

# Utilizing Problem-Based and Project-Based Learning in Developing Students' Communication and Collaboration Skills in Physics

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**Abstract** Education plays an essential part in the progress and development of a particular country. With the rapid economic and social changes resulting from technological advancement, it is indeed that globalization and internationalization of education are considered as challenges that every nation should uphold. This study aimed to utilize problem-based learning and project-based learning methods in developing students' communication and collaboration skills in physics. This study used a quasi-experimental pretest-posttest non-equivalent research design. Two different sections were utilized as participants of the study; one intact class was assigned as the first experimental group (n=42) using problem-based learning and the other intact class as the second experimental group (n=36) utilizing project-based learning method. The communication and collaboration was measured using an open-ended questionnaire and was scored using a researcher-made rubric with a Krippendorff's alpha of 0.97. Results revealed that significant improvement in communication and collaboration skills was shown in both teaching methods. Furthermore, there is no significant difference in students' communication and collaboration skills as influenced by the two teaching methods. The absence of difference could imply that the two teaching methods improved the scores of students equally. Based on this finding, it is recommended to use the two teaching methods in other science subjects that require content development and mastery of 21<sup>st</sup>-century skills.

**Keywords:** *authentic learning, inquiry-based, innovative teaching, learner-centered, science education, soft skills*

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## 1. Introduction

Globalization and internationalization of education are considered as challenges that every nation must uphold. The skills are required to meet these new challenges which span various disciplines, and one of the emphases of today's challenges in education is the promotion of 21<sup>st</sup>-century skills or transversal competencies among students [1]. Of the different skills, communication and collaboration skills have often left behind in the design and development of current curricula. Students possess communication skills when they can organize their thoughts, data, and findings and share these effectively through different media, especially in speaking and in writing. On the other hand, students exhibit collaboration skills when they can work together in answering questions or solving problems, accomplishing a common goal, and assuming shared responsibility for completing a task [2].

The Assessment, Curriculum, and Technology Research Centre (ACTRC) has explored and assessed 21<sup>st</sup>-century skills or transversal competencies in nine Asia-Pacific

jurisdictions: Australia, Hong Kong, India, Mongolia, Malaysia, Republic of Korea, Philippines, Thailand, and Vietnam. The Philippines reported having challenges that are primarily operational-systemic, which includes delay in implementation of policies, lack of teacher training and incentives, and the scarce availability of IT infrastructure and technical expertise. Also, the Department of Education (DepEd), Philippines, has integrated the 21<sup>st</sup>-century skills into its K to 12 reform agenda. Test items have also been developed and incorporated into National Achievement Tests (NAT) for these skills to be aligned with the learning goals of the K to 12. As in other countries, transversal competencies are not taught independently but imbedded in the various subjects of the curriculum, and it indicates that an extensive range of the skills is being taught and assessed by Philippine teachers. One of the challenges reported by teachers and administrators in the Philippines was the shortage of other assessment materials designed to target transversal competencies. Furthermore, other problems encountered were uncertainty regarding the definition of skills, lack of technical expertise in teaching and assessing the skills, and curriculum pressure to focus on the content of subject areas [3].

Developing students' full potential is one of the significant responsibilities of a teacher. Teacher's responsibility is not only limited to the four walls of the classroom or the compensation received but on the level of students' learning of the necessary skills and on how they apply it on their daily living and in bridging their journey to success. Like the schools in other countries, one of the primary goals of the Philippine education system is to develop students' 21<sup>st</sup>-century skills such as communication and collaboration. As shown in the NAT results reported [4], science had the lowest mean percentile score among other subjects. This goes to show that much should be done to improve the state and quality of science education in the Philippines. To achieve this, the government must impose a change in how educators should teach the learners in today's generation. It has been suggested that Problem-based Learning (PrBL) and Project-based Learning (PjBL) be used. These methods are of great advantage to propel the class towards interactive learning and change the course of teaching and learning from the traditional classroom practices into a much more modern and exciting environment [5].

The problem-based learning and project-based learning are types of experiential learning and teaching methods. These methods have the same orientation: both view learning in terms of authentic and constructivist approaches. These methods can powerfully engage the students to learn and are known as useful and when it comes to improving students' academic performance in school. It is with these reasons that this paper aimed to examine the development of students' skills using problem-based learning and project-based learning as teaching methods in Physics.

## 2. Objective of the Study

This study investigated the development of students' communication and collaboration skills utilizing problem-based learning and project-based learning methods in Physics. Specifically, this study answered these questions:

1. Is there an improvement in the communication and collaboration skills of students as influenced by the two teaching methods?
2. How do students' scores in the two teaching methods (PrBL and PjBL) differ in terms of:
  - a. communication; and
  - b. collaboration?

