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Effects of student-centered learning approaches towards interest in science

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Abstract

The need to improve the way science is taught in Philippine classrooms arises because of the decline in the performance in science among high school students. This study investigates the effects of student-centered approaches, such as inquiry-based learning (IBL) and problem-based learning (PBL), on students' interest in learning science. This study utilized an explanatory sequential mixed-method design. A total of 44 Grade 12 students served as respondents to the survey through a complete enumeration technique. Data were collected using a modified science interest questionnaire, a journal, and through a one-time recorded interview. Results revealed that IBL and PBL showed a significant difference in students' interest after exposure to both approaches. IBL and PBL activities encourage student engagement, critical thinking, and creativity. However, a few students felt distressed about IBL activities and disclosed negative views of PBL as difficult and time-consuming.

Keywords: Inquiry-based learning, interest, learning experiences, problem-based learning, science education

Introduction

Learning science has remained a problem for many of the students in the Philippines. The issue is apparent in the 2018 National Achievement Test (NAT) results among Grade 12 learners in one Department of Education (DepEd) region (Abina, 2021). It revealed that the mean percentage score for science is 31.81 percent, the lowest among all the subject areas and far beneath the national target passing rate of 75 percent as set by the department (Department of Education, 2019). Furthermore, according to the 2018 Programme for International Student Assessment scores, the Philippines scored 357 in science, much lower than the OECD average (Organisation for Economic Cooperation and Development [OECD], 2019). The declining trend of science education corresponds to the students' hostile attitude toward studying science (Hassan et al., 2016). When students are interested in learning, they spend their time, effort and focus on their studies. Thus, learning science motivates students to gain new knowledge and skills (Sadera et al., 2020).

Philippine educators strive to assimilate essential 21st-century skills to address the issue. Student-centered learning approaches offer problem-solving skills, creativity, analytical thinking, collaboration, communication, and accountability (Keiler, 2018). These approaches, such as inquiry-based learning (IBL) and problem-based learning (PBL), positively improved performance and interest in science. Interest boosts motivation leading to improved understanding, which indicates academic success (Harackiewicz et al., 2016). IBL has been proven to raise students' performance and affect students' positive attitudes toward science (Aktamiş et al., 2016; Baraquia, 2018; Kang & Keinonen, 2017; Laine et al., 2017). Meanwhile, PBL also increases critical thinking, problem-solving skills, and interest in science (Aweke Shishigu Argaw et al., 2017; Orozco & Yangco, 2016; Valdez & Bungihan, 2019).

Although a growing body of literature on the benefits of IBL and PBL in science classes is evident, a few research studies are available using these approaches to senior high school students in the Philippine setting, where K to 12 curriculum implementation is still in its early stage. IBL has already been implemented in the Senior High School curriculum of DepEd. However, using PBL in the Philippine K to 12 curricula needs more research.

From this perspective, this paper explores the effects of student-centered learning approaches, particularly IBL and PBL, on students' interest and experiences in learning science. This study seeks to provide insights to science educators in improving the implementation of these approaches in actual science classes to boost students' interest in the subject, thereby contributing to the academic achievement of science education in the Philippines.

