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Effectiveness of Inquiry-Based Physics e-Module on Secondary School Student Academic Performance in a Face-to-Face Collaborative Instruction

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Abstract
Aim: Filipino students registered dismal science results in international assessments like PISA and TIMSS. Enthused by this, the present study was aimed to document the effectiveness of inquiry-based physics e-modules on secondary school student academic performance in a face-to-face collaborative instruction.
Methodology: As a developmental study, this research aimed at determining the effectiveness of inquiry-based physics e-modules on Grade 10 student academic performance in a face-to-face collaborative learning set-up in three different parameters: achievement test, engagement, and classroom discourse quality using a quasi-experimental research design and 26 participants in each control (using printed modules) group and experimental group (e-modules). Data were collected from the achievement test scores, engagement survey, and audio recordings of whole-class sessions.
Results: Findings show no statistically significant difference in the achievement test scores between the control and experimental groups. Conversely, the control group had better overall engagement and cognitive and emotional engagement, with statistically significant difference, but inferior classroom discourse quality. The experimental group classroom discourse is marked by diverse extended student contributions such as explanation, evaluation, argumentation, and justification.
Conclusion: Given the results, it can be argued that the use of inquiry-based e-module can not only facilitate learning of physics concepts, but also ensure deep understanding among students, enabling them in a quality classroom discourse.
Keywords: inquiry-based, e-modules, engagement, classroom discourse

INTRODUCTION

The shift from teacher- to student-centered pedagogy

Education thrust in recent years shifted from teacher- to student-centered pedagogies because in teacher-centered learning environment, students play passive roles (Rogers, 1983, as cited in O'Neill & Macmahon, 2005), while in student-centered classroom, pedagogies highlights inquiry, making learning meaningful and authentic (Garrett, 2008). Student-centered pedagogy, which is rooted from the constructivist learning theory and progressive education movement (Mascolo, 2009), has emerged as a global reform strategy in Southeast Asian countries, including the Philippines (Del Valle, 2021). This education shift was also introduced in the Philippines through the Philippine Republic Act No. 10533 or the Enhanced Basic Education Act of 2013 (K to 12 Basic Education Reform), where the Department of Education (DepEd) was engaged to develop a curriculum that is learner-centered and shall use pedagogical approaches that are constructivist, inquiry-based, reflective, collaborative, and integrative. The K to 12 Basic Education Reform was aimed at improving Filipino students' mathematical and scientific competence (Enderun Colleges, 2022).

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Filipino students' performance

Despite the national initiative through the K-12 reform, the recent results of the Programme for International Student Assessment (PISA) 2022 and the Trends in International Mathematics and Science Study (TIMSS) 2019 show results contrary to expectations; Filipino students performed unfavourably in mathematics and in science when compared to their counterparts in other participating countries. These results reinforce the need to improve the way science is taught in Philippine schools (Sarsale & Langub, 2023) and to address them, efforts are focused in implementing inquiry-based learning, a pedagogy identified to be effective for science and mathematics instruction.

The roles of inquiry-based learning and collaborative learning

Inquiry-based learning (IBL) approach is a student-centered approach that fosters inquiry which is an essential part of science education. Its goal is to transform the learners from being passive to being active participants in the learning process and to empower both the teacher and the students to maximize the outcomes of the teaching-learning process. The students take a greater role and responsibility for their learning by constructing knowledge through the different means provided, such as engagement with problems, questions, and other related activities. Collaborative learning (CL) is another student-centered approach that involves learners in groups that are working together to perform or accomplish tasks, create an output, and find solutions to problems.

Education during the COVID-19 pandemic

As the shift from teacher-centered to student-centered education progressed, the COVID-19 pandemic happened in 2020, affecting the education system greatly. The pandemic abruptly changed the education landscape, translating education delivery to online teaching and learning (Dehghan et al., 2022) in a short period of time. Such a public health crisis accelerated the integration of technology in education and prompted us to find other ways to deliver educational content and one of these is through e-modules. These materials are basically modules in electronic format and are used through computers (Astalini et al., 2021). E-modules contain information in different forms like images, simulations, video clips, animations, and interactive questions that can support learning (Afriyanti et al., 2021).

