 38*(1), 285-300.

Tekkaya, C., Ozkan, O., & Sungur, S. (2001). Biology concepts perceived as difficult by Turkish high school students. *Journal of Education, 21*, 145-150.

Tarhan, L., Ayar-Kayali H., Ozturk Urek R., & Acar B. (2008). Problem-based learning in 9th grade chemistry class: 'intermolecular forces*.' Research in Science Education, 38*(1), 285-300.

Okoye, N. S., & Okecha, R. E. (2008). The integration of logical reasoning ability and socio-economic status on achievement in genetics among secondary school students in Nigeria. *College Student Journal, 42*(2), 617-624.

Wright, G., Shumway, S., Terry, R., & Bartholomew, S. (2012). Analysis of five instructional methods for teaching sketchpad to junior high students. *Journal of Technology Education, 24*(1), 54-72.