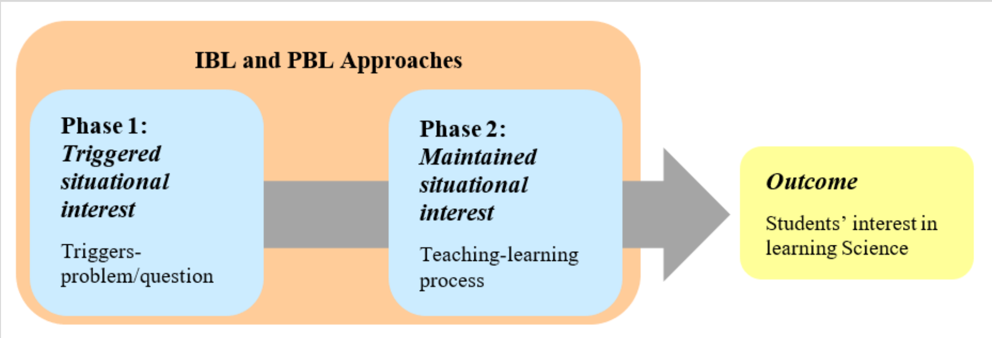
Conceptual framework

The study used Hidi and Renninger's (2006) model, which introduced interest stages. A triggered situational interest is the first stage of interest development which results from short-term changes in the affective and cognitive processes and evolves into the second phase when sustained (Hidi & Renninger, 2006). This stage is sparked by instructional conditions such as activities, group works, puzzles, and problems, which may become a precursor to re-engaging in similar content to develop into a higher phase of interest. Meanwhile, the maintained situational interest requires concentrated attention and persistence over an extended period. The situated interest is sustained through meaningful and personal involvement in tasks and learning activities such as cooperative group work and project-based learning.

As illustrated in Figure 1, Phase 1 includes the triggers, particularly the presentation of the problem or questions, that pique students' attention in the first part of the lesson in both IBL and PBL approaches. Phase 2 calls for the teaching and learning process, particularly the IBL and PBL lesson development, that provides meaningful and personally involving tasks and activities to sustain interest.

Only limited literature links IBL and PBL to students' interest in learning. With this, the researchers tried to explore the effects of these student-centered approaches on students' interest and experiences in learning science. The conceptual framework presents how the lesson process, including the presentation of trigger questions and problems and the tasks and activities in the lesson development of IBL and PBL approaches, may affect students' motivation in learning.

Figure 1
The Conceptual Framework



Research objectives

This study explores the effects of student-centered learning approaches on students' interest in learning science. Specifically, the study aimed to:

1. determine the level of students' interest in science before and after exposure to IBL and PBL approaches;
2. determine if there is a significant difference between the student's level of interest after exposure to IBL and PBL approaches; and
3. describe students' learning experiences while being exposed to IBL and PBL approaches.

Methodology

Research design

The study utilized an explanatory sequential mixed-method design to investigate the effects of student-centered approaches on students' interest in learning science. The method includes a linear data-gathering process that begins with quantitative data collection and analysis and progresses to qualitative data collection and analysis (Gay et al., 2011; Tashakkori & Teddlie, 2010). The study's quantitative data collection and analysis entails evaluating students' interest before and after exposure to IBL and PBL and determining the significant difference in the mean scores from the pretest to the post-test of both approaches. The qualitative data collection and analysis procedure includes recognizing students' experiences while exposed to IBL and PBL methods.

IBL, using 7-E Inquiry-Based Instructional Model by Eisenkraft (2003), was utilized since IBL is a recommended approach in teaching science in the K to 12 curricula of the Department of Education (Republic of the Philippines Department of Education, 2019). Aside from IBL, PBL was used since it possesses similarities in the teaching process. It can be used in teaching physical science as one of the subject offerings in the Humanities and Social Sciences (HUMSS) Strand of the K to 12 Curricula. The PBL approach is based on the Maastricht Seven-Jump Method developed initially by Maastricht University in 1976 (Maurer & Neuhold, 2012).

Locale

The researchers conducted the study in one of the national high schools in the Bontoc I district of the Division of Southern Leyte. The school provides both a junior high and a senior high school program. Under the senior high school program, the school explicitly offers General Academic Strand. The study is conducted only in one school to ensure that factors such as classroom conditions and class schedule, which may affect the results, are considered.

Respondents of the study

The respondents were forty-four (44) grade twelve students from two intact heterogeneous classes, wherein each group consisted of 22 students who were part of the General Academic Strand and took physical science in one of the school year's semesters. The two intact classes were randomly assigned as the IBL and PBL groups. The researchers considered some parameters in selecting the participants to ensure the study's validity. First, the researcher ensured that both classes were a heterogeneous group. Second, the mean level of interest before and after exposure to IBL and PBL of the two groups was treated to ensure that the groups were statistically comparable. Lastly, the two groups were exposed to the same classroom conditions and were studying the same lesson, as specified in the K–12 curriculum guide, taught by the same teacher.