## 3. Materials and Methods

This study used a mixed-method of quantitative and qualitative research, utilizing a quasi-experimental pretest posttest non-equivalent research design. Prior to the conduct of the study, a letter asking for permission to conduct an experimental study to the Grade 10 Junior High School Students of the Integrated Basic Education Department of San Isidro College was recommended by the IBED Principal and approved by the Executive Vice-President. From among the three sections of grade

10 students in the Integrated Basic Education Department of San Isidro College, the school year 2019-2020, two different classes were randomly considered as the participants of the study. One class (n=42) was assigned as the first experimental group utilizing the problem-based learning method and the other section (n=36) as the second experimental group utilizing project-based learning method. This study used a researcher-made test and peer-collaboration rubric. A six-item test was constructed using open-ended questions covering topics from the second quarter lessons of the grade 10. The test was used to measure students' communication skills in electromagnetic spectrum, light, electricity and magnetism. The second instrument that was used in this study was the peer-collaboration rubric. This rubric contains criteria wherein the students will be given the opportunity to rate their group members based on attendance, degree for preparation for class, listening and communication skills, ability to bring new and relevant information to the group, and ability to support and improve the functioning of the group as a whole. For communication, it was rated using a rubric based on interpretation, application and explanation. The teacher-made test was shown to science education experts for face and content validity. Based on reliability testing, the Krippendorff's alpha for communication instrument was found to be 0.97, which is highly reliable. The primary data that were collected were the pretest and posttest scores of the communication and collaboration test. The data were presented as mean and standard deviation, and differences were tested using paired t-test and analysis of covariance (ANCOVA) at 0.05 level of significance.

## 4. Results and Discussion

### 4.1. Communication

Communication skills refer to the ability to exchange information between individuals through a conventional system of symbols or signs. The communication skills of the participants for the two teaching methods were examined and are summarized in Table 1. It was found in the table the mean, standard deviation, and probability value of students' pretest and posttest scores utilizing the two teaching methods in developing students' communication. As gleaned from the table, significant improvement in communication skills was shown in both groups. This increase may be a result of the opportunities given to the students to converse with their group mates. Some of the opportunities include activities during the preparation and construction of their solutions to the problems presented. Accordingly, collaborative learning has been widely adopted around the world, and inquiry group project-based learning plays an important part in the learning process to comprehensively improve students' communication skills [6]. Moreover, the increase in students' scores may also be attributed to the fact that the students were given a chance to present their output to the whole class at the end of every PBL sessions. Furthermore, with the help of problem-based activities and other student-centered methods, many students are given opportunities to develop their communication skills [7].

**Table 1. Pretest and Posttest Scores in Communication**

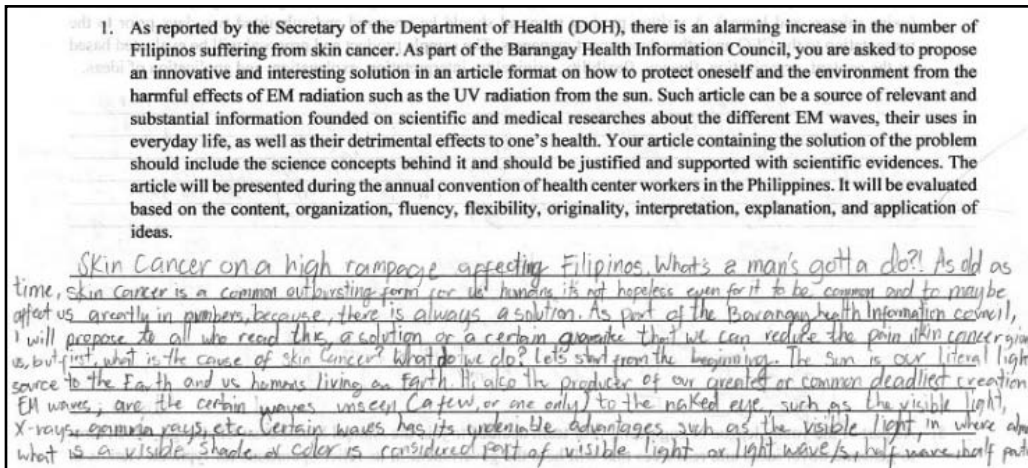
Method	Communication		t (df)	p-value
	Pretest	Post-test		
PrBL	27.80±11.48	45.86±11.47	-35.95 (35)	0.000*
PjBL	24.53±6.45	42.28±6.42	-126.74 (33)	0.000*

\*Significant at 0.05 level.

