frontiers in Education

TYPE Original Research
PUBLISHED 05 March 2026
DOI 10.3389/feduc.2026.1761262



OPEN ACCESS

EDITED BY
Pedro Mauricio Acosta Castellanos,
Santo Tomás University, Colombia

REVIEWED BY
Yashwantrao Ramma,
University of Mascareignes, Mauritius
Ogiarto Ate,
State University of Malang, Indonesia

*CORRESPONDENCE
Ricio Milo Salibay
✉ riciomsalibay@gmail.com

RECEIVED 05 December 2025
REVISED 17 February 2026
ACCEPTED 23 February 2026
PUBLISHED 05 March 2026

CITATION
Salibay RM (2026) Development and mixed-methods evaluation of an instructional manual for sustainable physics learning in higher education. *Front. Educ.* 11:1761262. doi: 10.3389/feduc.2026.1761262



# Development and mixed-methods evaluation of an instructional manual for sustainable physics learning in higher education

Ricio Milo Salibay*

Science Department, College of Education, Cebu Technological University – Main Campus, Cebu City, Philippines

This study presents the mixed-methods evaluation of the Emerging Junctures, Outstanding Physics Investigatory Projects Festival (EJOY PIPsFe) instructional manual, a structured teaching guide designed to enhance sustainable physics learning in higher education through investigatory projects and culminating project festival. The manual integrates best practices in science education, project-based and experiential learning, and festival-based pedagogy, providing step-by-step guidelines, scaffolding strategies, assessment tools, and feedback mechanisms to support teacher implementation. A developmental-evaluative approach informed the manual's creation and validation, followed by a sequential explanatory mixed-methods design to determine its effectiveness. Quantitative data were collected from 135 university students enrolled in Fluid Mechanics and Astronomy courses. Pretest–posttest comparisons revealed significant gains in conceptual understanding, with second-year students improving by 28 points and third-year students by 15 points ($p < 0.05$). Attitude surveys indicated substantial positive shifts in students' epistemological beliefs, engagement, effort beliefs, and views of learning authority. Qualitative insights from post-implementation interviews highlighted increased motivation, deeper conceptual connections, and active engagement supported by the manual's structured inquiry process and festival format. In totality, the EJOY PIPsFe instructional manual effectively fosters cognitive and affective learning, promotes meaningful and joyful learning experiences, and provides teachers with clear guidance for implementing investigatory project-based physics instruction. The study concludes that the manual is a sustainable and replicable model for strengthening scientific literacy, critical thinking, and long-term engagement in physics learning across diverse educational contexts.

KEYWORDS
**framework evaluation, instructional manual development, investigatory projects, mixed-methods research, physics education, project-based learning, student engagement, sustainable learning**

## 1 Introduction

Physics education worldwide continues to face persistent challenges that demand innovative solutions. Studies consistently report low student engagement, difficulty in mastering abstract concepts, and the persistence of misconceptions despite years of instruction. Traditional lecture-driven approaches, while efficient for content delivery, often leave learners disengaged and unable to connect physics with real-life applications (Verawati and Nisrina, 2025). Global evidence further shows that this is not a localized concern: research from Indonesia, Chile, Rwanda, and Kazakhstan highlights widespread difficulties in motivation, conceptual understanding, and problem-solving skills, alongside limitations in laboratory facilities and teaching resources. These challenges are compounded by increasing demands for 21st-century competencies—critical thinking, collaboration, creativity—that conventional physics instruction does not adequately cultivate (Deta et al., 2024; Fajriati et al., 2025).

In response, many educational systems have shifted toward project-based, inquiry-driven, and technology-enhanced pedagogies. Project-Based Learning (PjBL) and related approaches have demonstrated promise in improving motivation, conceptual mastery, and collaborative skills, but their effectiveness relies on structured design, clear assessment, and contextual adaptation (Rohmah et al., 2024; Wulandari et al., 2025).

At the same time, the literature indicates that the successful implementation of inquiry-based and project-based approaches is not automatic and depends on how these pedagogies are designed and enacted (Attard et al., 2021). Studies emphasize that without adequate instructional structure, clear guidance, and alignment with contextual constraints, such approaches may place increased demands on instructional time, challenge teacher preparedness, and result in uneven student participation and assessment difficulties. These observations underscore that inquiry-driven pedagogies require deliberate scaffolding and careful instructional planning to support meaningful conceptual learning rather than superficial task completion (Kurniawan et al., 2024).

At the policy level, the United Nations' Sustainable Development Goal 4 (Quality Education) reinforces the need for innovative, inclusive, and sustainable instructional models that strengthen the connection between theory and authentic practice (Kim et al., 2022; Grobler and Dittrich, 2024).

The Philippine context reflects similar concerns, with national and international assessments underscoring longstanding learning gaps. In the 2022 Programme for International Student Assessment (PISA), Filipino 15-year-olds scored 355 in mathematics, 347 in reading, and 355 in science—substantially below OECD averages—and ranked among the lowest-performing countries (Haw et al., 2021; Ines, 2023). Only a small proportion of students reached the baseline proficiency level across subjects, indicating a learning gap equivalent to 5–6 years of expected competencies (Cabural, 2024). These findings highlight an urgent need to adopt innovative physics teaching models that strengthen conceptual understanding, engagement, and scientific literacy (Zahara et al., 2024).