Research focus and relevance

Given the changes brought by the pandemic in the education system, the question arises on the relevance of the different digital resources for learning as schools return to face-to-face modality and the thrusts that innovations introduced during the pandemic must be utilized. This research is inspired by the efforts to shift from teacher-centered to student-centered education, and the need to address the low learning outcomes of students. This study determines the effectiveness of inquiry-based e-modules for physics in face-to-face collaborative instruction in students' academic performance in three different parameters: achievement test, engagement, and classroom discourse quality. The results of this investigation can provide feasible changes that can be adopted on the infrastructures and materials developed at the height of the pandemic so that they can be made more relevant for use in the post-pandemic era in the country and in other education systems similar to that of the Philippines.

Conceptual Framework

The inquiry-based physics e-modules were designed to guide the students in the exploration, understanding, and making meaning of different Physics concepts and were used in face-to-face collaborative instruction. This provided opportunities for students to engage in sharing and co-constructing knowledge with their peers, enhancing their achievement. This kind of set-up also promotes students' engagement through active involvement in the learning process. It also improves classroom discourse quality by fostering meaningful discussions, exchange and evaluation of ideas, and questioning. The above discussed ideas were summarized as shown in Figure 1 and it serves as the research framework of this study.

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Figure 1
Conceptual Framework

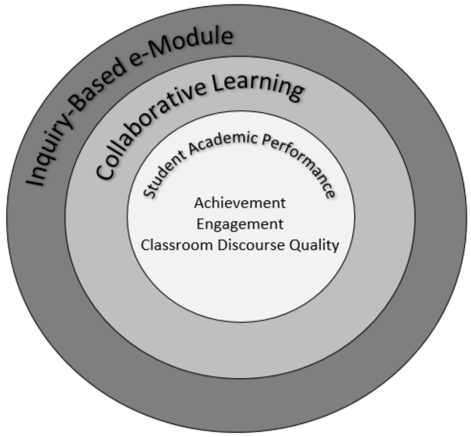

Figure 1 illustrates the relationship between the inquiry based e-module, collaborative learning, and student academic performance in terms of achievement, engagement, and classroom discourse quality.

Inquiry-based Learning (IBL)

IBL is the most frequently discussed constructivist teaching approach in a wide body of research and literature in science education and is promoted by different education departments and ministries across the world (Bächtold, 2013), including the Philippines. IBL are teaching and learning strategies that allow students to inquire into the nature of a problem or question, which serves as a mechanism to engage them in the learning process (Blessinger & Carfora, 2015), where they construct knowledge on their own (Aidoo et al., 2022). It is positively associated with students' attitudes and motivation towards learning science (Areepattamannil et al., 2020; Baldock & Murphrey, 2020; Ferreira et al., 2021). Several studies have shown that IBL is superior to the traditional method in teaching science (Ucar & Trundle, 2011; Vlassi & Karaliota, 2013).

There are existing instructional models that can be employed in IBL. The 5E model is the most mainstreamed in both the inquiry approach and STEM education (Ünlü & Dökme, 2022). It is a five-phase instructional framework including engaging, exploring, explaining, extending, and evaluation (Kaçan & Şahin, 2017). Each phase has its role to help the teacher organize a coherent instructional procedure and to help the students have a better understanding of scientific knowledge, skills, and attitudes (Grau et al., 2021).

Despite IBL's potential and the fact that Filipino teachers generally view it positively (Garcia et al., 2024), its implementation faced several challenges in Philippine classrooms such as the availability of materials and the time-consuming nature of IBL (Gutierez, 2015).

e-Modules

e-Modules are instructional materials that contain multimedia tools such as audio and video in addition to texts and images that are facilitated by ICT tools such as computers (Delita et al., 2022). One of the most common media formats of e-modules are pdf and flipbook formats. There is substantial research on the use of e-modules in online set-up where it was found to enhance students' learning outcomes (Misbah et al., 2021; Istuningsih et al., 2018) and critical thinking skills (Sujanem et al., 2020).

Collaborative Learning (CL)

CL is a range of instructional approaches to small group learning (Yang, 2023) which involves the shared effort of the students and teachers (Smith et al., 1992 as cited in Rumiantsev et al., 2023) to resolve problems or discuss concepts. Social interactions, social presence, and social media use are some factors affecting students' performance in CL (Qureshi et al, 2021). CL is found to promote social interaction, which results in better social presence and more active learning (Qureshi et al., 2021), academic achievement (Gokhale, 1995), student engagement

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(Warsah et al., 2021), and motivation (Loes, 2022). CL can also be facilitated with technology. Computer-supported collaborative learning has been part of different teaching and learning models. It can be designed to facilitate high-level cognitive achievement in both online and classroom learning environments (Järvelä et al., 2023).

