Development of a Science Experiment Book for Grade 5 Learners: A Project-Based Approach

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ABSTRACT

This study aimed to develop and validate a Science Experiment Book for Grade 5 learners using a project-based approach to enhance learners' science process skills, engagement, and conceptual understanding. The study was anchored on Constructivism, Experiential Learning Theory, and Project-Based Learning Theory (Vygotsky, 1978; Bruner, 1961; Thomas, 2000), which emphasize active learning, hands-on experiences, and real-world application of knowledge. A developmental research design was utilized, involving Grade 5 learners and science teachers from a selected elementary school as respondents and validators of the instructional material.

The findings revealed that learners demonstrated a generally high level of science process skills, with an overall weighted mean of 4.07 (81.4%), interpreted as moderately acceptable. Learners showed strong performance in measurement accuracy, performing multiple trials, and suggesting improvements in experiments. However, areas such as following procedures, organizing data, distinguishing observation from inference, and using scientific vocabulary were identified as areas needing improvement.

In response to these findings, a Science Experiment Book was developed incorporating step-by-step guided procedures, structured data recording tools, vocabulary enrichment sections, reflective tasks, and project-based activities aligned with the Grade 5 science curriculum. The material underwent expert validation and obtained an overall rating of 4.07 (81.4%), indicating that it is moderately acceptable in terms of content accuracy, clarity, organization, and usefulness. The results indicate that the developed material effectively supports learner engagement, critical thinking, and scientific inquiry skills, providing meaningful, hands-on learning experiences that promote deeper understanding of scientific concepts.

In conclusion, the project-based Science Experiment Book is a relevant and effective instructional material for Grade 5 learners. It is recommended for use as a supplementary resource in science instruction and for continuous refinement to further enhance learners' scientific skills and overall learning outcomes.

Keywords: Science Experiment Book, Grade 5 Learners, Science Process Skills, Project-Based Learning, Instructional Material Development

INTRODUCTION

Science education is essential in helping learners understand the world, especially at the elementary level where curiosity, exploration, and hands-on learning should be emphasized. However, many Grade 5 learners find science difficult and uninteresting due to the overuse of textbooks and lecture-based teaching, which limits their active participation. Experiments play a crucial role in enhancing learning because they allow learners to observe, test, and apply scientific concepts in real-life situations, leading to deeper understanding (Harris & Goldman, 2020). Despite this, many schools lack structured and age-appropriate experiment materials (Edwards & Fisher, 2022).

Project-based learning (PBL) is identified as an effective approach to address this issue, as it promotes investigation, problem-solving, collaboration, and meaningful learning experiences (Thomas, 2000; Krajcik &

Shin, 2014). A science experiment book designed using a project-based approach can serve as a valuable instructional material by providing clear procedures, guided activities, and engaging tasks for learners, while also helping teachers deliver organized and interactive lessons (Vaughan & Milne, 2021).

Previous studies support the importance of hands-on learning and instructional materials in improving engagement and academic performance (Johnson & Wheeler, 2021; Liang et al., 2022). However, there is a gap in the availability of structured, learner-friendly science experiment books specifically designed for Grade 5 learners and aligned with curriculum standards. Additionally, few studies focus on integrating project-based learning into such materials, particularly within the Philippine elementary context (Santos & Lazo, 2022). This study aims to address this gap by developing a project-based science experiment book tailored to the needs and abilities of Grade 5 learners.

CONCEPTUAL FRAMEWORK

The study followed an Input-Process-Output (IPO) framework, grounded in Constructivist and Experiential Learning principles, which hold that learners construct scientific understanding through direct, guided experience rather than passive instruction (Vygotsky, 1978; Bruner, 1961). As shown in Figure 1, the Input consists of the learners' current performance in conducting science experiments, the Grade 5 Science Curriculum, the identified learning needs and skill gaps, existing instructional materials, and the principles of the project-based approach. The Process involves the analysis of learners' performance data, the design and development of the Science Experiment Book, the integration of project-based and guided experimental activities, validation by teachers and experts, and revision based on feedback. The Output consists of the developed Science Experiment Book, the validation results in terms of content accuracy, clarity, organization, and usefulness, and the anticipated improvement in learner engagement and experimental skills. A feedback loop connects the Output back to the Input, representing the continuous refinement of the material based on validation results.