The Emerging Junctures, Outstanding Yields Physics Investigatory Projects Festival (EJOY PIPsFe) framework was conceptualized in response to these global and local challenges. Drawing from project-based learning, experiential learning theory, and festival-based pedagogy, the framework integrates best practices in science education with contextual insights from physics teachers and students. In response to documented implementation challenges in inquiry-oriented instruction, the framework places particular emphasis on structured scaffolding, standardized templates, and explicit instructional guidance through a comprehensive instructional manual (Riegle-Crumb et al., 2019). In this study, the term *framework* refers to the conceptual structure guiding the EJOY PIPsFe approach, while the *instructional manual* denotes the concrete set of materials and procedures used for classroom implementation. This manual served as the primary *intervention* (planned instructional action) evaluated. Despite the promise of inquiry-based and project-driven models, few studies have developed and evaluated comprehensive instructional manuals tailored to higher education physics contexts. This study addresses that gap by reporting the development and mixed-methods evaluation of the EJOY PIPsFe instructional manual, examining its effectiveness in enhancing students' conceptual understanding, shaping positive attitudes, and fostering engaging and sustainable physics learning experiences.

## 2 Methods

### 2.1 Research design

This study employed a developmental–evaluative research design encompassing the conceptualization of the EJOY PIPsFe Framework, the development of the EJOY PIPsFe instructional manual, expert validation, classroom implementation, and outcome evaluation (Eom et al., 2022; Halim et al., 2025). To guide the systematic creation and refinement of the manual, the study followed the Design and Development Research (DDR) model, specifically the Developmental–Evaluative variant. Consistent with DDR Type II, the process involved four iterative phases: (1) conceptualization grounded in theory and literature, (2) design and development of the instructional manual, (3) expert review and feasibility validation, and (4) classroom evaluation to determine clarity, usability, and effectiveness. The DDR model is appropriate for educational innovation studies requiring structured design, empirical testing, and theory-informed refinement.

To understand the effectiveness of the instructional manual in real classroom settings, a sequential explanatory mixed-methods design was also used. Quantitative data from pretests, posttests, and attitudinal surveys were collected first, followed by qualitative interviews to provide depth and explanation for observed trends (Nair and Prem, 2020). This combination of designs allowed the study to examine both learning outcomes and learner experiences while maintaining methodological coherence. Triangulation was achieved by examining convergence and complementarity across quantitative outcomes and qualitative themes, consistent with established mixed-methods research practices (Creswell and Plano Clark, 2018).

### 2.2 Development of the EJOY PIPsFe framework

The EJOY PIPsFe (Emerging Junctures, Outstanding Yields Physics Investigatory Projects Festival) framework was developed through a structured three-phase process consistent with DDR principles.

### 2.2.1 Conceptualization

A review of literature on constructivist learning, project-based learning, experiential learning, and festival-based pedagogy was conducted to establish the theoretical grounding. This was complemented by an analysis of global and local challenges in physics education, including engagement issues, conceptual difficulties, and limited access to inquiry-based learning opportunities.

### 2.2.2 Consultation

Focus group discussions with the physics teacher and students were conducted to identify classroom realities, persistent learning challenges, and feasible instructional interventions. These insights informed the contextual adaptation of the framework.

### 2.2.3 Validation

The initial version of the framework, including key components, implementation guidelines, and rubrics, underwent expert review by science educators and curriculum specialists. Feedback led to refinements in the sequencing of activities, clarity of competencies, and feasibility considerations.

## 2.3 Development of the EJOY PIPsFe instructional manual

The EJOY PIPsFe instructional manual was created to operationalize the framework into a structured classroom intervention. Guided by the DDR model, the manual development followed iterative design, expert validation, and field evaluation to ensure theoretical alignment, usability, and pedagogical coherence.

The manual includes step-by-step implementation procedures, project templates, scaffolding strategies, assessment rubrics, feedback mechanisms, and reflective tools to support inquiry-driven investigatory projects and the culminating physics festival. Before full implementation, the instructional manual underwent several validation steps.

### 2.3.1 Content validity assessment

Rubrics and toolkits were evaluated using content validity indices to ensure clarity, alignment with intended competencies, and appropriateness for higher education contexts.

### 2.3.2 Feasibility analysis

The manual was reviewed for time demands, resource requirements, alignment with instructional hours, and teacher readiness.

### 2.3.3 Pilot feedback sessions

Selected teachers provided feedback regarding clarity, pacing, scaffolding structures, and the manageability of festival activities. Their insights informed the manual's refinement.

## 2.4 Participants and setting

The pilot implementation was conducted at a state university involving four physics classes with a total of 135 Bachelor of Secondary Education major in Science (BSED Science) students: 71 first-year students enrolled in Fluid Mechanics and 64 third-year students enrolled in Astronomy. Students worked in small collaborative teams to encourage peer learning and shared responsibility.

The physics teacher served as both instructor and researcher-participant, a dual role justified by subject expertise and pedagogical familiarity with the courses. To strengthen objectivity and scoring reliability and triangulation of perspectives between students and the teacher-researcher, three additional teachers were invited to serve as independent evaluators of student outputs. They were selected based on their experience in teaching both Astronomy and Fluid Mechanics, developing physics-based instructional materials, and organizing or participating in science exhibits. Their observations regarding the conduct of the festival were documented and used as corroborating evidence in the analysis.

## 2.5 Implementation procedure

Implementation of the EJOY PIPsFe instructional manual proceeded in three stages, each designed to allow instructional consistency and replicability of the intervention.

### 2.5.1 Project development

Student teams developed investigatory projects on selected physics concepts using structured templates provided in the manual. These templates included sections for identifying the problem, reviewing related concepts, outlining procedures, documenting data, and drafting initial analyses. Weekly progress checkpoints ensured consistent project pacing and allowed the instructor to monitor adherence to the manual.