Student Academic Performance

There are different terms that are used synonymously to refer to this construct which includes "school readiness", "academic achievement" and "school performance" (Lamas, 2015). Since there is no consensus on the definition of academic performance, it is measured using different yardsticks. The most common way that has become the standard is the grade point average (Al Matalka & Al Dwakat, 2022) and scores in achievement tests and examinations (Said et al., 2018). These tests are intended to measure the students' degree of learning in a specific subject or content area (Elliott, 2017; Groth-Marnat, 2019).

Although academic performance is usually assessed using standardized metrics, it is also important to look at other critical elements like engagement. It is used to recognize what students are feeling, doing, and thinking about during the learning process (Zepke, 2018, as cited in Li and Xue, 2023). Hofkens and Ruzek (2019) argued that engagement is not a student's characteristics but rather the degree or quality of his/her involvement in various school activities, and it is malleable. Engagement is also multidimensional and consists of three interrelated but distinct domains: cognitive, behavioral, and emotional (Fredricks et al., 2004, as cited in Wang et al., 2016). In addition, Wang et al. (2016) argued that a social dimension should be added in measuring student engagement.

In addition to engagement, classroom discourse quality has a crucial role in the learning experience. It refers to all the talking that happens in the classroom or any educational setting (Jocuns, 2012). According to Kaya et al. (2016), classroom discourse comes as a triadic dialogue and may follow patterns such as question-answer-evaluation, initiation-response-evaluation, and initiation-response-follow up. Zastavker et al. (2013) argued that discourse analysis is a helpful tool to understand a classroom's culture that includes interaction of students and teachers which will ultimately help teachers to provide more effective learning opportunities for their students. According to Hardman (2019), a high frequency of extended student contributions is an indicator of a high-quality classroom discourse.

Objectives

While there is a substantial body of literature that explores the potential of the two student-centered approaches, IBL and CL, much of these have studied them separately. In addition, the majority of research on these two approaches was done in either online or onsite classroom settings, with less research on the integration of the two approaches. Moreover, the majority of the research in e-modules was either done in online or hybrid learning set-ups and there is limited research on the integration of e-modules in a face-to-face collaborative set-up. This study fills these gaps by exploring the effectiveness of the integration of inquiry-based Physics e-modules in face-to-face collaborative instruction on secondary school student academic performance.

Specifically, this study sought to address the following questions:

1. What is the performance of the control and experimental groups during and after the implementation of the treatment for Grade 10 Physics content in terms of the parameters listed below?
   a. achievement test
   b. engagement
   c. classroom discourse quality
2. Is there a significant difference in the achievement test scores of the control and experimental groups after the implementation of the treatment?
3. Are there marked differences in student engagement and classroom discourse quality of the control and experimental groups during the implementation of the treatment?

Hypothesis

1. There is no significant difference in the achievement test scores of the control and experimental groups after the implementation of the treatment.
2. There are no marked differences in the student engagement and classroom discourse quality of the control and experimental groups during the implementation of the treatment.

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METHODS

Research Design

As a developmental study, this research aimed to determine the effectiveness of inquiry-based physics e-modules for secondary school in a face-to-face collaborative learning set-up, using a quasi-experimental research design.

Developmental research deals with new educational models, procedures, and tools, their effectiveness, and efficiency in addressing problems in the field of education. As part of this, developmental research identifies findings that are context-specific and recognize its relevance to other contexts of teaching and learning (Richey et al., 2004). Being a developmental study, this research explored the integration of two student-centered approaches – IBL and CL – using e-modules in a face-to-face collaborative physics instruction and determined their effectiveness on student academic performance, filling the gap in the existing literature showing that their integration has not been widely explored.

Quasi-experimental research tests the causal hypothesis (White & Sabarwal, 2014) and mimics experimental conditions in which some subjects or participants are exposed to a treatment and others are not (Gopalan et al., 2020). Unlike a true experimental design which makes use of randomized participants to form research groups, in quasi-experimental designs, participants were not selected and assigned in the experimental and control groups because such assignment is not practical and may incur ethical considerations (APA Dictionary of Psychology, n.d.).