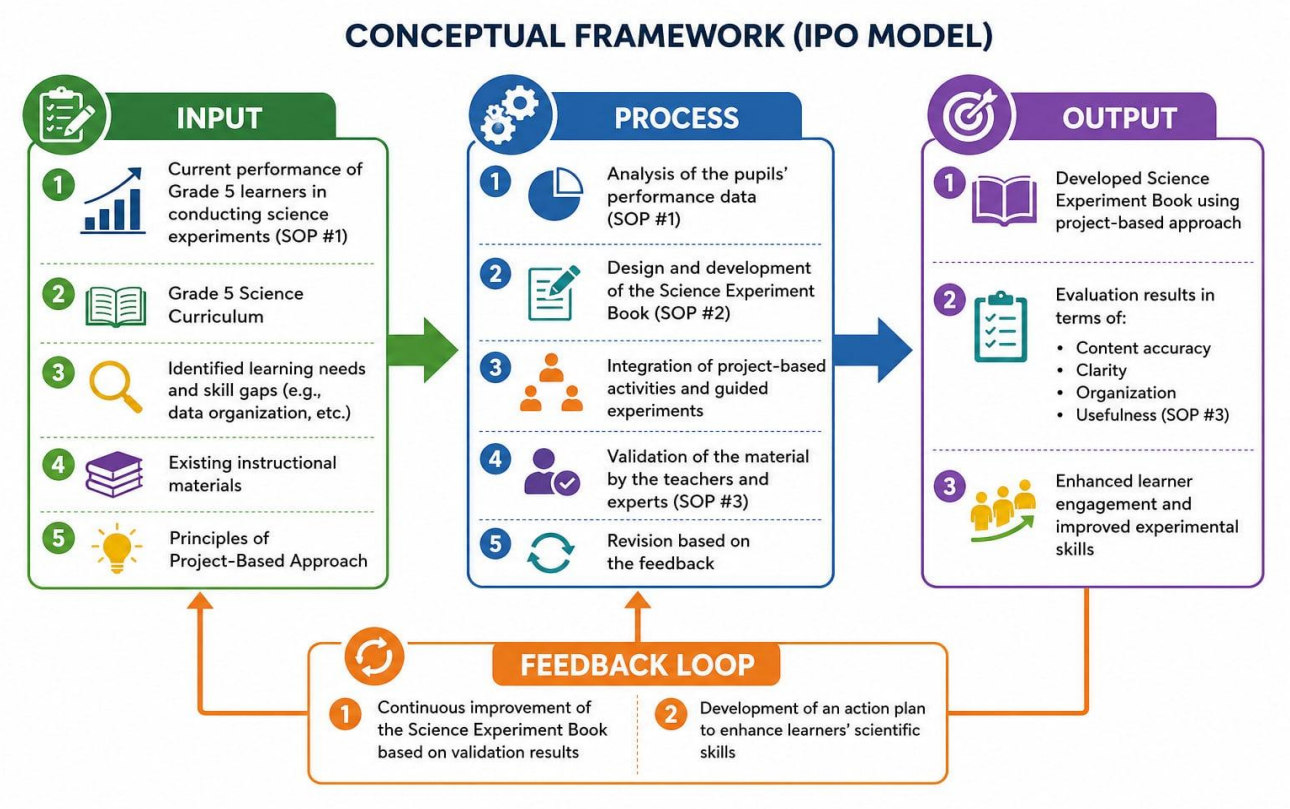

Figure 1. Conceptual Framework of the Study (IPO Model)

Objectives of the Study

This study aimed to:

1. Determine the current performance of Grade 5 learners in conducting science experiments in terms of:

a. following procedures;

b. organizing data;

c. distinguishing observation from inference; and

d. using scientific vocabulary.