### 2.5.2 Teacher facilitation

The teacher supported student inquiry through scheduled consultations, brief concept-clarification lectures, and scaffolded formative assessments. Feedback loops were integrated through written comments, rubrics, and verbal guidance. These facilitation procedures followed a common structure, ensuring consistency across classes and can be replicated by instructors adopting the manual.

### 2.5.3 Festival presentation

Students presented their completed projects during the culminating physics investigatory projects festival. Presentation formats (poster, prototype exhibit, and oral presentation), evaluation rubrics, and judging procedures were standardized across all groups to ensure comparability. A panel of three external teachers independently scored outputs using the same criteria, which are included in the instructional manual and available upon request to support replication.

## 2.6 Instruments

Three primary instruments were used for data collection.

Pretest and posttest questionnaires were administered to measure students' conceptual gains in physics across Fluid Mechanics and Astronomy. These instruments were researcher-developed and aligned with course learning objectives and the conceptual focus of the investigatory projects. The tests consisted primarily of 45 multiple-choice items and 5 structured reasoning questions, for a total of 50 items per test. They were designed to capture both conceptual understanding and applied reasoning relevant to the instructional intervention. For Fluid Mechanics, the items covered concepts such as fluid properties, pressure relations, buoyancy, and flow behavior. The Astronomy questions included key concepts such as celestial motion, gravitation, celestial phenomena, and conceptual reasoning. Both questionnaires also incorporated items reflecting the procedural and conceptual stages in conducting investigatory project work, which are central components of the EJOY PIPsFe manual.

To capture affective outcomes, attitude surveys were utilized to assess changes in students' epistemological beliefs, engagement, effort beliefs, and perceptions of learning authority following the implementation of the instructional manual. Responses were measured using a six-point Likert scale (1 = very negative change, 2 = negative change, 3 = slight negative change, 4 = slight positive change, 5 = positive change, 6 = very positive change).

In addition, semi-structured interviews with both students and teachers provided qualitative insights into their learning experiences, perceived instructional scaffolding, and the usability of the EJOY PIPsFe instructional manual.

## 2.7 Instrument development and validation

The pretest and posttest instruments were constructed to align with the course learning outcomes in Fluid Mechanics and Astronomy. They were also designed to reflect the conceptual demands of the investigatory projects implemented through the instructional manual. Item content focused on core physics concepts emphasized during project development and festival preparation. A Table of Specifications (TOS) guided item distribution to ensure systematic alignment between learning outcomes, conceptual domains, and expected reasoning levels. Both pretest and posttest were developed as parallel forms on the same specification matrix to maintain comparable scope and difficulty.

The attitude survey was developed to capture changes in students' epistemological beliefs, engagement, effort beliefs, and perceptions of learning authority. It reflects the motivational and experiential dimensions of the EJOY PIPsFe framework. The six-point Likert scale was selected to encourage directional response and reduce neutral tendencies.

All instruments underwent expert review by science educators with experience in physics instruction and educational assessment to establish content clarity, alignment, and appropriateness for the higher education context. Minor revisions were made based on expert feedback prior to implementation.

Given the exploratory and design-based nature of the study, instrument validity was established primarily through TOS-based content alignment, expert judgment, and triangulation with qualitative data. These procedures supported the instruments' ability to capture learning gains associated with the instructional intervention.

## 2.8 Data analysis

Survey data were analyzed using descriptive and inferential statistics. Pretest and posttest scores were compared through paired-sample t-tests to determine students' conceptual gains in physics, while descriptive statistics were used to summarize shifts in attitudinal survey responses across epistemological, behavioral, and contextual dimensions. Statistical analyses were conducted at the group level and findings were interpreted within the limits of a single-group pretest-posttest design. Semi-structured interview data were transcribed and subjected to thematic coding to identify recurring patterns and emerging categories related to student engagement, conceptual understanding, scaffolding experiences, and the usability of the instructional manual. Quantitative and qualitative findings were then triangulated at the interpretation stage using a construct-based comparison of patterns and themes. Convergence was identified when qualitative themes supported quantitative trends, while divergence was noted when findings differed. Complementarity was established when qualitative data helped explain the quantitative results, supporting a more comprehensive evaluation of the EJOY PIPsFe instructional manual.

# 3 Results

## 3.1 Theoretical grounding of the EJOY PIPsFe framework through a scoping review

Physics education continues to face persistent challenges globally, including low student motivation, difficulty in mastering abstract concepts, and limited opportunities for collaborative learning (Verawati and Nisrina, 2025). In the Philippine context, these concerns are heightened by large class sizes, limited resources, and minimal implementation of student-centered pedagogies (Trinidad, 2020).

Addressing these challenges, the EJOY PIPsFe framework was developed to transform traditional investigatory projects into engaging, real-world, and community-connected learning experiences. The scoping review informing its development followed the PRISMA-ScR process, as illustrated in Figure 1, which outlines the identification, screening, eligibility, and inclusion of studies.

The review revealed that constructivist and experiential approaches enhance physics understanding and engagement (Hossain et al., 2024), while project-based and motivation-oriented strategies strengthen problem-solving skills and interest in STEM (Laid and Adlaon, 2025). These findings informed five key literature strands—Constructivist Learning, Experiential Learning, Project-Based Learning, Self-Determination/Motivation Theories, and Authentic Learning—forming the theoretical base of the EJOY PIPsFe Framework.

These strands served as organizing principles for the design of the instructional manual and the selection of learning activities evaluated in this investigation.