Population and Sampling

The research participants were from two intact classes of Grade 10 of a private school located in an urban area. Before the start of the school year, the school assigned the students to their respective classes based on their general average from the previous school year, ensuring heterogeneity, each with students of varying levels of proficiency. Hence, random assignment to control and experimental groups was not possible. They were in the same age bracket of 15-16 years. They were exposed to the same curriculum aligned with the K-12 curriculum prescribed by the Philippine Department of Education that emphasizes student-centered approaches like IBL and CL, attending 50 minutes of Science class, five times a week. To further equate the control and experimental groups, proximity matching was done using the general averages of the students in Science and Math from the previous school year. Matching methods attempt to closely mimic the ideal conditions of randomized experiments by using observational data (Stuart & Rubin, 2008)."Proximity" refers to the similarity or closeness on the general averages of the students in Science and Math from the previous school year between the two groups. This was done to ensure comparability between the two groups, since random assignment was not feasible. However, this only matched the samples in the variables that are considered and measured in the process, and may reduce the sample size, limiting the generalizability.

Out of the 40 individuals from each class, 26 matches occurred (12 male, 14 female) and were considered as the participants of the study. The other students who were unmatched remained in the group, but their data in the research variables were pruned during the data analysis. The participants in both the control and experimental groups worked in collaborative groups with three members during the implementation of the treatment.

Instrument

There were a total of seven inquiry-based e-modules (IBeM) and seven printed modules (PM), both containing the same set of physics topics from Science 10 such as electromagnetism, electromagnetic spectrum, reflection and refraction of light. Both types of modules underwent peer-review and validation by five high school science teachers. The IBeM, containing materials, resources, and learning activities in the form of texts, images, video clips, simulations, and other online tools, were used by the experimental group in face-to-face collaborative setup during their Science period, through Google Classroom. Each collaborative group used one computer to access its IBeM. The researcher removed their access after each class session. On the other hand, one copy of the PM, which did not have multimedia materials, but contents and resources were in the form of text and images, was provided to each collaborative group in the control group during their Science period and was collected after each class session.

Each module included a series of activities that followed the 5E Model. During the Engage phase, the students' interests were stimulated by providing background information like historical accounts, real-life scenarios, demonstrations presented in multimedia elements (videos, simulations, and images) in the IBeM, and through text and

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images in the PM. Thought-provoking questions were posed to activate curiosity and introduce the topic. In the Explore phase, concepts were introduced and tackled through simulations, hands-on, and reading activities. The experimental group explored the lessons using interactive multimedia in the IBeM, while the control group used the information and procedures presented in the PM. The students were guided to observe and make predictions. During the Explain phase, students made meaning of their observations, guided by the questions in both the IBeM and PM. The experimental group answered through the digital document embedded in the IBeM, while the control group directly wrote on the PM. Thereafter, researcher-facilitated discussions were done to help students construct concepts and identify misconceptions. In the Elaborate phase, both the IBeM and PM provided additional tasks, like critical thinking, investigation, and hands-on activities, to reinforce the concept or transfer them to a new context. Afterwards, researcher-facilitated discussions were employed to deepen the understanding and rectify misconceptions. Lastly, in the Evaluate phase, short quizzes were provided to assess student conceptual understanding. The IBeM provided immediate feedback through Google Forms, where students submitted their responses. On the other hand, the researcher reviewed the answers with the class for the control group.

Achievement was measured by a test composed of researcher-made, fifty-objective type items that covered Physics topics in Grade 10 Science. The whole tool was content validated by three teachers with Master's Degrees in science teaching.

Engagement was determined using The Math and Science Engagement Scale developed by Wang et al. (2016), which is composed of thirty-three, five-point Likert Scale items, measuring four domains of engagement such as cognitive, behavioral, social, and emotional. The framework developed by Hardman (2019) guided the analysis of classroom discourse quality. It provides a description and code for each type of student talk move done. It also provides an example for each as a guide in coding. The framework classified the student talk moves to four main types: closed student questions (CSQ), open student questions (OSQ), brief student contributions (BSC), and extended student contributions (ESC). Hardman (2019) further classified ESC to different acts such as expand/add, connect, explain, rephrase, recount, evaluate, argue, justify, speculate, imagine, challenge, and shift position.

Data Collection

Before data collection, the researchers secured approval from the school administration and obtained informed consent from the students to administer the research instruments. The achievement test was administered to both the control and experimental groups after the eight-week implementation of the treatment.

The engagement surveys were administered to both the control and experimental groups at the end of each week during the eight-week implementation. The positively worded items used the following Likert scale: strongly disagree (1), disagree (2), neither (3), agree (4), strongly agree (5), while the negatively worded items used the reverse scale: strongly disagree (5), disagree (4), neither (3), agree (2), strongly agree (1).

For classroom discourse quality, all the audio recordings of each class session were transcribed and coded using the framework of Hardman (2019) then, the frequency of each type of student talk move during each topic of the module was recorded.