Data gathering procedures

The researchers conducted an orientation for the participants and their parents, particularly on the objectives and the ethical considerations to be undertaken during the study upon approval of the request to conduct the study from the school principal. The parents and students signed informed consent. After the orientation, a 14-item adopted questionnaire from Darlington (2017), wherein prior permission was sought, was administered to measure the student's level of interest before exposure to both approaches. The modified instrument was subjected to a reliability test and yielded a Cronbach's alpha value of 0.865, indicating an acceptable reliability level. After administering the questionnaire, the two groups were taught with IBL and PBL approaches using the 7E Inquiry-Based Instructional Model and the Maastricht Seven-Jump Method, respectively. The topics utilized in the study include factors affecting rates of chemical reactions, writing, and balancing chemical equations, types of chemical reactions, calculating amounts of reactants and products, limiting reactant and percent yield, interpreting speed and velocity motion graphs, laws of motion, the law of universal gravitation, momentum, and reflection and refraction.

All students kept a journal of their experiences after each PBL and IBL session. After completing all teaching sessions, the researcher re-distributed the survey-adopted questionnaire. The responses to the questionnaire before and after exposure to both teaching approaches were recorded, tabulated, and analyzed using the appropriate statistical tests. Also, the interview and journal responses were gathered, transcribed, compiled, coded, and sorted to form categories. Lastly, the researcher invited the students to participate in a one-time semi-structured recorded interview focused on their experiences while exposed to IBL and PBL.

Data analysis

The study utilized weighted means to compare the level of interest in science before and after exposure to IBL and PBL approaches. Levene's test determined the homogeneity of variation between scores. A paired t-test determined the significant difference in the student's interest levels after exposure to both approaches. Furthermore, the researchers performed thematic analysis to collect qualitative data. The researchers transcribed the responses from the recorded interview and compiled them with their journal entries. The responses were coded, and related experiences were grouped to generate themes. Further, the researchers ensured that the quantitative and qualitative data were independently analyzed, following Tashakkori & Teddlie's (2010) guidelines for conducting mixed-method studies.

Findings and discussion

Level of students' interest before and after exposure to IBL and PBL

Table 1 shows students' interest levels before and after exposure to IBL and PBL techniques. The findings revealed that students exposed to IBL had a mean score of 3.2018 (neither interested nor disinterested) before exposure, while the mean score improved to 3.4818 after exposure (interested). It means that students grew interested in learning science after being exposed to IBL.

Table 1
Level of Students' Interest before and after Exposure to PBL and IBL

Group		*N*	*M*	*SD*	Description
IBL	Before exposure	22	3.2018	0.52255	Neither interested nor disinterested
	After exposure	22	3.4818	0.45012	Interested
PBL	Before exposure	22	3.5336	0.40853	Interested
	After exposure	22	3.6950	0.41231	Interested

Note. 1.00-1.80 – Highly disinterested; 1.81-2.60 – Disinterested; 2.61-3.40 – Neither interested nor disinterested; 3.41-4.20 – Interested; 4.21-5.00 –Highly interested

The results are in congruence with several studies that demonstrate the positive impacts of IBL on student performance, subsequently improving interest in the learning process. IBL develops higher-order and critical thinking skills, thus significantly increasing students' motivation to learn science concepts since there is a connection between real-life scenarios (Archer-Kuhn et al., 2020; Kang & Keinonen, 2017; Wilson, 2020; Lia Yuliati et al., 2018). Furthermore, IBL serves to empower students by giving them voices and choices, naturally enhancing motivation (Gholam, 2019).

