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Project-Based Learning: A Basis for Enhanced Implementation in Science, Technology, Engineering, and Mathematics Strand

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Abstract. This descriptive research aimed to study the factors of Project-Based Learning (PBL) to academic performance of STEM students in terms of learning environment, students' participation, and learning responsibility. One hundred forty-two (142) STEM students from Palayan City National High School were selected using a stratified random sampling to answer the structured questionnaire. The data gathered through the use of Likert Scale surveys were analyzed using weighted mean, and correlation. The findings of the study revealed that research projects are the most common project that the STEM students experienced, while environmental-related projects are the least. Variables such as the learning environment, students' participation, and learning responsibility gained an average weighted-mean of 3.09, 3.22, and 2.86, respectively, which are described as often. Based on the results the profile of the respondents in terms of sex is significantly correlated to students' participation and learning responsibility, age is significantly correlated to students' participation and the general average of the learners is significantly correlated to learning environment, students' participation and learning responsibility. Furthermore, the results of the study revealed that Project-based learning resulted in students to be more active in class discussion resulting in deeper comprehension of lessons, it also enhanced students' communicating skills, discipline, and time management when conducting hands-on activities.

Keywords: *Academic performance; Project-Based learning; STEM students*

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1. Introduction

Education, particularly in the fields of Science, Technology and Engineering, and Mathematics strand (STEM), is undergoing a change towards more student-centered approaches, one of them is Project-Based learning (PBL) that stands out as a method that places students at their own learning journey. STEM education incorporates a better understanding of science, math skills and technology with the ability to perform engineering project courses. It is composed of four disciplines, namely Science, Technology, Engineering and Mathematics.

This research aims to explore the factors of PBL when implemented in STEM (Science, Technology, Engineering, and Mathematics) programs, with a focus on key variables derived from the Constructivist Learning Theory: Learning Environment, Learning Responsibilities, and Student Participation. Constructivist Learning Theory emphasizes the importance of an environment that encourages active engagement, collaboration, and critical thinking.

When applied to PBL in STEM programs, the learning environment becomes a critical factor influencing student outcomes. How the physical and virtual spaces are designed, the accessibility of resources, and the integration of real-world contexts all contribute to shaping a student's learning environment, project-based tasks in STEM classrooms transform the traditional setting into dynamic spaces where students are challenged to explore, inquire, and solve problems collaboratively.

By investigating how the learning environment affects student engagement and understanding in STEM-related projects, this research seeks to provide insights into optimizing these spaces for enhanced learning outcomes. In learning responsibilities, Constructivist Learning Theory underscores the importance of learners actively constructing their knowledge through authentic experiences. Learning responsibilities examines how the distribution of responsibilities impacts student learning, self-efficacy, and the development of essential skills. In students' participation, Constructivist Learning Theory proposed that learners actively participate in the construction of their knowledge.

Understanding how different modes of participation, such as group collaboration, individual exploration, and peer interaction, contribute to learning

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outcomes is vital, by searching into the dynamics of student participation within the context of project-based STEM learning, this research aimed to discover patterns that influence the effectiveness of PBL. Analyzing the impact of varied participation levels on knowledge, problem-solving skills, and overall STEM competency will provide valuable insights for educators seeking to optimize their instructional strategies.

This research aimed to study the factors of project-based learning in Science, Technology, Engineering and Mathematics Strand. This study sought to answer the following:

1. How may the profile of the respondents be described in terms of:
    1.1 Age;
    1.2 Sex;
    1.3 General average in the previous semester; and
2. Type of project-based learning they usually participate in?
3. How may the project-based learning in STEM strand be described in terms of the following factors:
    2.1 Learning environment;
    2.2 Students' participation; and
    2.3 Learning responsibility?
4. What difficulties do STEM students encounter in implementing project-based learning?
5. Is there a significant relationship between the profile of the respondents and the factors of project-based learning in the STEM strand?
6. What intervention plan may be proposed to enhance the implementation of project-based learning among SHS students?

2. Methodology

This study used the descriptive-correlational research design. Descriptive design was used in the presentation of the respondents' profile and the factors of projects-based learning and correlational design was used in determining the relationship of the respondents' profile and the factors of project-based learning.

2.1. Sampling Procedure

This research used stratified probability sampling to group the participants according to their age, sex, and average grade. The sample size of 142 students was obtained from the population of 224 students using Raosoft Calculator.

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2.2. Respondents

The respondents of the study were Senior High School students under STEM strand who were presently enrolled in Palayan City National High School in the Division of Nueva Ecija, for the School Year 2023-2024.

2.2.1 Research Site

This research was conducted at Palayan City National High School whose commitment to STEM education provides a rich environment for studying the impact of project-based learning on student outcomes in terms of adapting to learning environment, participating in group activities, and their responsibility as an individual.

3. Results and Discussion

3.1. Profile of the Respondents

The profile of the respondents shows that majority of the respondents 64 or 45.07% were 17 years of age. Practically, there is equal number of male and female respondents. Moreover, it shows that most learners, 72 learners or 50.70% have an average ranging from 86 to 88.