## 3.2 Description of the EJOY PIPsFe instructional manual

The EJOY PIPsFe instructional manual operationalizes the framework into a structured guide for teachers. EJOY PIPsFe refers to "Emerging Juncture, Outstanding Yields" Physics Investigatory Projects Festival, which describe the intentional design of learning moments that prompt inquiry, reflection, and decision-making, as well as the tangible outputs produced through

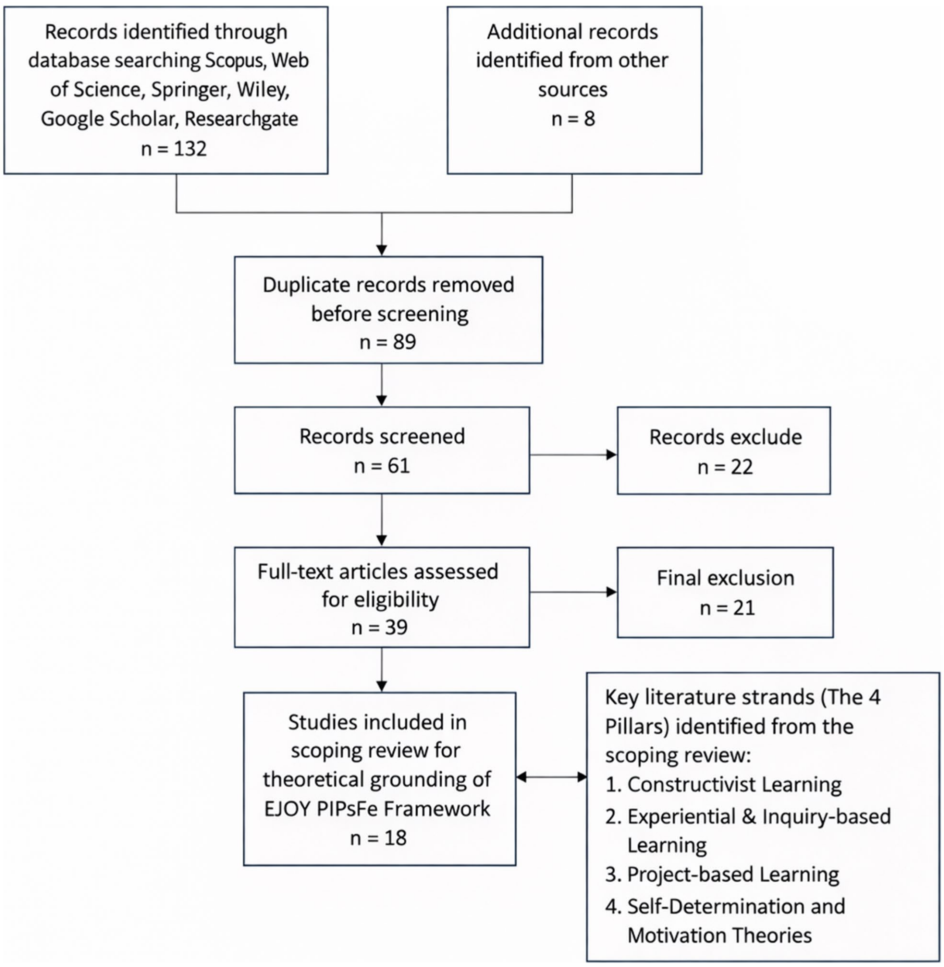



FIGURE 1
PRISMA-ScR flow diagram showing the identification, screening, eligibility assessment, and inclusion of studies for the theoretical grounding of the EJOY PIPsFe Framework. The diagram follows PRISMA-ScR guidelines and summarizes the literature selection process used to establish the framework's theoretical base.

investigatory projects and culminating festival. Figure 2 provides an overview of the instructional manual, including its cover page and major sections.

The instructional manual incorporates constructivist, experiential, inquiry-based, and motivation-focused approaches, offering step-by-step procedures, lesson templates, assessment rubrics, scaffolding tools, and reflective practices. Research supports that such structured manuals improve teacher confidence and instructional consistency (Ilić et al., 2024; Wang et al., 2025), while motivation-oriented designs enhance student autonomy and engagement.

Similarly, the instructional manual functioned as the primary intervention evaluated across the reported learning and attitudinal outcomes.

## 3.3 Learning gains based on pretest and posttest results

Students' conceptual understanding improved significantly after implementation of the instructional manual. Results are summarized in Table 1, which presents the pretest and posttest means, learning gains, and statistical significance. As shown in the table, second-year students demonstrated a 28-point gain and third-year students a 15-point gain, both statistically significant ($p < 0.05$).

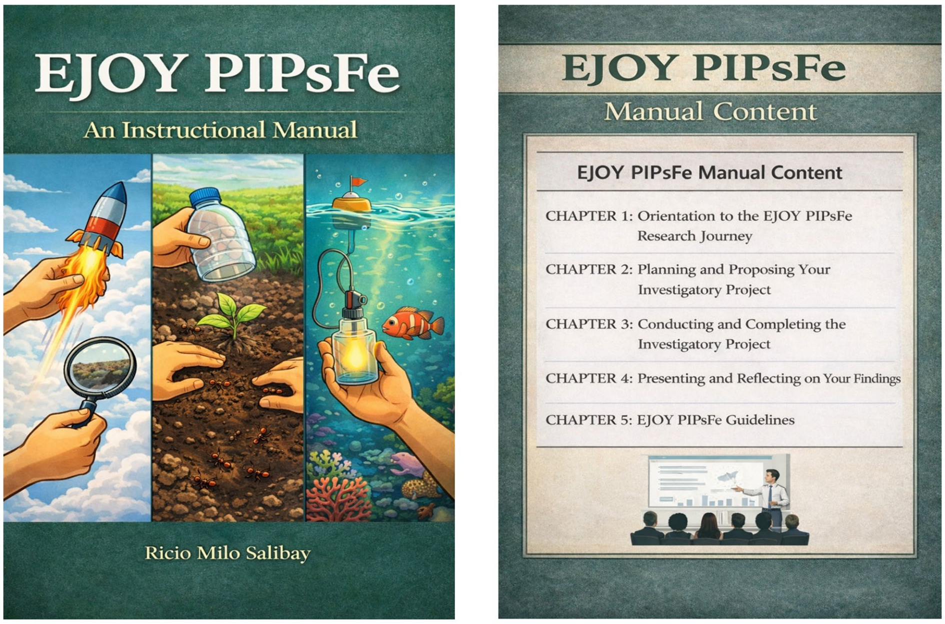
These results were obtained using paired-sample t-tests comparing pretest and posttest scores within each cohort, indicating a positive change in conceptual understanding following implementation of the instructional manual.

