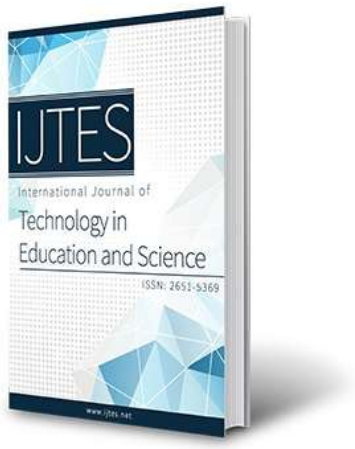

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Project-Based Learning vs Phenomenon-Based Learning in Teaching Redox Reaction

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Abstract

To address the changes that exist in the educational field, educators and curriculum developers are in constant search for innovations to keep up and foster alongside this timely educational revolution. In this case, this study emphasized the integration and parallel use of Phenomenon and Project based learning methods in High School General Chemistry classes. The study utilized quasi-experimental, pretest-posttest nonequivalent comparison group design and employed purposive sampling in identifying respondents. The research instruments used in this study were pretest and posttest, both 30-itemed. In view of the findings, the use of two different learning methods showed different results. The Phenomenon-based learning group showed no significant difference in their pretest and posttest scores, unlike the Project based learning group that yielded an improved academic performance based on their posttest. In connection to this, the result shows that Project based learning is seen to have substantive merit toward innovative learning approach in the instruction of General Chemistry, specifically in the topic of Redox Reaction.

Introduction

The Philippines have gained different perspectives and practices from the numerous foreign occupancies and colonization, all aspects of the society have been affected and changed. These changes were more evident in the education sector; numerous changes in the curriculum and teaching pedagogies were seen throughout history. As societal changes are always relevant and present, the society and the education system must also change to adapt and answer to the needs of the people. Innovations in education are understood as improvement of what is existing and changing of what is needed. These innovations, as they are manifestations of the ongoing changes, must address problems and needs of the modern society (Dilobarkhon, 2019). In the Philippines, the implementation of the K-12 Basic Education Curriculum was the onset for more advanced and innovative classroom practices, a way to cater the needs of 21st century learners. In connection with this, 21st century learning is seen as a loosely governed, self-directed and learner-driven educational landscape, as posited by Hargadon (as cited by Rich, 2010). This notion gives light to the relevance of implementing such innovative teaching and learning methods such as Project-based and Phenomenon-based approaches, among others.

Having such an innovative and learner-centered learning environment ensures more engaging and effective

learning to students, as these methods are specifically molded to cater the students' level and needs. Utilizing these two methods can be beneficial for many, not just for students and teachers. Project-based learning, as the name suggests, introduces students in a learning environment that reflects what they may face in the real world. Students will be needed to produce a project or output that resolves the issue imposed (Practera, n.d.). On the other hand, phenomenon-based learning relates concepts from the lesson to a certain situation existing in the real world, making use of the analogy to deepen their understanding regarding the said lesson (Andreev, 2024). It enables students to actively explore the idea, and gain knowledge and skills to understand it themselves. With this mentioned, the idea of implementing the mentioned methods will not only help teachers to discover new ways of instruction, but for students to unveil different ways of learning befitting their needs and interests.

Science, in its nature, requires learners to explore and understand that the concepts taught are being experienced and created by us, ourselves. Project and Phenomenon based learning are two ways to impose experiential learning for the 21st century learners, it gives them the liberty to discover and learn scientific concepts in their own way at their own pace. These strategies also push students to take charge of their learning, making them more engaged in unraveling new knowledge themselves. In connection to this, such innovations can help 21st century learners develop skills and competencies they will need in their future professions. In science teaching, utilizing such innovations not only ensures that the learners learn, it also assures that learners gain vital skills that can be used outside the learning environment.