Moreover, before exposure, the PBL group had a mean score of 3.5336 (interested) and remained interested (3.6950) after exposure. The results implied that most students in the PBL group were inclined to learn science as they were already introduced to inquiry-based approaches since their junior high school as part of implementing the Deped K to 12 curricula (Republic of the Philippines Department of Education, 2019). The findings support Ahmad Wafa Nizami, and Ali Mahmudi's (2018) study that PBL boosts students' learning interest in science. PBL enhances student engagement, creativity, critical and problem-solving abilities, reflective thinking, communication and teamwork abilities, and self-direct learning (LaForce et al., 2017). PBL has also improved student learning and increased students' enthusiasm to learn (da Silva et al., 2018).

Significance between the students' interest after exposure to IBL and PBL

Table 2 demonstrates the results of Levene's test. Since the significance value is higher than 0.05 (0.480), the variability between scores is relatively the same, which implies that a t-test can determine the significant difference between students' interests after exposure to IBL and PBL.

Table 2

Equality of Variances on Students' Interest after Exposure to IBL and PBL

	Levene's test for equality of variances		*t*-test for equality of means				
	F	Sig.	*t*	*df*	Sig. (2-tailed)	*M* difference	*SE* difference
Students' interest after exposure	0.509	0.480	1.638	42	0.109	0.21318	0.13014

Table 3 presents the difference between the students' interest after exposure to IBL and PBL using a paired t-test. Based on the table, the group's interest significantly increased (IBL, p=0.022; PBL, p=, 0.012) despite the slight gain in their mean scores before and after exposure. The findings indicate that the difference in mean score from the pretest to the posttest is statistically significant for IBL and highly significant for PBL. It implies that both IBL and PBL significantly impact students' motivation to learn science. The results agree with the study of Aydeniz et al. (2012) and Aweke Shishigu Argaw et al. (2017). The results are opposite to Maxwell et al.'s (2015) findings that IBL's impact on interest is limited, potentially due to the non-routine nature of the approach (Frezell, 2018). Besides, the level of interest is also influenced by the success achieved in student learning.

Table 3

Significant Difference between the Students' Interest after Exposure to IBL and PBL

Group		Paired differences			*t*	*df*	*p*-value
		M	*SD*	*SE* mean			
IBL	Before-after exposure	-0.1614	0.30691	0.6543	-2.466	21	0.022*
PBL	Before-after exposure	-0.2800	0.4794	0.1022	-2.739	21	0.012**

Note. ns - not significant; * - significant; ** - highly significant

Student's experiences on IBL and PBL

This section presents the themes generated from the student's interviews and journals.

IBL promotes student engagement

Inquiry-based learning improves both learning outcomes and student motivation for learning. According to research, inquiry-based learning increases student engagement in the classroom (Archer-Kuhn et al., 2020). Student engagement is a state of emotional, social, and cognitive readiness to learn characterized by curiosity, participation, and a desire to learn more (Abla & Fraumeni, 2019). Some students expressed an increased level of engagement after being exposed to IBL. It is evident in some students' responses to how IBL changed their learning viewpoints. "To be honest, I am not really into it [science] because I thought it [IBL] is boring, but I eventually enjoyed it, especially when we do the activities" (SS1). "I am not a fan of science, but now I am starting to like it because I felt amazed and happy when I can accomplish the tasks" (SS2).

When students enjoy what they do in class, they are engaged in the lesson. Furthermore, when students have fun with the activities, they are satisfied and learn more. Since the primary aim of IBL is to answer a posed question on a specific topic, the activities assigned to them lead them to evaluate the answers to these questions. IBL allows students to explore and discover the solution on their own. As a result, autonomy develops (Isik-Ercan, 2020). Students get a sense of independence in learning. It means that their opinion matters. Empowering students naturally increases interest and curiosity (Bayu Sandika, & Herlina Fitrihidajati, 2018; Gholam, 2019). It is evident in the students' comments about how IBL piques their interest and makes them want to learn more as they become engrossed in the topics presented. "I find it more interesting. It can attract my attention and makes me want to learn more about the topic" (SS3). "When doing the [IBL] activities, I became interested because I find it fun and amazing" (SS4). "At first, I thought I would have difficulty in the lesson. And I find it challenging because I'm not good in chemistry and physics. I know that science is hard, but as the days go on, I find it fun and interesting" (SS5).