2. Design and develop a Science Experiment Book based on the identified needs and performance of the learners.

3. Validate the developed Science Experiment Book in terms of:

a. content accuracy;

b. clarity;

c. organization; and

d. usefulness.

METHODOLOGY

Research Design

This study utilized the developmental research design, which focuses on creating and evaluating instructional materials. Developmental research is appropriate because the goal is to develop a Science Experiment Book for Grade 5 learners and assess its acceptability and usefulness. The study followed a systematic process of designing, developing, and validating the instructional material based on the principles of project-based learning (Thomas, 2000).

Respondents of the Study

The study involved Grade 5 SSC learners and science teachers from a selected elementary school. The teachers served as content validators and evaluators of the developed Science Experiment Book, providing feedback on its content, clarity, organization, and usefulness. Selected Grade 5 learners were also involved in pilot-testing some of the activities to ensure that the experiments are age-appropriate, engaging, and easy to understand.

Sampling Technique

This study employed purposive sampling, a non-probability sampling technique, in selecting the respondents. Purposive sampling was deemed appropriate because the study focused on the development and validation of a Science Experiment Book specifically designed for Grade 5 learners. Thus, the selection of participants was based on their relevance, expertise, and direct involvement in the implementation and evaluation of the instructional material.

The respondents consisted of Grade 5 learners and science teachers from a selected elementary school. The teachers were chosen as content validators due to their subject matter expertise and experience in teaching science, enabling them to provide informed and reliable evaluations in terms of content accuracy, clarity, organization, and instructional usefulness. Meanwhile, the Grade 5 learners were selected to participate in pilot testing to assess the material's appropriateness, comprehensibility, and level of engagement.

Purposive sampling allowed the researcher to obtain rich, relevant, and context-specific data necessary for the refinement and validation of the developed material. Since the primary objective of the study was not to generalize findings to a larger population but to design and evaluate an instructional resource, the use of

purposive sampling ensured that the participants possessed the necessary characteristics to provide meaningful and credible feedback.

Research Instruments

The study utilized a combination of quantitative and qualitative research instruments to gather comprehensive data on the science process skills of Grade 5 learners and to evaluate the developed Science Experiment Book. These instruments were carefully designed and validated to ensure the reliability and accuracy of the results.

Survey Questionnaire on Science Process Skills. A researcher-made survey questionnaire served as the primary instrument for data collection. It was designed to measure the learners' science process skills in terms of following procedures, organizing data, distinguishing observation from inference, using scientific vocabulary, and conducting experiments. The questionnaire consisted of statements rated using a five-point Likert scale ranging from strongly disagree to strongly agree. The items were aligned with the Grade 5 Science Curriculum and the Most Essential Learning Competencies, or MELCs (Department of Education, 2016). The instrument was reviewed by science teachers to ensure content validity, clarity, and appropriateness for the learners' level.

Evaluation Checklist for the Science Experiment Book. A structured evaluation checklist was used to assess the acceptability of the developed Science Experiment Book. This instrument was answered by science teachers and selected learners who served as evaluators. It focused on key criteria such as content accuracy, clarity of instructions, organization of activities, and usefulness of the material. The checklist ensured that the instructional material met the required standards for classroom use and effectively supported learners' understanding of scientific concepts.

Science Experiment Book (Intervention Material). The Science Experiment Book itself served as a research instrument and the main output of the study. It contains project-based activities, guided experiments, step-by-step procedures, a materials list, data recording sheets, and reflection tasks. The content was aligned with the Grade 5 Science Curriculum and designed to address the identified learning needs of the learners. The material underwent validation by teachers and experts to ensure its quality, safety, and effectiveness as an instructional tool.

Data Gathering Procedure

The study followed a systematic procedure in gathering the necessary data to ensure accuracy and reliability of the results. First, permission to conduct the study was secured from the school principal and other concerned authorities. After approval, the researcher coordinated with the Grade 5 science teachers regarding the schedule and implementation of the data collection process.