These findings align with previous studies showing that constructivist, project-based, and experiential learning approaches improve conceptual mastery in physics (Sasikirana et al., 2023) and that motivation-oriented strategies support sustained engagement in STEM (De Loof et al., 2021; Perera, 2022).

## 3.4 Attitudinal gains in physics as influenced by the EJOY PIPsFe instructional manual

Attitudinal results are presented in Table 2, which summarizes changes in epistemological beliefs, engagement, effort beliefs, and perceptions of learning authority.

As indicated in the table, both second- and third-year students demonstrated "Very Positive Change" across all attitudinal dimensions. Based on the six-point Likert scale used, this category corresponds to mean scores reflecting strong perceived positive change following the intervention.




(a) (b)

FIGURE 2
Overview of the EJOY PIPsFe instructional manual. **(a)** Cover page of the self-help manual for conducting physics investigatory projects. **(b)** Five-chapter content, signaling a coherent, rubric-guided framework for monitoring student performance across the investigatory, project-making, and presentation processes.

TABLE 1 Pretest and posttest performance of second-year (Fluid Mechanics) and third-year (Astronomy) students following implementation of the EJOY PIPsFe instructional manual, showing overall improvements in conceptual understanding across both year levels.

| Year level | *n* | Pretest mean | Posttest mean | Learning gain | Interpretation |
|---|---|---|---|---|---|
| 2nd | 71 | 64 | 92 | 28 | Significant increase ($p < 0.05$) |
| 3rd | 64 | 81 | 96 | 15 | Significant increase ($p < 0.05$) |
| Total/Average | 135 | 72.5 | 94 | 21.5 | Significant increase ($p < 0.05$) |

Pretest and posttest scores were obtained using researcher-developed parallel-form assessments described in section 2.6. *n* denotes the number of student participants in each cohort.

TABLE 2 Students' attitudinal changes across three domains—conceptual structure and problem-solving sophistication, personal engagement and effort beliefs, and learning context and authority—after implementation of the EJOY PIPsFe instructional manual, showing consistent positive shifts across Fluid Mechanics and Astronomy courses.

| Attitudinal factor | Year level/ course | Pretest mean | Posttest mean | Mean change | Level of attitude change |
|---|---|---|---|---|---|
| 1. Conceptual structure and problem-solving sophistication (epistemology) | 2nd year/Fluid Mechanics | 3.40 | 5.60 | 2.20 | Very positive change |
| | 3rd year/Astronomy | 3.60 | 5.62 | 2.02 | Very positive change |
| 2. Personal engagement and effort beliefs (behavioral/ affective) | 2nd year/Fluid Mechanics | 4.4 | 5.71 | 1.31 | Very positive change |
| | 3rd year/Astronomy | 4.50 | 5.88 | 1.38 | Very positive change |
| 3. Learning context and authority (source of knowledge) | 2nd year/Fluid Mechanics | 4.20 | 5.81 | 1.61 | Very positive change |
| | 3rd year/Astronomy | 4.12 | 5.90 | 1.78 | Very positive change |

Attitudinal responses were measured using a six-point Likert scale (interpretation described in the Instrument section 2.6).

These gains reflect previous findings that project-based and experiential approaches enhance students' motivation and positive attitudes toward STEM (Chinwong et al., 2025) and that self-determination strategies promote persistence, autonomy, and positive disposition (Howard et al., 2021; Nyuhuan, 2024).

## 3.5 Qualitative insights into learning and engagement

As summarized in Table 3, three qualitative themes emerged from the interview data. Teacher interviews were used primarily to

TABLE 3 Emergent qualitative themes from student and teacher interviews—*Moments of Discovery*, *Joyful Learning*, and *Guided Exploration*—summarizing recurring patterns in participants' experiences with the EJOY PIPsFe instructional manual.

| Emergent themes | Illustrative quotes | Connection to learning outcomes |
|---|---|---|
| Moments of discovery: Connecting concepts to real life | *"…made the theory click"* (SP12, 2nd year); *"…understand Astronomy beyond the book"* (SP45, 3rd year) | Supports conceptual understanding; aligns with pretest-posttest learning gains |
| Joyful learning: boosting confidence and interest | *"…looked forward to physics class"* (SP28, 2nd year); *"…felt proud solving the problem"* (SP62, 3rd year) | Reinforces positive attitudes and motivation; aligns with posttest attitude improvements. |
| Guided exploration: structured support for active participation | *"…focus on experimenting without getting lost"* (SP34, 2nd year); *"…everyone could participate"* (TP3); *"…guided them step by step"* (TP2); *"…easier to monitor progress at each stage"* (TP1) | Highlights active engagement, scaffolding, and teacher facilitation; supports sustainable learning practices. |

contextualize instructional processes and corroborate patterns observed in student accounts. The following sections elaborate on these themes by examining how students and teachers experienced discovery, enjoyment, and guided participation during the EJOY PIPsFe implementation.