The Tayabas Western Academy, while dedicated to enhancing the overall quality of education for its students, recognizes the need for continual improvement in teaching strategies, particularly in the domain of science education. Science, being an inherently experiential subject, demands teaching strategies that facilitate the efficient assimilation of scientific knowledge. To address this, the researchers have identified the importance of adopting teaching approaches that prioritize the experiential aspect of learning. Consequently, they have chosen to explore and implement both Project-based and Phenomenon-based teaching approaches. The rationale behind selecting these approaches lies in their accessibility and ease of implementation for teachers, even those unfamiliar with them. Recognizing the significance of bridging the gap between theoretical understanding and practical application in science education, the researchers believe that Project-based and Phenomenon-based approaches provide valuable avenues for students to engage with scientific concepts experientially. These methodologies not only align with the nature of science as an experiential discipline but also empower teachers with practical and accessible tools to enhance the learning experience for their students.

Moreover, secondary schools such as Tayabas Western Academy are encouraged to implement such innovations to cater the ever-changing nature of student's learning, as well as to awaken their interest in learning Science. By utilizing these approaches, the Science teachers in Tayabas Western Academy may observe if such pedagogies are effective to their students, resulting in their improved academic performance. Thus, the focus of this study is to find out the effectiveness of Project-based and Phenomenon-based learning as effective methods in teaching the Science subject, specifically the area of General Chemistry. This study aimed to help science teachers to recognize the importance of experiential learning in the subject, helping them to make strategies to implement it. This study aimed to answer these following questions regarding the differences between two learning

interventions namely, Phenomenon-based learning and Project-based learning:

1. What is the performance of the respondents before the integration of:
   1.1. Phenomenon-based learning;
   1.2. Project-based learning?
2. What is the performance of the respondents after the integration of:
   2.1. Phenomenon-based learning;
   2.2. Project-based learning?
3. Is there a significant difference between the pretest and post-test scores of the Phenomenon-based and Project-based learning group?
4. What are the inferences that can be derived from the results?

Null hypotheses:

1. There are no significant differences between the pretest and post test scores of the Phenomenon based learning group.
2. There are no significant differences between the pretest and post test scores of the Project based learning group.

Theoretical Framework

Project-Based Learning Theory

The Project-Based Approach (PjBA), as proposed by Thomas (2000), is rooted in the idea that learners thrive best when they are constantly involved in authentic, real-world projects. He emphasizes the importance of active participation of the learners in the learning process by implementing a multifaceted project that requires the application of knowledge and skills required and acquired in the classroom. These projects are interdisciplinary by nature, serve as a catalyst for collaboration, drivers of critical thinking, and as vehicles of synthesis formation.

Phenomenon-Based Learning Theory

Countering the Project-based Approach, the theoretical framework for Phenomenon-Based Learning (PhBL) theory, which is grounded in constructivist principles, asserting that effective learning occurs when students engage with authentic and contextually relevant phenomena (Kilpatrick, 1918). PhBL emphasizes the importance of students actively exploring and investigating real-world situations, events, or occurrences that serve as meaningful entry points for learning (Kilpatrick, 1918). By immersing learners in phenomena, PhBL aligns with the principles of experiential learning, allowing students to connect new information to existing knowledge through firsthand experiences.

Bloom’s Taxonomy

The third theoretical underpin of this research that will support both the Project-Based Approach and the Problem-based approach is the Bloom's Taxonomy, a seminal framework in educational psychology introduced by Bloom

et al. (1956). Bloom's Taxonomy classifies cognitive skills into six hierarchical levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. Bloom's taxonomy provides the scaffold the educators need in designing their learning objectives that progress from basic recollection of knowledge to higher levels of cognitive understanding. With the incorporation of Bloom's taxonomy, the researcher aims to evaluate the depth of cognitive engagement facilitated by the integration of PjBA and PhBA.

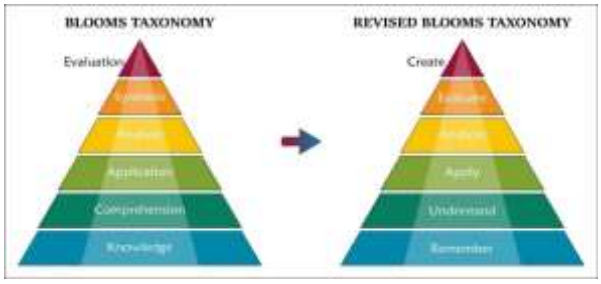

Figure 1. Bloom's Taxonomy proposed by Benjamin Bloom in 1956, and the Revised Bloom's Taxonomy of Lorin Anderson in 2001