Treatment of Data

The weighted average/arithmetic mean was used to analyze the data from the achievement test and the engagement surveys for both the control and experimental groups. The weekly averages from the engagement survey for each domain were summarized to calculate the mean for each domain throughout the implementation. The overall engagement was calculated from the mean of all the domains of engagement. The mean ratings for student engagement are classified based on Table 1.

Table 1

Likert Scale Interpretations for Student Engagement

Mean Rating	**Interpretation**
4.21 – 5.00	Very High Engagement
3.41 – 4.20	High Engagement
2.61 – 3.40	Moderate Engagement
1.81 – 2.60	Low Engagement
1.00 – 1.80	Very Low Engagement

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An independent t-Test was used to determine if there was a significant difference in the weighted average/mean of the achievement test scores of the control and experimental groups. The same statistical analysis was used to determine if there were marked differences in the engagement, including its four domains, between the two groups. Such differences were significant if the p-value was less than the 0.05 level of significance.

Cohen's d was used to determine the magnitude of the difference between the two groups in terms of the achievement test and engagement, including its four domains. Values of 0.2, 0.5, and 0.8 represent small, medium, and large effect sizes, respectively.

Classroom discourse quality was analyzed by recording, categorizing, and counting the frequency of the different types of student talk moves, then expressing each type as a percentage of the total talk moves made. Marked differences in classroom discourse quality were determined by comparing the frequency of each type of student talk move between the two groups, with higher frequencies of extended student contributions indicating greater differences.

Ethical Considerations

The participants were informed about the nature of the study, its duration, and any potential benefits or risks. Participation of students from the two Grade 10 sections was voluntary with the full consent of their parents or guardians. They had the right to withdraw at any point during the conduct of the study. To ensure confidentiality, all the individual data from the participants that were collected through the instruments in this study and the class audio recordings are accessible only to the researcher.

RESULTS and DISCUSSION

Achievement Test

The achievement test results of the control and experimental groups are shown in Table 2. Notably, the control group had a higher mean (37.08) than the experimental group (33.92). The control and experimental group's mean, 74.16% and 67.84% of the highest possible score, are above the school's standard passing score of 60%, suggesting that the use of IBeM or PM in face-to-face collaborative instruction effectively delivered the Physics content of the Science 10 Curriculum. The p-value obtained from the independent t-test conducted was 0.15, indicating no significant difference, since it is greater than 0.05 confidence level. The Cohen's d value of 0.410 suggests a small-to-medium effect size, indicating that while the control group had higher achievement test score, the difference was not large.

Table 2
Mean of the Achievement Test of the Control and the Experimental Group

Group	Mean	Standard Deviation	p Value	Cohen's d
Control	37.08	5.41	0.150	0.410
Experimental	33.92	9.47		

The results indicate that the IBeM and the PM used in face-to-face collaborative instruction had roughly the same effect on achievement test scores, despite being in different formats. This finding appears consistent with previous studies, that found no difference between print and digital learning materials in terms of knowledge acquisition (Donkor, 2010), learning proficiency (Quiroz et al., 2015), learning independence (Utami & Saefudin, 2018), and reading comprehension and retention (Porion et al., 2015; Taylor, 2011). This implies that the choice of material to use is not an issue of which is more effective, but rather of availability in the school and, perhaps, student preference.

Engagement

Engagement reflects the level of involvement of the students in the learning process including what they are thinking, doing, and feeling. The overall engagement rating shown in Table 3 was calculated by averaging the mean of the engagement scores across the four domains.

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Table 3
Overall Mean of the Engagement of the Control and Experimental Groups

Group	Mean	Standard Deviation	Interpretation	p-Value	Cohen's d
Control	3.95	0.44	High Engagement	0.028	0.283
Experimental	3.84	0.33	High Engagement		

Both groups demonstrated high levels of engagement during the implementation of the treatment, with the control group having a higher mean (3.95) than the experimental group (3.84). This difference was statistically significant (p=0.028) with small to medium effect size (Cohen's d = 0.283). This result implies that using either the IBeM or the PM in face-to-face collaborative instruction is effective in fostering high levels of engagement, although the PM may have slightly fostered higher engagement outcomes. This could be attributed to the more tactile and traditional nature of the printed module, which allowed the students to make annotations and note-taking (Pálsdóttir, 2019), which might have helped maintain the engagement of the control group.