Next, the researcher administered the survey questionnaire to the Grade 5 learners to assess their science process skills. The purpose of the questionnaire was explained clearly to the respondents, and they were guided on how to answer the items properly. The responses were then collected, checked, and organized for analysis.

Following this, the Science Experiment Book was developed based on the identified needs and performance of the learners. The material was carefully designed to include project-based activities, guided experiments, and structured procedures aligned with the curriculum.

After the development phase, the Science Experiment Book was presented to selected science teachers and experts for validation. They evaluated the material using the structured evaluation checklist, focusing on content accuracy, clarity, organization, and usefulness. Their feedback and suggestions were collected and analyzed.

Finally, the researcher revised and improved the Science Experiment Book based on the evaluators' recommendations. All gathered data were then tabulated, analyzed using appropriate statistical tools, and interpreted to answer the research objectives of the study.

Statistical Treatment of Data

The data gathered in this study were organized, analyzed, and interpreted using the following statistical tools to ensure the accuracy and reliability of the findings.

Mean. The arithmetic mean was used to determine the average performance of the learners in terms of their science process skills and to describe the overall acceptability of the Science Experiment Book.

Standard Deviation and Variance. Standard deviation was used to measure the variability or consistency of the learners' and evaluators' responses, while variance further described the dispersion of the data and how far the scores deviated from the mean.

Frequency and Percentage Distribution. This tool was used to present the distribution of responses and to describe the profile of the respondents, using the formula $P = (n / N) \times 100$, where P is the percentage, n is the number of responses, and N is the total number of respondents.

Weighted Mean. The weighted mean was used to interpret the responses gathered from the survey questionnaire and evaluation checklist based on the five-point Likert scale shown in Table 1.

Table 1. Five-Point Likert Scale Used to Interpret the Weighted Mean

Scale	Interval	Verbal Interpretation
5	4.20 – 5.00	Highly Acceptable
4	3.40 – 4.19	Moderately Acceptable
3	2.60 – 3.39	Acceptable
2	1.80 – 2.59	Less Acceptable
1	1.00 – 1.79	Not Acceptable

These statistical tools enabled the researcher to analyze both quantitative and qualitative data effectively and to draw meaningful conclusions from the findings.

RESULTS AND DISCUSSION

The results showed that Grade 5 learners have a generally high level of science process skills, with an overall rating of 4.07 (81.4%), interpreted as Moderately Acceptable. Learners performed best in measurement accuracy, performing multiple trials, and suggesting improvements, indicating strong practical and critical thinking skills. However, lower results were observed in following procedures, organizing data, distinguishing observation from inference, and using scientific vocabulary, showing areas that need improvement. To address these gaps, a project-based Science Experiment Book was developed with guided procedures, data tools, and reflective activities. The material was also rated 4.07 (81.4%), indicating that it is moderately acceptable and effective in supporting science learning. Overall, the findings suggest that structured, hands-on materials can improve learners' skills and engagement in science (Harris & Goldman, 2020; Santos & Lazo, 2022).

Summary of Grade 5 Learners' Science Process Skills

This table presents the initial assessment of the learners' science process skills, highlighting both their strengths and areas of difficulty in conducting scientific investigations prior to the implementation of the developed instructional material. The data serve as a diagnostic tool to identify specific skill gaps, particularly in following procedures, organizing data, distinguishing observation from inference, and using scientific vocabulary. It also shows areas where learners demonstrate strong competence, such as measurement accuracy, performing multiple trials, and suggesting improvements. These findings provide a baseline for comparison in determining the effectiveness of the Science Experiment Book and in measuring the learners' improvement in science process skills after the intervention.