Motivation, engagement, academic achievement, and interest strongly link to positive emotions like satisfaction and more profound learning (Buchanan et al., 2016; Hernik & Jaworska, 2018). The respondents' experiences show that IBL improves student performance in the classroom and fosters positive attitudes such as increased interest. When adequately implemented, students can have more meaningful learning experiences and develop deeper learning.

IBL makes the students feel distressed

IBL requires that students participate actively in the lessons. As a result, teachers encourage students to speak up and participate in activities. In contrast, while some students have pleasant feedback with IBL, others struggle. A few students stated that, while they enjoyed the topics, they were initially nervous. "I find it enjoyable but is quite challenging" (SS6). "I was a little bit nervous at first, but later, I had fun in the activities" (SS7).

While IBL encourages student engagement, it may be challenging for those with difficulty speaking up and those with poor comprehension and higher-order thinking skills. According to Frezell (2018), IBL can increase student interest and make other students feel distressed due to a lack of direct instruction. Because students are accustomed to routine and direct instruction, they may feel "unsecured" in taking risks with inquiry learning. Due to the indirect instruction, some students found the hands-on activities of IBL challenging. Students believed they were left to fend for themselves in learning many concepts through trial and error. It can sometimes be difficult for students, leaving them dissatisfied with the IBL approach. Some students discussed how they felt while learning after being exposed to IBL.

"I had fun, but it is tiring" (SS8). "Honestly, I don't clearly understand what the lesson is all about" (SS9). "The approach, honestly, is boring for me" (SS10).

The IBL approach requires that students understand the instructions for the learning process to run smoothly. Otherwise, students spend more time asking questions than investigating, which leads to confusion. These experiences should be prioritized when implementing the IBL approach in the classroom. Teachers should consider giving guided inquiry lessons to students who are slow learners.

PBL promotes student engagement

PBL is a learner-centered approach that employs relevant, meaningful, real-life problems or scenarios to provide students with hands-on experience with the presented concepts (Stentoft, 2017). According to one student, PBL offers experiential learning, which aids in conceptual understanding. "To be honest, I didn't find our lesson interesting at first. We were allowed to answer the problem on our own until we could arrive at the correct answers. I like it because the problems build on my experience, and it helps me understand more" (SS11).

Teachers should create PBL problems that pique students' interest in a specific topic. Well-crafted scenarios significantly impact student learning motivation because students learn more effectively when the problems are familiar. According to a study by Siew and Ruslan Mapeala (2017), using PBL in the classroom significantly impacts student motivation when teachers focus on real-life scenarios. Some students mentioned how much they enjoyed the activities that used everyday household items. "The [PBL] activities were fun and exciting…because we do it hands-on" (SS12). "I learn a lot because the problems have so much to do with our daily lives, and the materials that we used are all household items" (SS13).

Motivation is the driving force that stimulates, controls, and sustains students' interest in learning about the topic (Koca, 2016). Furthermore, motivation and student engagement are strongly intertwined (Dewi Mustamiah, & Nurul Sih Widanti, 2018; Nayir, 2017). It simply means that when students are engaged in their lessons, they are more motivated to complete the tasks, leading to a more meaningful experience and increased interest. "The activities were interesting and fun, and the way the teacher teaches us to make me learn a lot more. After doing all the activities, I can say that I am more interested in science more than before" (SS14).

Like IBL, interest develops as a result of student engagement. Engaged students learn more and remember more concepts because they are presented with real-world problems and allowed to experiment to find the best solution (Kardoyo et al., 2020). The theme highlights a critical realization: Teachers, as tutors in PBL classes, should design realistic problems to stimulate learning.