The tool used to assess the student engagement consists of four distinct domains. Cognitive engagement pertains to strategies for deep learning, self-regulation, and comprehension (Bond & Bergdahl, 2023). Behavioral engagement describes the extent of students' participation in the classroom activities (Gregory et al., 2013). Emotional engagement pertains to the feelings students experience in response to their learning activities (Li et al., 2024). Lastly, social engagement pertains to students' constructive interactions (Bond & Bergdahl, 2023). Engagement in each domain was calculated by averaging the weekly scores of each domain throughout the eight-week implementation period. Table 4 presents the mean ratings for each engagement domain of the control and experimental groups and their interpretation.

Table 4
Mean of Engagement per Domain of the Control and the Experimental Group

Domain	Control	SD	Interpretation	Experimental	SD	Interpretation	p-Value	Cohen's d
Cognitive	3.88	0.54	High Engagement	3.76	0.40	High Engagement	0.006	0.253
Behavioral	3.93	0.41	High Engagement	3.84	0.38	High Engagement	0.059	0.228
Emotional	3.93	0.57	High Engagement	3.76	0.46	High Engagement	0.026	0.328
Social	4.06	0.46	High Engagement	4.01	0.43	High Engagement	0.345	0.112

Note: SD=Standard deviation

The control group scored highest in the social domain (4.06), followed by the behavioral and emotional domains (both 3.93), while the cognitive domain (3.88) had the lowest mean. Additionally, the experimental group scored highest in the social domain (4.01), followed by the behavioral domain (3.83), then the cognitive and emotional domains (both 3.76). Since both groups demonstrated high engagement across all domains, this suggests that both the IBeM and PM in face-to-face collaborative instruction are effective in promoting student engagement.

Analysis shows a significant difference in the levels of cognitive (p=0.006) and emotional (p=0.026) engagement of the two groups. Cohen's d values of 0.253 and 0.328, respectively, indicate small-to-medium effect sizes. These results indicate that while both the IBeM and the PM used in face-to-face collaborative instruction fostered high engagement, the latter was more effective in these domains, with a modest effect. Conversely, the p-values for the behavioral (p=0.059) and social (p=0.345) domains suggest no significant difference in these domains of

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engagement between the two groups, with Cohen's d values of 0.228, suggesting small-to-medium effect size, and 0.112, suggesting very small effect. These indicate that the IBeM and the PM used in face-to-face collaborative instruction are equally effective in these domains.

Classroom Discourse Quality

The classroom discourse quality was determined by analyzing and coding all the talk moves made by students in the control and experimental groups during the whole-class sessions. Student talk moves were mainly classified into four types: closed student questions (CSQ), which are closed/procedural questions; open student questions (OSQ), which are open/authentic questions; brief student contributions (BSC), which are brief/pre-specified information without development; and extended student contributions (ESC), which are non-specific information and thinking that are developed to some extent (Hardman, 2019). Table 5 summarizes the distribution of the different talk moves throughout the implementation, expressed as percentage.

Table 5

Overall Percentage Distribution of Student Talk Move

Student Talk Move	Control	Experimental
Closed Student Question (CSQ)	16.47	17.44
Open Student Question (OSQ)	4.07	4.09
Brief Student Question (BSC)	51.82	46.57
Extended Student Contribution (ESC)	27.37	31.89

The majority of student questions in both the control and experimental groups were CSQ, which means they sought more procedural clarifications and asked questions that needed factual responses from the teacher. The experimental group had a marginally higher percentage of CSQ (17.44%) than the control group (16.74%). This indicates that the IBeM used in face-to-face collaborative instruction slightly increases the tendency to ask more CSQ compared to the PM. Moreover, the frequencies of OSQ in both groups were nearly identical and were rare in both the control (4.07%) and the experimental group (4.09%). The very small difference suggests that both the IBeM and the PM used in face-to-face collaborative instruction did not encourage the students to generate open and authentic questions. It is also important to note that both the control and experimental groups asked fewer OSQ compared to CSQ suggesting that both the IBeM and the PM used in face-to-face collaborative instruction have the same effect on the type and quality of questions asked by the students. These findings echo previous research highlighting the challenges of fostering high-quality, open student questions in the classroom. Almeida (2012) underlines that only a few students spontaneously ask questions, and even fewer ask open and high-level questions. Likewise, Chin and Brown (2002) found that the majority of student questions during science learning were basic information questions, and very few questions focusing on curiosity, extension of ideas, prediction, and knowledge discrepancies. According to Mahmud (2015) students tend to ask questions due to factors such as curiosity induced by learning materials, underscoring their role in motivating the students to ask questions. Therefore, it is important to design lessons that appeal to students' interests, pose challenges, and show real-life connections which will foster curiosity leading to more open student questions. The marginal difference between the control and experimental groups indicates that, despite the innovative features, both the IBeM and PM used in face-to-face collaborative instruction do not differ significantly in fostering open student questions, a critical aspect in fostering deeper learning. This result underscores the challenge of stimulating higher-order questioning as presented by the previous studies.