### 3.5.1 Theme 1: moments of discovery

Students frequently described "moments of discovery" as they connected physics concepts to real-life phenomena during their investigatory projects. These experiences helped transform abstract ideas into concrete understanding, allowing learners to see how theoretical principles operate in everyday contexts. One student shared, "I finally understood why fluids behave differently when we did the experiment—it made the theory click for me." (SP8) Such realizations often sparked curiosity, increased confidence, and deepened engagement, as reported by participants, demonstrating the value of contextualized inquiry in strengthening conceptual comprehension and relevance.

### 3.5.2 Theme 2: joyful learning

Participants described a sense of "joyful learning" that emerged from the collaborative and creative nature of the project and festival activities. The process fostered increased confidence, pride in their work, and genuine enjoyment of physics. As one student expressed, "Presenting our project at the festival was so fun—I actually looked forward to physics class." (SP12) These positive emotional experiences were articulated by students and reinforced motivation, sustained engagement, and willingness to persist with challenging tasks. They illustrate how celebratory and student-centered environments can transform learners' attitudes toward physics.

### 3.5.3 Theme 3: guided exploration

Students and teachers highlighted the value of "guided exploration," noting that the structured scaffolding provided by the instructional manual helped them navigate complex tasks with clarity and focus. The manual's step-by-step guidance, templates, and checkpoints supported active participation and collaborative problem-solving. One student noted, "The step-by-step instructions helped us focus on experimenting without getting lost," (SP9) while a teacher added, "The structure allowed everyone to contribute and learn together." (TP3) Another teacher similarly noted, "Students were more confident presenting their ideas because the manual guided them step by step." (TP2) A teacher also emphasized, "The manual made it easier to monitor progress and support groups at each stage of their project." (TP1) These accounts reflect participant-reported experiences and demonstrate how intentional scaffolding promotes confidence, autonomy, and meaningful engagement throughout the inquiry process.

Moreover, these findings align with prior research showing that experiential and project-based learning fosters deeper understanding and intrinsic motivation (Maynard et al., 2021), while problem-based approaches improve collaboration and communication (Saldo and Walag, 2020). Constructivist, scaffolded environments further promote active participation and critical thinking (Dolenc Orbanić et al., 2016; Abiasen and Reyes, 2021).

The qualitative themes help explain the quantitative gains reported in *Sections 3.3* and *3.4* by showing how guided project work, enjoyment, and discovery processes contributed to the observed improvements in conceptual understanding and attitudes.

## 4 Discussion

The findings of this study suggest that the EJOY PIPsFe instructional manual, which operationalizes the EJOY PIPsFe framework, is associated with enhanced student conceptual understanding and attitudes toward physics across two higher education courses. Statistical analyses confirmed significant improvements in students' conceptual understanding, indicating that the manual can translate the framework's theoretical foundations—constructivist, experiential, and project-based principles—into meaningful cognitive outcomes. Attitudinal findings likewise showed consistent positive shifts across epistemological, behavioral, and contextual dimensions, suggesting that the manual supports both cognitive and affective development within the contexts examined.

These outcomes align with established research showing that student-centered, inquiry-driven, and project-based approaches strengthen conceptual mastery, engagement, and problem-solving performance in physics and related STEM fields (Saunders-Stewart et al., 2012). The structure of the instructional manual—particularly its scaffolding strategies, step-by-step processes, and emphasis on authentic performance tasks—reflects best practices identified in the literature for guiding inquiry-based instruction and sustaining learner motivation. Qualitative findings deepen these insights by illustrating how learners experience the manual in practice. Students reported "moments of discovery" as they connected physics concepts to real-life applications, expressed confidence and enjoyment during project development and the culminating festival, and emphasized the usefulness of structured guidance in navigating complex tasks. These patterns align with previous studies showing that experiential and scaffolded learning environments foster intrinsic motivation, deeper understanding, and meaningful engagement in STEM learning (Remington et al., 2023).

Viewed collectively, the quantitative and qualitative results indicate that the EJOY PIPsFe instructional manual offers a coherent, research-informed, adaptable, and scalable approach to enriching physics education. By operationalizing the framework's core principles through structured scaffolds, authentic inquiry, and celebratory learning experiences, the manual supports measurable cognitive gains, strengthens students' attitudes toward physics, and promotes sustained engagement as reflected in student-reported experiences and observed learning outcomes across different course contexts. The model's emphasis on inquiry, collaboration, creativity, and community-oriented presentations positions it as a potentially valuable pedagogical innovation for higher education physics instruction.

Future research may explore how the manual functions across a wider variety of physics topics, different institutional settings, or diverse instructional modalities, such as hybrid or laboratory-enhanced approaches. Further inquiry may also examine how specific components—such as the festival format or its scaffolding mechanisms—contribute to different aspects of learning, offering opportunities to refine and broaden the model's applicability.

## 5 Conclusion

This study indicates that the EJOY PIPsFe instructional manual can function as an effective model for strengthening physics learning in higher education. By unifying inquiry, experiential tasks, joyful engagement, and structured scaffolding, the manual provides a practical way to translate the EJOY PIPsFe framework into classroom practice. Rather than focusing solely on improving test scores or attitudes, the approach supports a more empowering learning environment where students make meaningful conceptual connections and experience physics as relevant, creative, and enjoyable as reflected in experiences shared by students.

The qualitative narratives highlight the perceived value of the model: guided exploration, authentic project work, and celebratory learning moments create conditions for curiosity, persistence, and deeper understanding. These learning dynamics suggest that the manual's contribution lies not only in cognitive gains but also in shaping productive learning dispositions—an essential aspect of long-term engagement with STEM.