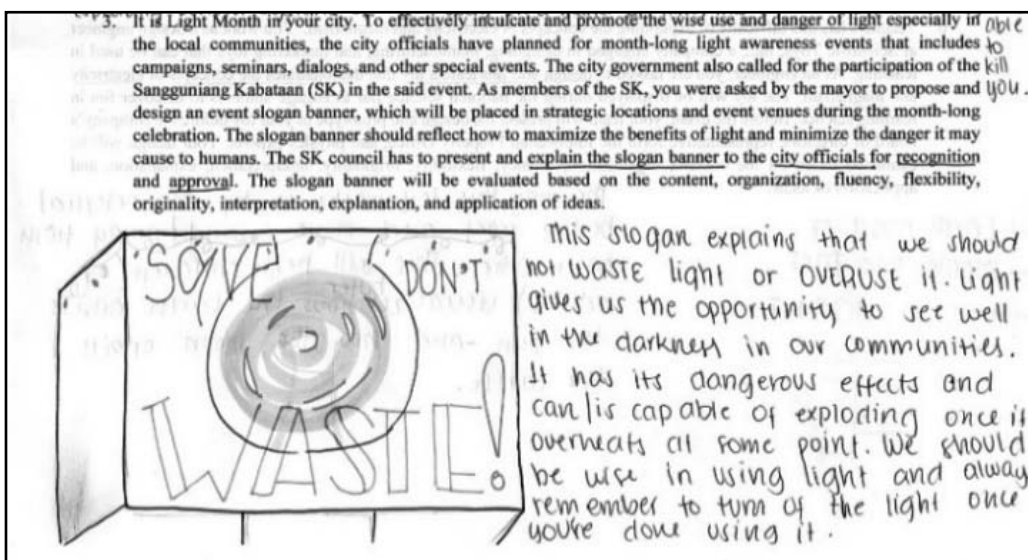
It is also seen from the same table that the computed probability values in both the teaching methods are significant. This implies that the pretest and posttest scores of the students had increased positively in communication skills and attained an improvement as exposed to problem-based learning and project-based learning methods. This may be because students were grouped and were given all the opportunities to research, create, and present their solutions based on the problems presented during each PrBL session. Well-designed collaborative problem-based learning strategies have the potential to support the development of academic knowledge and skills [8]. Besides, when students are grouped into small members and are provided with an

unstructured problem, they acquire communication skills in generating ideas [9].

As shown in Figure 1 and 2, students' responses clearly illustrate well-organized answers. The students understood and explained the problems concisely and accurately with minor issues. Also, the ideas are sequenced to show relationships, transitions are varied, and the language, style, and tone are appropriate to the task and have few errors in grammar, usage, and mechanics. Effective written communication should use short and familiar words, express thoughts logically, and avoid unnecessary words [10]. This is true to the answers of the students in question numbers 1 and 3, wherein the answers were expressed logically and followed the conventions of writing in science as a discipline. Additionally, written communication is one of the essential learning outcomes among higher education institutions, and writing should involve critical and reflective engagement of one's ideas and skill in producing captivating arguments [11]. This is very noticeable to students' answers where ideas were conveyed clearly and briefly.



**Figure 1.** Student's response in question number 1



**Figure 2.** Student's response in question number 3

Differences in the pretest and posttest scores of the students in communication for both teaching methods were examined using one-way ANCOVA and are summarized in Table 2. The analysis of the covariance yielded an F value of 1.434 and a computed probability value of 0.235, which is higher than the 0.05 level of significance. This led to the failure of rejecting the null hypothesis. This means that there is no significant difference in students' communication skills as influenced by the two teaching methods. This suggests that students' scores in the two experimental groups were not significantly different from one another.

**Table 2. One-way ANCOVA Table Examining the Difference in Communication Skills for the Two Teaching Methods**

Source	Df	Sum Sq	Mean Sq	F value	p-Value
Pretest	1	5996	5996	1159.69	0.000
Group	1	7	7	1.434	0.235 <sup>NS</sup>
Residuals	67	346	5		

\*Significant at 0.05 level, <sup>NS</sup>Not significant.

Engaging students in problem-based learning would lead them to become adept at group working and enhancing their communication skills [12]. This is in congruence with the result of another study, which states that problem-based learning can improve students' oral communication skills [13]. Furthermore, project-based learning allows students to significantly improve and develop their oral and written communication skills [14], [15]. This could have been the basis for the lack of difference for both teaching methods. This further indicates that the lack of differences could mean that both groups may have equally developed the communication skills for both teaching methods.