3.2 Type of Project-Based Learning

Research projects is the most frequent project-based learning type encountered by learners, followed by Media/Video Projects in second, Problem Solving Practices as third, at fourth is Arts Projects and Environmental-related projects is the least.

3.3 Description of Factors of Project-Based Learning in STEM Strand

3.3.1 Learning Environment

Table 3. Learning Environment as a Factor of Project-Based Learning

Statements	Weighted Mean	Verbal Description
1. I struggle to learn in a loud environment.	3.11	Often
2. I feel comfortable and safe while learning.	3.47	Always
3. I struggle to focus on my studies because of other people.	3.27	Always
4. I feel comfortable learning in quiet room.	3.02	Often
5. I struggle to learn in a messy room.	3.43	Always
6. I find it easier to accomplish a project when collaborating with others.	3.06	Often
7. I become more productive to do the project when I am with group mates.	2.90	Often
8. I struggle to focus on my studies because of other people.	3.00	Often
9. I can easily approach my teachers if seeking help is needed.	2.70	Often
10. I am comfortable on my learning environment.	2.93	Often
Average weighted mean	**3.09**	**Often**

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It shows that in terms of learning environment, the highest factor is the learners always (mean=3.47) “feeling comfortable and safe while learning", while the least factor is the learners often (mean=2.70) "can easily approach their teachers if seeking help is needed.”, Overall, learning environment is often (mean=3.09) a factor of Project-based learning.

3.3.2 Students' Participation

Table 4. Students' Participation as a factor of Project-Based Learning

Statements	Weighted Mean	Verbal Description
1. I engage myself in class discussions.	3.09	Often
2. I participate on class activities.	3.50	Always
3. I engaged myself in group projects.	3.40	Always
4. I engaged learning in outdoor-related activities.	3.19	Often
5. I participate on art activities.	3.36	Always
6. I give suggestions to my group mates to make our project better.	3.24	Often
7. I understand the lesson easily when I actively participate on class discussion.	3.22	Often
8. I engaged myself in group projects.	3.22	Often
9. I am comfortable expressing myself in a group discussion	2.90	Often
10. I understand the concept of a lesson easily when I participate in peer discussion.	3.10	Often
Average weighted mean	**3.22**	**Often**

The table shows in terms of students' participation, the highest factor is the learners always (mean=3.50) "participating on class activities ", while the least factor is the learners often (mean=2.90) “are comfortable expressing themselves in a group discussion". In general, students' participation is often (mean=3.22) a factor in Project-based learning.

3.3.3 Learning Responsibility

Table 5. Learning Responsibility as a factor of Project-Based Learning

Statements	Weighted Mean	Verbal Description
1. I always rely on my group mates depending on the difficulty of the task given to me.	2.47	Sometimes
2. I am making a to-do list or checklist to determine which project I prioritize depending on its deadlines.	3.27	Always
3. When faced with a challenging problem in a project, I am confident in my ability to find a solution.	2.87	Often
4. I separate my personal issues from my groups to get a project done in advance.	3.20	Often
5. I cooperate with my classmates.	3.00	Often
6. I review our lessons.	2.50	Often
7. I can work on projects on different subjects at the same time and submit them on time.	2.70	Sometimes
8. I complete the assignments given to me.	2.67	Often
9. I submit output/project on time.	2.97	Often
10. I prioritize my project that captures my interest.	3.00	Often
Average weighted mean	**2.86**	**Often**

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Table shows that in terms of learning responsibility, the highest factor is the learners always (mean=3.27) "are making a to-do list or checklist to determine which project they prioritize depending on its deadlines.", while the least factor is the learners sometimes (mean=2.47) "relying to their groupmates depending on the difficulty of the task given to them.". Overall, students' learning responsibility is often (mean=2.86) a factor in Project-based learning.

3.4. Difficulties in Implementing Project-Based Learning to STEM Students

Table 6. Difficulties STEM Students Encountered in Project-Based Learning

Statements	Weighted Mean	Verbal Description
1. I struggle to collaborate with my groupmates.	2.24	Sometimes
2. I am not very good at managing my time.	2.55	Often
3. I am not motivated to engage in group projects.	2.07	Sometimes
4. I am not confident enough to engage in group projects.	2.10	Sometimes
5. I find it hard to comprehend the assignment provided to me.	2.29	Sometimes
6. I feel shy consulting with my teacher online.	2.07	Sometimes
7. I find it hard to arrange a group meeting.	2.27	Sometimes
8. I find it challenging to travel to my group members' locations.	2.55	Often
9. I lack the skill to do the project.	2.60	Often
10. I find it hard to manage my group projects.	2.42	Sometimes
Average Weighted Mean	**2.32**	**Sometimes**

It shows that learners often (mean=2.60) "lack the skill to do the project" is the most encountered difficulty in implementing Project-based learning. Both the learners often (mean=2.07) “are not motivated to engage in group projects" and often (mean=2.07) “are feeling shy consulting with their teachers online” are the least encountered difficulty in implementing Project-based learning. In general, the learners sometimes (mean=2.32) encounter difficulty in the implementation of Project-based learning.