As a whole, the findings suggest that the EJOY PIPsFe instructional manual represents a research-informed pedagogical approach aligned with 21st-century competencies and global education priorities. Its emphasis on creativity, inquiry, and real-world relevance indicates potential adaptability beyond physics, offering possible benefits to other science disciplines and interdisciplinary STEM contexts. Future research may investigate its integration into digital platforms, laboratory settings, or institution-wide programs to further refine its utility and broaden its impact.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

The study involved minimal-risk educational research conducted within a regular classroom setting. This study constituted minimal risk involvement of human participants conducted within regular classroom setting. All activities implemented during the research aligned with routine classroom learning experiences and did not require students to perform tasks beyond those ordinarily expected in their coursework. The research protocol was reviewed and approved by the Cebu Technological University – Main Campus College of Education. The study complied with Philippine Republic Act 10173, the Data Privacy Act of 2012, ensuring that all participant information was treated confidentially, securely stored, and used exclusively for academic and research purposes. Participants were informed of the purpose and procedures of the study. Their participation was voluntary and all individuals provided written informed consent prior to taking part in the process.

## Author contributions

RS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declared that financial support was not received for this work and/or its publication.

## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declared that Generative AI was used in the creation of this manuscript. ChatGPT was used exclusively to improve the writing quality of this manuscript, including refinement of grammar, clarity, structure, and transitions. It was not used to generate, manipulate, or analyze research data, nor to produce findings, interpretations, or conclusions. All conceptualization, data collection, analysis, interpretation, and scholarly judgment were conducted solely by the author.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2026.1761262/full#supplementary-material

## References


Abiasen, J. T., and Reyes, G. A. (2021). Teachers' and students' assessment on the extent of constructivism in the senior high school physics learning environment in Benguet, Philippines. *Mount. J. Sci. Interdiscip. Res.* 81, 100–116. doi: 10.70884/mjsir.v81i1.284

Attard, C., Berger, N., and Mackenzie, E. (2021). The positive influence of inquiry-based learning teacher professional learning and industry partnerships on student engagement with STEM. *Front. Educ.* 6:693221. doi: 10.3389/feduc.2021.693221

Cabural, A. (2024). Beyond benchmarking: a diagnostic inquiry into the underlying determinants of low performance in Philippine PISA science. *J. Tertiary Educ. Learn.* 2, 46–57. doi: 10.54536/jtel.v2i3.3063

Chinwong, S., Nedkun, P., Photharin, S., Hirankittiwong, P., Thaoyabut, P., Pongphaw, N., et al. (2025). Enhancing attitudes and engagement in first-year computer engineering students: integrating TinkerCAD and physical experiments for learning angular acceleration, torque, and moment of inertia. *Comput. Appl. Eng. Educ.* 33:e70020. doi: 10.1002/cae.70020

Creswell, J. W., and Plano Clark, V. L. (2018). *Designing and Conducting Mixed Methods Research*. 3rd Edn. Thousand Oaks, CA: Sage Publications.

De Loof, H., Struyf, A., Boeve-de Pauw, J., and Van Petegem, P. (2021). Teachers' motivating style and students' motivation and engagement in STEM: the relationship between three key educational concepts. *Res. Sci. Educ.* 51, 109–127. doi: 10.1007/s11165-019-9830-3

Deta, U. A., Ayun, S. K., Laila, L., Prahani, B. K., and Suprapto, N. (2024). PISA science framework 2018 vs 2025 and its impact in physics education: literature review. *Momentum Phys. Educ. J.* 8, 95–107. doi: 10.21067/mpej.v8i1.9215

Dolenc Orbanić, N., Skribe Dimec, D., and Cencič, M. (2016). The effectiveness of a constructivist teaching model on students' understanding of photosynthesis. *J. Balt. Sci. Educ.* 15, 575–587. doi: 10.33225/jbse/16.15.575

Eom, M., Kim, H., Noh, A., Shim, H., Jin, S., Hyun, M., et al. (2022). Developing a framework for the design and operation of metaverse-based classes. *J. Educ. Issues* 84, 55–79. doi: 10.24299/kier.2022.353.55

Fajriati, L., Alhusni, H. Z., and Lintangesukmanjaya, R. T. (2025). A comprehensive analysis of STEAM learning implementation to foster critical thinking skills for equitable and quality physics education in high schools. *J. Curr. Stud. SDGs* 1, 33–46. doi: 10.63230/jocsis.1.1.7

Grobler, S., and Dittrich, A. K. (2024). Envisioning quality education for sustainability transformation in teacher education: perspectives from an international dialogue on sustainable development goal 4. *Int. J. Comp. Educ. Dev.* 26, 270–285. doi: 10.1108/ijced-06-2023-0048

Halim, R. A., Mohemad, R., Ali, N., Bakar, A. A., and Ujir, H. (2025). Validation of an adaptive decision support system framework for outcome-based blended learning. *Int. J. Adv. Comp. Sci. Appl.* 16, 1210–1219. doi: 10.14569/IJACSA.2025.01602119

Haw, J. Y., King, R. B., and Trinidad, J. E. R. (2021). Need-supportive teaching is associated with greater reading achievement: what the Philippines can learn from PISA 2018. *Int. J. Educ. Res.* 110:101864. doi: 10.1016/j.ijer.2021.101864

Hossain, M. A., Deehan, J., and Gibbs, L. (2024). Unveiling the pedagogical approaches in STEM classroom: a scoping review. *Int. J. Learn. Teach. Educ. Res.* 23, 1–22. doi: 10.26803/ijlter.23.12.1

Howard, J. L., Bureau, J., Guay, F., Chong, J. X., and Ryan, R. M. (2021). Student motivation and associated outcomes: a meta-analysis from self-determination theory. *Perspect. Psychol. Sci.* 16, 1300–1323. doi: 10.1177/1745691620966789

Ilić, J., Ivanović, M., and Klašnja-Milićević, A. (2024). Effects of digital game-based learning in STEM education on students' motivation: a systematic literature review. *J. Balt. Sci. Educ.* 23:20. doi: 10.33225/jbse/24.23.20

Ines, J. (2023). PH still among lowest in math science, reading in global student assessment, Rappler. 81, 100–116. Available online at: https://www.rappler.com/philippines/for-second-time-ph-ranks-among-lowest-pisa-2022/ (Accessed: 17 November 2025).