## 4.2. Collaboration

Collaboration refers to two or more people or organizations working together to complete a task or achieve a goal. The collaboration skills for the two teaching methods were inspected and are summarized in Table 3. It is illustrated in the table the mean, standard deviation, and probability value of students' pretest and posttest scores utilizing the two teaching methods in developing students' collaboration. As shown from the table, significant improvement in collaboration skills was shown in both groups. The pretest scores of the students in collaboration are similar in both of the teaching methods as well. The improvement in students' collaboration may be the result of the teacher feedback and the peer-collaboration feedbacking, which were done every end of a PBL session. It can also be attributed to the group activities given to them wherein they were required as a group to discuss, construct, and propose possible solutions to the real-life scenarios that were presented to them. This is also revealed in another study done, which highlights the relevance of integrating useful feedback, for it can be used as a critical element in developing students' learning and engagement in the class [16]. One more study explored and analyzed the nature of teacher feedback during a collaborative activity. It was found out that when

a teacher gives feedbacks like suggestions and questions instead of direct corrections, the students respond constructively and therefore improve their collaboration skills since they discuss the content they are working with [17].

Additionally, it is displayed from the table that the computed probability values in both the teaching methods are significant. This indicates that the pretest and posttest scores of the students had increased positively in collaboration skills. This further implies that the students attained an improvement in developing their collaboration skills as exposed to problem-based learning and project-based learning methods. Collaborative groups and group dynamics processes of problem-based learning can lead to students' collective and independent ownership of learning [18]. Consequently, the project-based learning method enables the development of students' 21<sup>st</sup>-century skills like communication and collaboration skills [19]. Moreover, it was emphasized that the full potential of PBL could be realized when it is conducted as a research activity where the students are given freedom of action and thought and the sense of ownership of experience [20].

**Table 3. Pretest and Posttest Scores in Collaboration**

Method	Collaboration		t (df)	p-value
	Pretest	Post-test		
PrBL	21.47±2.93	23.10±1.47	-4.27 (35)	0.000*
PjBL	21.32±2.73	22.65±1.76	-3.71 (33)	0.000*

\*Significant at 0.05 level.

As shown in Figure 3 and Figure 4, students' are working collaboratively in small groups towards a common goal, and that is to solve a problem and to finish a project. The collaboration of students would also mean attending group meetings regularly, contributing ideas to group discussion, completing assignments on time, preparing work in a quality manner, and demonstrating a cooperative and supportive attitude. It is noted that students appreciated the quality of working relationships, the independent way in which group work was facilitated, and the chances for freedom of action and thought [20]. This is due to the real-life activities and ample time that was given to the students to solve problems and create projects. Likewise, among the five fundamental elements involved in collaborative learning, students who are utilizing PrBL and PjBL developed individual and group accountability, group processing, interpersonal, and small group skills [21].



**Figure 3.** Students working together to finish a project



Figure 4. Students working together to finish a project

Differences in the pretest and posttest scores of the students in collaboration for both teaching methods were studied using one-way ANCOVA and are summarized in Table 4. The analysis of the covariance yielded an F value of 2.144 and a computed probability value of 0.148, which is higher than the 0.05 level of significance. This led to the failure of rejecting the null hypothesis. This means that there is no significant difference in students' collaboration skills as influenced by the two teaching methods. This suggests that students' scores in the two experimental groups were not significantly different from one another. The current research was found consistent with another study wherein the students make substantive decisions based on group agreement, take an essential role in implementing the project, work also depend on each other to complete the project [22]. This means that students' collaboration skills have developed. It has also been reported that the appropriate use of social skills can generate a positive impact on collaboration [23]. Besides, PrBL and PjBL are about learning and motivation for learning by the application of more student-centered learning principles [24]. This could have been the explanation for the absence of difference for both of the teaching methods. This further implies that the lack of difference between the two teaching methods could mean that both groups may have equally developed collaboration skills.

Table 4. One-way ANCOVA Table Examining the Difference in Collaboration Skills for the Two Teaching Methods

Source	Df	Sum Sq	Mean Sq	F value	p-Value
Pretest	1	69.68	68.68	41.41	0.000
Group	1	3.61	3.61	2.144	0.148 <sup>NS</sup>
Residuals	67	112.73	1.68		

\*Significant at 0.05 level, <sup>NS</sup>Not significant.

## 5. Concluding Statements

The students' communication and collaboration skills have increased positively after the utilization of the two teaching methods. This means that when these teaching strategies are utilized, students can develop their communication and collaboration skills as a result of the plenty of opportunities provided to interact and communicate among themselves. Also, there were no significant differences found in students' scores for the two skills as influenced by the two teaching methods. This

could be because both the problem-based learning and project-based learning methods are inquiry-based teaching methods that are student-centered, problem-focused, self-directed, self-reflective, and the teacher serves as facilitator. Problem-based learning and project-based learning as methods of teaching have significantly developed the students' communication and collaboration in physics. Educators, therefore, may utilize inquiry-based teaching methods that are learner-centered to develop students' 21<sup>st</sup>-century skills, especially collaboration and communication skills.

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