3.5. Correlation between the Profile of the Respondents and the Factors of Project-Based Learning in STEM Strand

Table 7. Relationship between the Profile of the Respondents and the Factors of Project-based Learning

Profile Variables	Learning Environment		Students’ Participation		Learning Responsibility	
	r	p-value	r	p-value	r	p-value
SEX	- 0.16	0.056	0.20*	0.02	0.17*	0.04
AGE	- 0.13	0.136	0.21*	0.002	0.61	-.044
GENERAL AVERAGE	0.18*	0.03	0.29*	<0.001	0.20*	0.01

It can be gleaned from the table that sex have a significant positively correlation with students’ participation (r=0.20 and p-value=0.02). This implies that females are expected to have greater students’ participation than their male

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counterparts. Also, sex and learning responsibility have a significant positive correlation (r=0.17 and p-value=0.04). This implies that females tend to have higher learning responsibility than males.

Moreover, age have significant positive correlation (r=.21 and p-value=.002) with students' participation and it shows that older learners tend to have a greater students' participation than younger learners.

It can also be shown that the average grade of the learners is significantly positively correlated (r = 0.18 and p-value=0.03) with learning environment. Learners with higher average grades are expected to have a better learning environment. Also, average grade of the learners have a significant positive correlation (r=0.29 and p-value=0.003) with students' participation. Learners with higher average grade tends to have greater students' participation. Furthermore, it is shown that learners' average grade have a significant positive correlation (r=0.20 and p-value=0.01) with learning responsibility and it shows that learners with higher average grades are expected to have higher learning responsibility.

3.6. Proposed plan to enhance the implementation of Project-Based Learning

PROPOSED ENHANCED IMPLEMENTATION OF PROJECT-BASED LEARNING TO STEM STUDENTS

Goals and Objectives	Activities and Strategies	Persons Involved	Resources Needed	Time Frame	Success Indicator
To ensure an engaging environment and encourage a more positive interaction with their teachers and classmates to better improve their learning experiences and success	Encourage students to activities like group discussions, class debates, and implementing activities including teachers and students.	Teachers and Students	Materials used in presentations like papers, posters and other written materials for discussions and debates. Audio resources can also be used in the activities.	Conduct the activities quarterly inside the classroom guided by the teacher.	Increased the engagement of students making them more active in class and building a good relationship with their peers and with their teachers.
To encourage students' participation inside their classroom and to encourage them to collaborate with their classmates	Encourage students to share their ideas by doing collaborative activities like problem-solving, puzzles, pair-sharing activities and offering a Socratic seminar inside their classroom.	Teachers and Students	Workshop materials like presentation, handout, and visual resources for collaborative activities. Audio materials for talking in the seminar.	Plan and conduct the activities professionally by the teachers guiding the program.	Enhancing the active participation of students while also developing their cognitive thinking and building their teamwork within their peers
To encourage students to be a responsible learner to further improve their learning ability and to enhance their skills on performing	Collaborative activities like pair sharing, case studies, and peer review can further improve their knowledge and understanding.	Teachers and Students	Reference material like books can be used for peer studying. Online or Internet materials like fact sheets, online resources such as blogs, teaching guides,	Conduct and plan by teachers using internet materials such as	Improving the learner's responsibility on their studies while collaborating with others, enhancing their skills and knowledge on performing the task assign to them.

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task and projects	Encourage students to manage their time by doing a to-do list.		lesson plans, and video clips on sites such as YouTube as their learning materials.	lesson plans and video clips.	
To foster creativity, enhance real talents, develop critical thinking, enhance the participation in group activities, collaboration, communication, and self-directed learning.	Implement a variety of engaging activities and effective strategies. Incorporate hands-on activities aimed at reinforcing project skills, share inspiring success stories, and assign collaborative projects to foster teamwork and communication in authentic contexts.	Teachers and Students	Workshop materials such as presentations and audio-visual equipment for conducting informative talks and seminars. Utilize collaboration tools like online platforms, and white boards	Scheduled collaborative group projects on a quarterly basis, with continuous guidance and support from teachers throughout the duration.	Increased participation, as well as enhanced moral and physical support from teachers towards their students during project-based learning activities. Additionally, monitor improvements in collaboration and communication skills among students as key indicators of success.
To enhance students' skills, confidence, motivation, and interest in completing project-based learning activities through hands-on exercises, success stories, and collaborative projects.	Offer hands-on activities to practice project skills, share success stories, and assign collaborative projects to enhance teamwork and communication in real world scenarios.	Teachers and Students	Workshop materials such as handouts, presentations and audio-visual equipment for seminars and talks. collaboration tools for group projects such as online platforms, whiteboards, and time management resources a planner.	Assigned collaborative group projects quarterly, with ongoing guidance and support from teachers.	Increase participation and engagement in project-based learning activities while enhancing collaboration and communication skills among students.

Conclusions

It is observed that in the implementation of Project-based learning, Research project is the most encountered activity. The learners often experience learning environment, students' participation and learning responsibility as effects of project-based learning. Also, STEM Students sometimes encounter difficulties in Project-based learning. Moreover, the profile of the learners has significant relationship on the factors of project-based learning in STEM strand.

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