Method

Research Design

The researchers utilized quasi-experimental, pretest-posttest nonequivalent comparison group design. According to The World Bank Group (2023), quasi-experimental research design is a type of research design that seeks to identify the impact of a certain intervention or treatment by comparing the experimental group - the group given the intervention to the control group. This design does not require randomization of participants. On the other hand, as defined by Yang (2023), the pretest - posttest non-equivalent comparison group design refers to a type of quasi-experimental research where both the experimental and control groups are given similar pretests, then the experimental group is given an intervention while the control group proceeds without any intervention, and then are given the same posttest. This method was used to measure the impact of the given intervention and compare it from the results of the pretest, where students are not given any interventions yet.

This research design was implemented to study the integration of Project-based and Phenomenon-based learning approaches and to compare their significant influences on student's learning. This study was focused on determining whether there are significant differences between the two approaches and the learning performance of the two groups; the Project-based learning group and the Phenomenon-based learning group.

Research Instrument

The researchers used a set of pretest and posttest questions derived from the prescribed teaching manual by the Commission on Higher Education, with utilization of Table of Specification that specifies the learning competencies based on the K-12 General Chemistry 2 Curriculum Guide. The questions from both the pretest and posttest are validated by their General Chemistry 2 Teacher, and two other teachers specializing in science.

Population and Sampling

The participants of this study are the Grade 12 STEM Students enrolled in Tayabas Western Academy School Year 2023-2024. The researchers applied purposive sampling to select the participants. As posited by Frost (n.d.), the non-probability sampling method allows the researchers to select specific participants for their study, as they see that these participants can help them to achieve the study's goals. Two heterogeneous classes were designated, categorized as Project-based learning group and Phenomenon-based learning group. Grade 12 Galilei as the Project-based learning group has 52 students, and Grade 12 Newton, the Phenomenon-based learning group has 53 students. This sums up to 105 respondents.

Research Procedure

The researchers and their research adviser jointly initiated this study, wherein both agreed to undertake the research to investigate innovative teaching and learning approaches namely, Project-based and Phenomenon-based learning. The researchers reviewed numerous studies which served as their pattern and inspiration for their study. After identifying the respondents, the researchers sought approval from the College Dean and the school principal to conduct the study with the selected respondents. Afterwards, the researchers then created the pretest and posttest administered, these tests are based on the competencies in the K-12 curriculum with agreement to a Table of Specification. Then, the crafted research instruments were validated by three professionals in the field of education, specifically in the area of Science. The validators assessed both the face and content aspects of the instrument for both the pretest and posttests. After the approval of the research title, statement of the problem, and instrument; the researchers then proceeded with the conduct of the study.