Kim, J., Florian, L., and Pantić, N. (2022). The development of inclusive practice under a policy of integration. *Int. J. Incl. Educ.* 26, 1068–1083. doi: 10.1080/13603116.2020.1773946

Kurniawan, L., Kuswanto, H., and Dwandaru, W. S. B. (2024). The use of scaffolding in physics learning: a systematic review. *Jurnal Ilmu Pendidikan Fisika (JIPF)* 9, 200–210. doi: 10.26737/jipf.v9i2.5082

Laid, S. M. T., and Adlaon, M. S. (2025). A systematic review of innovative teaching strategies in science: exploring hands-on learning, technology integration, and student-centered approaches. *Acta Pedagogia Asiana* 4, 101–114. doi: 10.53623/apga.v4i2.645

Maynard, C., Garcia, J., Lucietto, A., Hutzel, W., and Newell, B. (2021). Experiential learning in the energy-based classroom. *Int. J. Eng. Pedag.* 11, 4–26. doi: 10.3991/ijep.v11i6.16539

Nair, S. S., and Prem, S. S. (2020). A framework for mixed-method research. *Shanlax Int. J. Manag.* 8, 45–53. doi: 10.34293/management.v8i2.3220

Nyuhuan, G. (2024). Beyond rewards and punishments: enhancing children's intrinsic motivation through self-determination theory. *World J. Adv. Res. Rev.* 21, 1576–1583. doi: 10.30574/wjarr.2024.21.2.0457

Perera, K. D. R. L. J. (2022). Application of SDT to promote students' motivation and engagement in learning: non-Asian and Asian contexts. *Asian Rev. Soc. Sci.* 11, 17–21. doi: 10.51983/arss-2022.11.1.2935

Remington, T. F., Chou, P., and Topa, B. (2023). Experiential learning through STEM: recent intitiatives in the United States. *Int. J. Train. Dev.* 27, 327–359. doi: 10.1111/ijtd.12302

Riegle-Crumb, C., Morton, K., Nguyen, U., and Dasgupta, N. (2019). Inquiry-based instruction in science and mathematics in middle school classrooms: examining its association with students' attitudes by gender and race/ethnicity. *AERA Open* 5:2332858419867653. doi: 10.1177/2332858419867653

Rohmah, N., Rosyidha, A., and Saputri, L. A. D. E. (2024). Unlocking the potential of project-based learning in English language education: a systematic review of benefits, challenges, and implementation strategies. *J. Eng. Lang. Teach. Appl. Linguist.* 6, 161–167. doi: 10.32996/jeltal.2024.6.4.17

Saldo, I. J. P., and Walag, A. M. P. (2020). Utilizing problem-based and project-based learning in developing students' communication and collaboration skills in physics. *Am. J. Educ. Res.* 8, 232–237. Available at: https://pubs.sciepub.com/education/8/5/1/index.html

Sasikirana, L., Fatin, R. N., and Setiaji, B. (2023). Analisis meta dengan machine learning: tingkat efektivitas project-based learning untuk meningkatkan pemahaman konsep fisika. *Phys. Educ. Sci. J.* 1, 12–12. doi: 10.47134/physics.v1i1.151

Saunders-Stewart, K. S., Gyles, P. D., and Shore, B. M. (2012). Student outcomes in inquiry instruction: a literature-derived inventory. *J. Adv. Acad.* 23, 5–31. doi: 10.1177/1932202X1142

Trinidad, J. E. (2020). Understanding student-centred learning in higher education: students' and teachers' perceptions, challenges, and cognitive gaps. *J. Furth. High. Educ.* 44, 1013–1023. doi: 10.1080/0309877X.2019.1636214

Verawati, N. N. S. P., and Nisrina, N. (2025). Reimagining physics education: addressing student engagement, curriculum reform, and technology integration for learning. *Int. J. Ethnosci. Technol. Educ.* 2, 158–181. doi: 10.33394/ijete.v2i1.14058

Wang, C. K. J., Reeve, J., Liu, W. C., Kee, Y. H., Ng, B., Chua, L. L., et al. (2025). An autonomy-supportive intervention program for STEM teachers to enhance engagement among students. *Heliyon* 11:e42150. doi: 10.1016/j.heliyon.2025.e42150

Wulandari, A. M., Handoyo, E., Wardani, S., Subali, B., and Widiarti, N. (2025). Literature study of e-modules based on project-based learning to improve critical thinking skills of students. *Edunesia: Jurnal Ilmiah Pendidikan* 6, 1039–1054. doi: 10.51276/edu.v6i2.1241

Zahara, L., Adnyana, P. B., Wesnawa, I. G. A., and Ariawan, I. P. W. (2024). Constructivism as a foundation in developing physics teaching strategies. *Kappa J. Phys. Phys. Educ.* 8, 351–358. doi: 10.29408/kpj.v8i3.27615