Table 2. Summary of Grade 5 Learners' Science Process Skills

Skill Area	Weighted Mean	Percentage	Interpretation
Measurement Accuracy (Use of Units)	4.59	91.8%	Highly Acceptable
Performing Multiple Trials	4.54	90.8%	Highly Acceptable
Suggesting Improvements	4.56	91.2%	Highly Acceptable
Following Procedures	3.54	70.8%	Moderately Acceptable
Organizing Data (Tables/Graphs)	3.65	73.0%	Moderately Acceptable
Distinguishing Observation & Inference	3.67	73.4%	Moderately Acceptable
Using Scientific Vocabulary	3.87	77.4%	Moderately Acceptable
Overall	4.07	81.4%	Moderately Acceptable

The data in Table 2 showed a comprehensive breakdown of the science process skills of Grade 5 learners, revealing distinct patterns in their strengths and areas for improvement. Measurement Accuracy (Use of Units) emerged as the strongest area of competency, recording the highest weighted mean of 4.59 and a percentage of 91.8%, interpreted as Highly Acceptable. Similarly, Performing Multiple Trials (4.54; 90.8%) and Suggesting Improvements (4.56; 91.2%) also reflected high levels of proficiency, indicating that learners are capable of applying accuracy, consistency, and critical thinking in conducting experiments (Harris & Goldman, 2020).

On the other hand, skills such as Using Scientific Vocabulary (3.87; 77.4%), Distinguishing Observation from Inference (3.67; 73.4%), Organizing Data (3.65; 73.0%), and Following Procedures (3.54; 70.8%) were rated lower, though still within the Moderately Acceptable range. Among these, Following Procedures was identified as the most challenging area for learners, showing the lowest performance.

Overall, the results indicate a clear pattern in learners' competencies, where they excel in practical and analytical aspects of experimentation but encounter difficulties in procedural accuracy, data organization, and scientific communication. This highlights the need for more structured and guided instructional support to achieve a more balanced development of science process skills.

Identified Needs and Proposed Features of the Science Experiment Book

The level of science process skills reflects how well learners are able to perform and understand scientific investigations, including their ability to follow procedures, organize data, distinguish observation from inference, and communicate using appropriate scientific vocabulary. Mastery of these skills is essential in developing scientific literacy and critical thinking among Grade 5 learners. This assessment serves as an important basis for identifying specific learning gaps and determining the appropriate instructional support needed to enhance learners' performance in science.

Table 3. Identified Needs and Proposed Features of the Science Experiment Book

Identified Skill Gap	Percentage	Proposed Feature in the Experiment Book
Procedural Consistency	70.8%	Step-by-step guided experiment format
Data Organization	73.0%	Ready-made data tables and graph templates
Observation vs. Inference	73.4%	Practice exercises and comparison charts
Scientific Vocabulary	77.4%	Science word bank and reflection sections

The results showed that learners performed best in practical science skills such as measurement accuracy, performing multiple trials, and suggesting improvements, all of which obtained high ratings. In contrast, lower performance was observed in following procedures, organizing data, distinguishing observation from inference, and using scientific vocabulary. Among these, procedural consistency registered the lowest percentage (70.8%), indicating that learners have difficulty following the correct sequence of steps during experiments.

These findings suggest that learners possess basic scientific understanding but encounter challenges in applying structured processes and communicating their ideas effectively. This indicates a gap between performing tasks

and understanding the systematic and conceptual aspects of scientific investigation, which is common among elementary learners.

This result is supported by educational theories such as Constructivism and Experiential Learning, which emphasize that learners develop deeper understanding through guided, hands-on experiences (Vygotsky, 1978; Bruner, 1961). Studies also suggest that learners require structured support, repeated practice, and clear guidance to fully develop scientific process skills (Johnson & Wheeler, 2021).

It can be inferred that while Grade 5 learners are capable of engaging in experiments, they need more structured, guided, and practice-oriented activities to strengthen their procedural skills, data organization, and scientific communication. Science process skills play a vital role in helping learners understand and explain scientific concepts clearly. However, learners often experience difficulties due to lack of structured guidance and limited opportunities for practice. Identifying these gaps is essential in designing appropriate instructional materials, such as a project-based Science Experiment Book, to improve learners' overall performance and engagement in science.