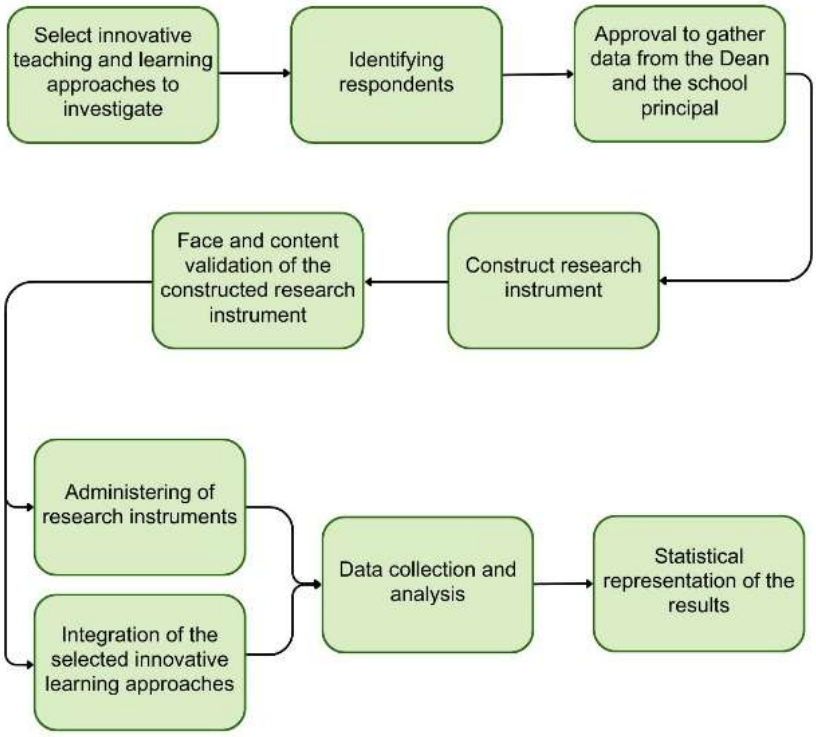

Figure 2. Research Procedure

The researchers assigned a teacher to handle General Chemistry 2 in both of the Grade 12 STEM, one section adopted the Project-based learning approach while the other integrated Phenomenon-based learning approach. Both groups took the same pretest about the topic, about Quarter IV of General Chemistry 2, to find out if there was a significant difference in the performance among the two groups. After the test, both groups were given instructions about the same topic, integrating their respective interventions. Towards the end of the instruction, they are assessed using the same set of posttests. The scores of the two groups are then statistically compared to determine whether both innovative learning approaches were effective.

Results

Table 1 shows the performance of the respondents in their pretest. Nine students, making up the 20% of the Phenomenon based learning group, and four students or 9.1% of the Project based learning group are considered to be Developing students as they acquired scores in the 6–11-point range.

Table 1. Performance of the Respondents in Pretest

PhBL Group				**PjBL Group**		
Scores	*f*	*%*	*Description*	*f*	*%*	*Description*
24 - 30	-	-	Outstanding	-	-	Outstanding
18 - 23	4	9.1%	Proficient	6	13.6%	Proficient
12 - 17	31	70.5%	Approaching Proficiency	34	77.3%	Approaching Proficiency
6 - 11	9	20%	Developing	4	9.1%	Developing
0 - 5	-	-	Beginning	-	-	Beginning
TOTAL	44	100%		44	100%	

Note. PhBL: Phenomenon-Based Learning; PjBL: Project-Based Learning

On the other hand, the major portion of the two groups were considered to be students with Approaching Proficiency, this group are composed of students gaining scores in the 12-17 score range, 30 students or 70.5% of the Phenomenon based learning group and 34 or 77.3% of the Project based learning group constitutes this group. These results revealed that both groups were seen to have Approaching Proficiency about the topic, which was anticipated by the researchers since the learners have beginning knowledge about related topics from their previous subjects.

Table 2 reveals the performance of the respondents in the post test. The 15.9% or 7 students from Phenomenon based learning group, and 8 or 18.2% of students in the Project based learning group were revealed to be included in the Developing group which scores are in the 6-11 score range. Conversely, learners that are considered to have Approaching Proficiency is still composed of the majority of the respondents, consisting of 34 or 77.3% and 35 or 79.6% of the Phenomenon based learning group and Project based learning group, respectively. This result shows that integrating self-directed learning methods, specifically Phenomenon based learning and Project based learning bears no significant improvement or changes in the academic performance of the learners.

Table 2. Performance of the Respondents in Posttest

PhBL Group				PjBL Group		
Scores	*f*	*%*	*Description*	*f*	*%*	*Description*
24 - 30	-	-	Outstanding	-	-	Outstanding
18 - 23	3	6.8%	Proficient	1	2.3%	Proficient
12 - 17	34	77.3%	Approaching Proficiency	35	79.6%	Approaching Proficiency
6 - 11	7	15.9%	Developing	8	18.2%	Developing
0 - 5	-	-	Beginning	-	-	Beginning
TOTAL	44	100%		44	100%	

Note. PhBL: Phenomenon-Based Learning; PjBL: Project-Based Learning

Table 3 reveals the test of difference between the pretest and post test scores of the two respective learning group. Giving emphasis to the Phenomenon based learning group, the said group tallied a mean of the score not higher than and not lower than 14 out of 30 both in the pretest and post test. In this instance, the result led to record a p-value of 0.940082, which indicates that there are no significant difference between the performance of the students even after the implementation of Phenomenon based learning method.