It is also shown that the majority of student contributions in both the control and experimental groups were BSC. However, it is important to note that the control group had a higher percentage of BSC (51.82%) compared to the experimental group (46.57%). Conversely, the experimental group's percentage of ESC (31.89%) was higher than the control group (27.37%). This indicates that the students' talks in the experimental group were more extended and more profound discourse. All these findings signify that the IBEM used in face-to-face collaborative instruction stimulated the students more to take part extensively in in-depth and meaningful discussions. According to Murphy et al. (2009, as cited in Murphy et al., 2018), discussion in the classroom is an effective way to promote critical-analytic thinking and epistemic cognition about texts, aligning with the goals of IBL where students actively construct knowledge through meaningful discourse. Additionally, the results also echo literature indicating that digital resources promote

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high-quality classroom interactions. For instance, Haleem et al., (2022) stated that digital tools and resources contribute to setting up a better classroom atmosphere and a more compelling teaching-learning process. In addition, ICF Consulting Services Ltd. (2015) emphasized that the effective use of digital tools and resources can enhance the speed and depth of learning mathematics and science, writing, comprehension, listening, and speaking skills.

ESC is further classified into different acts or subtypes. Table 6 summarizes the distribution of the subtypes of ESC made by the students in the control and experimental groups throughout the implementation, expressed as percentage.

Table 6
Overall Percentage Distribution of ESC

Subtypes of ESC	Control	Experimental
Student expand/add (SE/Add)	3.17	1.51
Student connect (SCon)	0	1.81
Student explain/analyse (SE/Ana)	51.13	37.65
Student rephrase (SRep)	1.81	3.92
Student recount (SRec)	6.33	9.64
Student evaluate (SEval)	5.43	12.35
Student argue (SArg)	8.14	6.93
Student justify (SJus)	10.41	12.65
Student speculate (SSpec)	8.60	9.34
Student imagine (SImag)	1.36	1.20
Student challenge (SChal)	1.36	3.01
Student shift position (SSP)	2.26	0

SE/Ana is the most common type of ESC in both the control (51.13%) and experimental groups (37.65%). However, it is more common in the control group. The greatest difference between the two groups is marked in this type of ESC. This demonstrates that the control group's talks were primarily explanations and assertions and that they employed a more limited form of ESC. On the other hand, the ESC made by the experimental group was more diverse, making ranges of talk other than SE/Ana. This indicates that they engaged in more evaluation, justification, and speculation during the implementation of the modules.

The percentages of SE/Add, SE/Ana, SArg, SImag, and SSP were higher in the control group. The data indicates that while there were other ESCs made by the control group, the PM used in face-to-face collaborative instruction primarily fostered understanding and explaining among the students. Conversely, the percentages of SCon, SRep, SRec, SEval, SJus, SSpec, and SChal were higher in the experimental group. This implies that the IBeM used in face-to-face collaborative instruction promoted a greater degree of critical and evaluative discourse. Additionally, it fostered rephrasing and recounting, demonstrating a focus on introspection and information clarification. These findings underscore the potential of using IBeM in face-to-face collaborative instruction to foster more profound, evaluative, and argumentative discourse among students, which is essential for productive and high-quality classroom discourse (Aghekyan & Kerrigan, 2021; Soysal, 2019). Although using the IBeM or PM in face-to-face collaborative instruction promoted student participation in classroom discourse, the IBeM was more effective in fostering extensive contributions, critical thinking, and evaluation. These highlight the significance of digital learning materials in enhancing the science discourse skills of the students (Morokhova, 2022).

Implications

The findings of this study provide insights into the use of IBeM and PM for physics in face-to-face collaborative instruction.The lack of a significant difference in the achievement test scores between the two groups indicates that both the IBeM and PM used in face-to-face collaborative instruction can be effective in teaching Physics concepts. On the other hand, the marked differences in the levels of engagement and classroom discourse quality shows that the two materials may serve different purposes.