Overall Result of the Validation of the Intervention Material: "Science Experiment Book for Grade 5 SSC Pupils"

The level of acceptability reflects how effectively the Science Experiment Book supports the development of learners' science process skills through its content, activities, and instructional design. This evaluation focuses on specific indicators related to learners' performance during scientific tasks, providing a detailed measure of how the material enhances their skills in experimentation, critical thinking, and scientific communication.

Table 4. Overall Result of the Validation of the Science Experiment Book

Indicator	Weighted Mean	Percentage	Interpretation
Using correct units in measuring	4.59	91.8%	Highly Acceptable
Suggesting improvements in experiment	4.56	91.2%	Highly Acceptable
Performing multiple trials	4.54	90.8%	Highly Acceptable
Showing curiosity in real-world application	4.31	86.2%	Highly Acceptable
Reading and understanding safety rules	4.15	83.0%	Moderately Acceptable
Explaining failed/unexpected results	4.13	82.6%	Moderately Acceptable
Preparing workspace and materials	4.11	82.2%	Moderately Acceptable
Predicting outcomes	4.09	81.8%	Moderately Acceptable
Identifying tools and variables	4.00	80.0%	Moderately Acceptable
Using scientific vocabulary	3.87	77.4%	Moderately Acceptable
Listening to lab partners	3.81	76.2%	Moderately Acceptable
Distinguishing observation from inference	3.67	73.4%	Moderately Acceptable
Organizing data in tables/graphs	3.65	73.0%	Moderately Acceptable
Following correct sequence of steps	3.54	70.8%	Moderately Acceptable

The data in Table 4 showed that the Science Experiment Book was generally rated positively across all indicators, with all items falling under either Highly Acceptable or Moderately Acceptable. The highest-rated indicators were using correct units in measuring (M=4.59; 91.8%), suggesting improvements in experiments (M=4.56; 91.2%), and performing multiple trials (M=4.54; 90.8%), all interpreted as Highly Acceptable. These results indicate that the material effectively enhances learners' accuracy, consistency, and higher-order thinking skills during experiments. Additionally, showing curiosity in real-world application (M=4.31; 86.2%) also received a high rating, suggesting that the material successfully promotes engagement and relevance of science concepts.

On the other hand, several indicators received Moderately Acceptable ratings, particularly in using scientific vocabulary (M=3.87; 77.4%), distinguishing observation from inference (M=3.67; 73.4%), organizing data in tables or graphs (M=3.65; 73.0%), and following the correct sequence of steps (M=3.54; 70.8%), which was identified as the lowest-rated indicator. These findings suggest that while learners are capable of performing

experiments, they still experience challenges in procedural accuracy, data organization, and scientific communication.

Overall, the results reveal a clear pattern in learners' performance, where they excel in practical and application-based skills but require further support in structured and conceptual aspects of scientific investigation. This implies that while the Science Experiment Book is an effective and acceptable instructional material, enhancements in guiding procedures, data presentation, and vocabulary development are necessary to further improve its effectiveness in supporting comprehensive science learning (Miller, 2021).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

It can be concluded that the Science Experiment Book is a valid, reliable, and acceptable instructional material for Grade 5 learners. The systematic development process ensured that the material is aligned with curriculum standards and responsive to learners' needs. The positive validation results indicate that the book is effective in supporting science learning and promoting essential process skills. However, the presence of moderately rated areas suggests that instructional materials should undergo continuous evaluation and improvement to maintain their quality and effectiveness (Vaughan & Milne, 2021).

Recommendations

In view of these findings, it is recommended that the Science Experiment Book be continuously refined and improved based on feedback from its users. Teachers should be encouraged to participate in the validation and improvement process to ensure that the material remains relevant and effective in different classroom contexts. Schools and administrators should also support the development and use of teacher-made instructional materials as part of improving the teaching-learning process. Furthermore, future researchers are encouraged to conduct experimental or longitudinal studies to evaluate the long-term effectiveness of the material in enhancing learners' academic performance, scientific inquiry skills, and motivation (Thomas, 2020). Expanding the use of the material to different grade levels and educational settings is also recommended to strengthen its applicability and generalizability.

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