Table 3. Test of Difference between the Phenomenon Based Group and Project Based Group in terms of Pretest and Posttest

	PhBL GROUP		PjBL GROUP	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Mean	14.02	14.07	14.48	13.48
Known Variance	9.65	6.44	5.14	4.58
Observations	44	44	44	44
P (Z <= z) two-tail	.940082		.033369*	
z Critical two-tail	1.959964		1.959964	

*Note: p-value < 0.05 – there is a significant difference**

On the contrary, the Project based learning group have recorded the mean of the score of not higher than and not lower than 14 in the pretest, while 13 in posttest; this is out of 30 items. This result reflected to a p-value of 0.033369 with respect to the scores in both pretest and posttest. In this case that the p-value is below 0.05 means that there is a significant difference between the test performance of the students after the implementation of Project based learning method. Thus, this result implies that integration of Project based learning method yields effective in learning redox reactions.

In light of these discoveries, the researchers recommend that future studies should prioritize identifying the underlying cause of why the PhBL was ineffective as an intervention using a qualitative approach rather than a quantitative one. The qualitative approach will greatly narrow down the scope of further studies of this topic. With the analysis of the results, the researchers have deemed PjBL to be effective and viable as a teaching strategy that

can be implemented in the classroom. This supports the findings of Santos et al. (2021), and Thomas and Ertl (2019), their study highlights the positive impacts of PjBL to the learning performances of learners. Their findings and the researchers' study suggest that PjBL offers a dynamic approach to education that aligns well with the demands of 21st-century learning, where students are encouraged to take an active role in their education through real-world problem-solving projects.

However, despite the promising results of these studies, the researchers recommend further refinement and study of PjBL before its implementation in the Philippine curriculum. This is due to some challenges identified during the study. These challenges have been documented by Walker and Leary (2019), including logistical difficulties, time constraints, and the need for adequate teacher training. These challenges underscore the importance of ensuring that the infrastructure, resources, and professional development opportunities necessary for successful PjBL implementation are in place. Without addressing these issues, the effectiveness of PjBL may be compromised, leading to inconsistent outcomes and potential difficulties for both educators and students.

With these considerations, the researchers recommend that future studies should focus on refinement and optimization of the pedagogy. Although the researchers have stated that PjBL has been successful in implementation in the classroom, it still has its downside. Future researchers should address these shortcomings and improve upon them for a smoother, and rigid structure.

Summary of Findings

This study aimed to explore the integration of Phenomenon based learning and Project based learning methods in Grade 12 STEM General Chemistry classes at Tayabas Western Academy school year 2023-2024.

The following are the pivotal findings of the study.

1. *The performance of the respondents before the integration of:*
   1.1. Phenomenon-based learning;
   1.2. Project-based learning?

The pretest performance of the Phenomenon and Project based learning group reveals that both groups are in Approaching Proficiency level as 70.5% and 77.3% of the two groups fall into this classification, respectively.

2. *The performance of the respondents after the integration of:*
   2.1. Phenomenon-based learning;
   2.2. Project-based learning?

The performance of the respondents in the post test do not fall far from the pretest results, as both of the groups still fell on the Developing Proficiency classification, comprised of 77.3% and 79.6% of students, respectively.

3. *The significant difference between the pretest and post-test scores of the Phenomenon-based and Project-*

based learning group.

Out of the 30-item tests, the Phenomenon based learning group has 14.02 as the mean of the score in the pretest while having 14.07 in the posttest. Also, this result shows that there is a p-value of 0.940082, meaning that there are no significant difference between the pretest and posttest scores of the said group as $p > 0.05$.

On the other hand, in the pretest, the Project-based learning group recorded 14.48 as its mean of the score, while recording 13.48 in the posttest after the integration of Project based learning method. Unlike the previous, this learning group have shown an improvement in their academic achievement after obtaining a p-value of 0.033369. Thus, this result reveal that there is a significant difference as $p < 0.05$.

4. The inferences that can be derived from the results

In essence, these results shows whether the Phenomenon and Project based learning method are tested to be effective in learning General Chemistry, specifically the topic of Redox Reactions. Grade 12 STEM students of Tayabas Western Academy are introduced to the aforementioned interventions after their prior knowledge are gauged through a 30-item pretest, and their learnings are evaluated after through a posttest.