PBL develops critical thinking and creativity

PBL gives students a more compelling opportunity to practice problem-solving skills (da Silva et al., 2018). As a result, students must move around, communicate, and collaborate with their teammates to solve the problems presented to them (Noor Hafidzah Jabarullah, & Hafezali Iqbal Hussain, 2018). According to several studies, PBL improves critical and creative thinking skills (Anip Dwi Saputro et al., 2020; Tortorella & Cauchick-Miguel, 2018). Critical thinking skills and creativity significantly impact learning achievement (Any Fatmawati et al., 2019). Furthermore, students who achieve higher levels of learning have a greater desire to learn (da Silva et al., 2018). Some students experience how PBL activities help them learn. "The activities enhanced my ability and skills in solving problems..." (SS15). "It [PBL activities] enhanced my problem-solving skills and creativity" (SS16). "The activities make me critically think...for me to arrive at a correct generalization" (SS17).

PBL is difficult

Like IBL, a few students also reported negative feedback on PBL. While some students easily accept PBL and enjoy exploring the activities, others have a negative experience with the subject, forcing them to work harder to catch up with their teammates. Some students shared their experiences, stating that while PBL activities are enjoyable, they are also tricky. "Although PBL is fun and interesting, it is challenging because I have bad impressions of science before" (SS18). "I find the activity fun but challenging. Honestly, the [PBL] activities are quite difficult, but thankfully, I learned a lot at the end" (SS19). "I enjoyed solving the problems presented to us, but the [PBL] activities are quite challenging" (SS20).

Furthermore, PBL activities naturally arouse students' curiosity, but they also require students to relate concepts from different disciplines, making it difficult and challenging for them to understand the concepts (Warr & West, 2020). Students are concerned and perplexed in this case as they participate in the activities. Some students expressed their confusion during the intervention. "Although the activities are fun, I was left confused most of the time" (SS21). "The activity is fun and, at the same time, confusing" (SS22).

The main takeaway from this theme is that teachers should design problems appropriate for the type of learners because not all students have had the same prior learning experiences; some have had negative learning experiences, which necessitates careful consideration. It can be difficult for the tutor because PBL classes are designed for small groups of students who work collaboratively to solve problems and have mature experience and knowledge.

PBL is time-consuming

A few students also reported that PBL activities can also be time-consuming. Implementing these activities in the classroom usually takes more time to arrive at a relevant solution since it follows a sequence, which may take study time away from other subjects. According to Yew and Goh (2016), the quality of the problem presented to students significantly impacts how much time is spent solving the problem. It is evident in some students' responses that PBL takes up more of their time. "PBL activities are fun; it is boosting my enthusiasm to learn, but problem solving is time-consuming, and it takes so much of my time" (SS23). "It is time-consuming. Sometimes, an hour is not enough to finish solving the problem presented to us" (SS24).

While the desire to accomplish PBL activities on time is essential, following steps in carrying out PBL to achieve success is also imperative. PBL activities that are carefully planned and implemented result in increased learning achievements.

Conclusions and recommendations

The quantitative and qualitative investigation revealed that IBL and PBL effectively fostered and maintained students' interest in learning science. IBL and PBL activities encourage student engagement, critical thinking, and creativity. However, while most students expressed positive feelings about IBL and PBL activities, others disclosed negative views of both approaches. The main takeaway from these unexpected responses from some students is that teachers should design problems that are appropriate for the type of learners because not all students have had the same prior learning experiences; some have had negative learning experiences, which necessitates careful consideration.

The study's findings offer insights into implementing IBL and PBL in the actual science classes. School administrators should encourage teachers to employ IBL and PBL in their classes because they increase students' interest and improve students' understanding of science. Teachers should also consider differentiated instruction to minimize the negative learning experiences of students exposed to these approaches. Further, a comparative study should be conducted with larger class sizes and other topic areas.

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