This study reveals a nuanced relationship between the use of IBeM and PM in face-to-face collaborative

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instruction. Although there was no significant difference in the achievement test scores of students who used the IBeM to those who used the PM, this offers the critical insight and takeaway that both types of modules can yield comparable academic outcomes. This implies that the choice to use IBeM and/or PM in face-to-face collaborative instructions should take into account contextual conditions and factors such as access to technology and financial resources. In areas where availability of digital resources and access to the internet are limited, the PM may be the more practical alternative, as they do not require computer use and internet connectivity. Conversely, areas or schools that are equipped with better access to computer resources and reliable internet can use the IBeM in face-to-face collaborative instruction, which, although may result in varying degrees of student engagement, promotes deeper and extensive classroom discourse. This study also reveals that while the use of the PM in face-to-face collaborative instructions fostered higher engagement, this did not translate into a statistically significant higher score on the achievement test. On the other hand, the use of IBeM in face-to-face collaborative instruction, although fostered lower engagement, stimulated more profound and critical discourse on complex ideas, promoting higher-order thinking among students.

From a practical viewpoint, this study emphasizes the broader implications of availability of learning resources in educational environments. The PM, although effective in fostering and maintaining higher levels of student engagement, incurs extra financial expenses for physical materials such as paper and ink added to the costs tied to printing, reproduction, and delivery. In contrast, IBeM provides a more economical option, especially in settings where there is an abundance of access to digital and computer resources, offering considerable benefits in fostering critical thinking and in-depth classroom discourse. In addition, educators can restructure the instructional materials and learning modules developed for online and distance learning during the pandemic following IBL strategies such as the 5E learning model. The modules can be in the form of e- or printed modules depending on the needs. For example, IBeM may be developed for topics and content that will need in-depth discussions among the learners and with the teacher, on the other hand, PM may be developed for topics and content that will need high student engagement.

Moreover, this study also sheds light on the role of different learning materials – digital or print – in the context of post-pandemic education. With the rapid integration of online and digital learning resources such as e-modules due to the pandemic, this study shows that printed learning materials, such as printed modules, still have an important role in the classroom, particularly in fostering engagement in a face-to-face collaborative learning environment. On the other hand, leveraging the strengths of IBeM in face-to-face collaborative instruction will help create a classroom atmosphere that fosters high-quality student talk, where students are taking an active role in their learning. Moving forward, teachers should be mindful in using the IBeM and/or the PM in collaborative learning set-up and employ diverse learning materials, combining the strengths of both materials in a way that they will complement, rather than replacing one with the other. Similarly, teachers should look into ways to enhance and optimize the integration of both the IBeM and the PM in blended learning, especially in situations where access to resources is not consistently available. By employing an approach that is more flexible and resource-conscious, we can set up equitable and efficient learning environments for the students that will foster a more meaningful and holistic learning experience which will be essential for their success in an ever-changing 21st century.

Conclusion

The effectiveness of the Physics IBeM on secondary school student academic performance in a face-to-face collaborative instruction varies across three parameters. The lack of a significant difference in the achievement test scores ($p=0.150$) shows that both the IBeM and PM are equally effective in facilitating learning of physics concepts. The PM resulted in higher overall engagement ($p=0.028$) and cognitive ($p=0.006$) and emotional ($p=0.026$) engagement domains, while the IBeM fostered better classroom discourse quality, marked diverse extended student contributions such as explanation, evaluation, argumentation, and justification. To conclude, it can be argued that based on the context and findings of this study, the IBeM used in face-to-face collaborative instruction is effective in facilitating the learning and understanding physics concepts which enable students to participate in a quality classroom discourse. This highlighted the need for a more balanced approach in using the IBeM and/or PM in face-to-face collaborative learning set-up, combining the strengths of both materials in a way that complement, rather than replace, one with the other.

There are limitations that must be acknowledged. First, all participants were from one grade level in one school resulting in a small sample size which may affect the generalizability of the findings of this study. In addition, the implementation of the treatment was done within eight weeks, hence limited topic coverage which may affect the

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validity of the findings. With these limitations, future researchers could include replication studies on a larger population and sample size may be conducted. For example, the modules could be implemented at different grade levels in secondary school to cover more competencies in high school science hence allowing more data to be analyzed. In addition, exploring the long-term effects of the modules by extending their implementation period would be valuable. These actions would increase the reliability of the study and make it more conclusive. Moreover, the effectiveness of the modules in individual learning set-up in terms of the same parameter in this study may be explored. Furthermore, the effectiveness of the modules in terms of other metrics of student academic performance, such as motivation and metacognition among others, could be explored.

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