After conducting statistical tests, their raw test scores yield different results. Firstly, the Phenomenon based learning group's numbers are tested to have no significant difference between the pretest and posttest, meaning the said learning method is yet ineffective to implement for the topic in hand. However, the Project based learning group's number appeared to have a significant difference between the pretest and posttest, which leads to an inference that it is effective and ready to be integrated in learning the topic of Redox Reactions.

Conclusions

Based on the indicated findings, the conclusions were hereby drawn:

1. Out of the two learning methods, the Project based learning method is the only one that resulted to an improved academic performance for Grade 12 STEM students based on their pretest and posttest scores.
2. The Project based learning method is effective in General Chemistry 2 instruction, specifically in learning the topic of "Redox Reactions"
3. The null hypothesis stating that there is no significant difference between the pretest and posttest scores of the Phenomenon based learning group is accepted and the alternative hypothesis is rejected.
4. The null hypothesis stating that there is no significant difference between the pretest and posttest scores of the Project based learning group is rejected and the alternative hypothesis is accepted.

Recommendations

Based on the findings and conclusions made, the following are hereby formulated:

1. Curriculum developers may improve the means for students' self-directed learning to effectively cultivate and foster their responsibility for learning and critical thinking. Through this, learners can confidently and successfully traverse the ever-changing educational landscape.
2. School heads, administrators and teachers can learn more about these learning methods prior to their implementation, discover its advantages in improving the delivery of instruction in General Chemistry, as well as to other subjects.
3. Teachers may integrate these learning methods as a creative way of instruction not limited to General Chemistry but also to other subjects that these methods are well-suited. However, they must be mindful of the various factors to consider in implementing such elaborate method, specifically its appropriateness to the subject matter to be taught.
4. Labeled as 21st century learners, students are encouraged to be responsive and open to such instructional reforms as these can help them develop the 21st century skills they will need to be productive citizens in the future. Moreover, these learning methods can help them to improve their creativity, communication skills and critical thinking, leading them to be actively participating in their learning.
5. Parents are encouraged to become advocates of educational reforms that can help their child/children attain improved academic performance and discover more of their skills through their guidance and constant support in providing necessary materials for their educational endeavors.
6. Future researchers may use this study as a framework and inspiration for future studies tackling similar or other learning methods in a wider scope of population.

References

Activate Learning. (2023, September 21). *What is Phenomena-Based Learning and How Does it Engage Students?*. Activate Learning. https://activatelearning.com/what-is-phenomena-based-learning/#:~:text=Phenomena%2Dbased%20learning%20provides%20several,why%20or%20how%20something%20happens

American Montessori Society. (n.d.). *What is Montessori education?*. What Is Montessori Education? https://amshq.org/About-Montessori/What-Is-Montessori

Andreev, I. (2024, July 31). *What is phenomenon-based learning? its benefits & examples*. Valamis. https://www.valamis.com/hub/phenomenon-based-learning?_gl=1%2Awzlefc%2A_up%2AMQ..%2A_ga%2AMTQ5MTYwNDM4My4xNzAxMDg5NTY2%2A_ga_WH32P1Y0T3%2AMTcwMTA4OTU2NS4xLjAuMTcwMTA4OTU2NS4wLjAuMA..#benefit-of-phenomenon-based-learning

Andersen, L. R. (n.d.). *What is Building? European Association for the Education of Adults.*

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-Based Learning: An Approach to Medical Education.* Springer.

Bercasio, R. R., & Adornado, R. A. (2023). Enriching High School English Lessons with Global Citizenship Education Using Phenomenon-based Learning. *Randwick International of Education and Linguistics Science Journal, 4(*2), 216–232. https://doi.org/10.47175/rielsj.v4i2.651

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain. David McKay Company.

Boss, S. (2011, September 20). *Project-Based Learning: A short history*. Edutopia. https://www.edutopia.org/project-based-learning-history

Brandt, W. C. (2020). *Measuring student success skills: A review of the literature on self-directed learning* (thesis). National Center for the Improvement of Educational Assessment.

Cailey, R. J. (2024, February 10). *Project-Based Learning: Equipping learners for the future, a comprehensive guide for professionals*. LinkedIn. https://www.linkedin.com/pulse/project-based-learning-equipping-learners-future-guide-cailey-oqxyf#:~:text=Critical%20Thinking%20and%20Problem%2DSolving,after%20in%20today's%20dynamic%20world.

Chen, J., & Chen, C. (2019). Exploring the effectiveness of phenomenon-based learning in a science class in Taiwan. Journal of Baltic Science Education, 18(5), 695-707.

Dave, S. (2023, July 29). *Project based learning: Benefits & techniques of PBL*. Practera. https://practera.com/project-based-learning-benefits-and-techniques/#:~:text=Project%2Dbased%20learning%20(PBL),is%20cost%2Deffective%20and%20simple

de Guzman, A. B. (2003). The dynamics of educational reforms in the Philippine basic and higher education sectors. *Asia Pacific Education Review*, *4*(1), 39–50. https://doi.org/10.1007/bf03025551

De Los Reyes, M., & Orongan, M. J. (2023). Digital project-based learning (PBL) on students' academic achievement and technological skills in grade 10 science. *International Journal of Multidisciplinary Research and Development*, *10*(4), 23–27.

Dilobarkhon, K. (2019). The importance of modern innovation in education. *European Journal of Research and Reflection in Educational Sciences*, *7*(12), 659–661.

Doles, K. (2012, July 17). *What is project-based learning?*. PBS. https://www.pbs.org/wgbh/frontline/article/what-is-project-based-learning/

Drew, C. (2023, September 5). *Phenomenon based learning, explained!*. Helpful Professor. https://helpfulprofessor.com/phenomenon-based-learning/

Driscoll, M. (2021, January 14). *Education in the 21st Century*. Think Strategic for Schools. https://thinkstrategicforschools.com/education-21st-century/

Eleazar, M., Aragoncillo, A., Nguyen, M. X., & Felipe, A. L. (2020). *Bringing PBL to Philippines's higher education: How much are teachers geared for the transition from traditional to PBL approach?* (thesis).

Environmental Education Alliance of Georgia. (n.d.). *Phenomenon-based learning*. https://www.eealliance.org/phenomenon-based-learning.html

Frost, J. (n.d.). *Sampling Methods: Different Types in Research.* https://statisticsbyjim.com/basics/sampling-methods/

Haatainen, O., & Aksela, M. (2021, March 29). *Project-based learning in integrated science education: Active teachers' perceptions and practices* (thesis). *LUMAT General Issue*.

International Journal of Science Education. (2019). *The effectiveness of phenomenon-based learning in science*

education: A meta-analysis. Retrieved from https://iopscience.iop.org/article/10.1088/1742-6596/1842/1/012071/meta

Johnson, A., & Smith, B. (2018). Student resistance to phenomenon-based learning: A case study in a US high school. *Journal of Educational Psychology, 110*(3), 442-454.

Kharbach, M. (2023, September 29). *What is self directed learning?*. Selected Reads. https://www.selectedreads.com/what-is-self-directed-learning/

Kilpatrick, W. H. (1918). The project method. Teachers College Record, 19(4), 319-335.

Knowels, M. (1975). *Self-Directed Learning: A Guide for Learners and Teachers.* New York. https://eric.ed.gov/?id=ED114653

Kurt, G., & Akoglu, K. (2023). Project-Based Learning in Science Education: A comprehensive literature review. *Interdisciplinary Journal of Environmental and Science Education*, *19*(3). https://doi.org/10.29333/ijese/13677

Larmer, J. (2015, October 21). *Debunking 5 myths about Project-based learning*. Edutopia. https://www.edutopia.org/blog/debunking-five-pbl-myths-john-larmer

Lee, H., et al. (2020). The effects of Phenomenon-Based Learning: A meta-analysis. *Educational Research Review, 29*, 100311.

Lee, S., & Cuthbert, K. (2023, March 30). *Phenomenon-based learning: What, why and how*. Times Higher Education. https://www.timeshighereducation.com/campus/phenomenonbased-learning-what-why-and-how

Leonard, G. (2023, March 26). Project-Based Learning: Applying theories and experimenting through projects has proven to be a much better learning method. *Linkedin*. February 9, 2024, https://www.linkedin.com/pulse/project-based-learning-applying-theories-through-has-gerald-j-

LiFT Learning. (2021). *The history of Project-Based Learning (PBL)*. https://liftlearning.com/the-history-of-pbl/

Main, P. (2022, September 26). *Project-Based Learning*. Structural Learning. https://www.structural-learning.com/post/project-based-learning

Pardes Jewish Day School. (2023, January 31). *8 great benefits of Project-Based Learning*. https://www.pardesschool.org/8-great-benefits-of-project-based-learning/

PBLWorks. (n.d.). *What is PBL?*. PBLWorks. https://www.pblworks.org/what-is-pbl

PowerSchool. (2021, June 24). *Project-Based Learning: Benefits, Examples, and Resources*. Powerschool.com. https://www.powerschool.com/blog/project-based-learning-benefits-examples-and-resources/

Practera. (n.d.) *Project Based Learning: Benefits & Techniques of PBL*. Practera. https://practera.com/project-based-learning-benefits-and-techniques/

Resaba, M., & Gayeta, N. (2021). Utilization of project-based learning (PBL) resources in Senior High School. *Ioer International Multidisciplinary Research Journal*, *3*(2), 252–259.

Reyes, M., et al. (2020). Challenges and opportunities in implementing project-based learning in Philippine schools. *Asia Pacific Journal of Education, 40*(1), 63-77.

Rich, E. (2010, October 11). *How do you define 21st-century learning?* https://www.edweek.org/teaching-learning/how-do-you-define-21st-century-learning/2010/10.

Santos, A., et al. (2021). Enhancing critical thinking through project-based learning: A local perspective. *Philippine Journal of Educational Research and Evaluation, 5*(1), 14-28.

Schaffar, B., & Wolff, L.A. (2024). Phenomenon-based learning in Finland: A critical overview of its historical and Philosophical Roots. *Cogent Education*, *11*(1). https://doi.org/10.1080/2331186x.2024.2309733

Shabbir, R. (2023, September 5). *6 steps to implement project-based learning in the classroom*. Educationise. https://www.educationise.com/post/6-steps-to-implement-project-based-learning-in-the-classroom

Silander, P. (2019). *Phenomenon based learning*. Phenomenal Education. http://www.phenomenaleducation.info/phenomenon-based-learning.html

Strobel Education. (2023, November 15). *Unlocking the benefits of innovative teaching strategies*. Strobel Education. https://strobeleducation.com/blog/unlocking-the-benefits-of-innovative-teaching-strategies/#:~:text=Instead%20of%20relying%20solely%20on,a%20more%20engaging%20learning%20environment

Thomas, J. W. (2000). *A Review of Research on Project-Based Learning.* Autodesk Foundation. http://www.bobpearlman.org/BestPractices/PBL_Research.pdf

Thomas, J. W., & Ertl, B. (2019). Project-based learning: A review of the literature. *Journal of STEM Education: Innovations and Research, 20*(2), 11-18.

Tsybulsky, D., & Muchnik-Rozanov, Y. (2021). Project-based learning in science-teacher pedagogical practicum: The role of emotional experiences in building preservice teachers' competencies. *Disciplinary and Interdisciplinary Science Education Research*, *3*(1). https://doi.org/10.1186/s43031-021-00037-8

Walia, A. (2023, September 18). *Exploring the benefits and challenges of Project-Based Learning*. Learning Routes. https://www.learningroutes.in/benefits-and-challenges-of-project-based-learning/

Walker, A., & Leary, H. (2019). Challenges of implementing project-based learning in secondary schools. *Research Papers in Education, 34*(4), 429-448.

Yuliati, L., & Parno. (2018). Exploration of physics problem-solving skills within phenomenon-based learning in senior high school students. *International Conference on Education*, *4*, 97–103. https://doi.org/10.17501/icedu.2018.4111

Zhang, Y., & Li, X. (2017). The impact of project-based learning on high school chemistry students' conceptual understanding, attitudes, and scientific reasoning. *Chemistry Education Research and Practice, 18*(1), 16-27.

Zhukov, T. (2015, June 27). *Phenomenon-Based Learning: What is PBL?* Retrieved from Noodle.com. https://resources.noodle.com/articles/phenomenon-based-learning-what-is-pbl/

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