Available online at: https://jurnal-fkip.ut.ac.id/index.php/ijrse/issue/archive
International Journal of Research in STEM Education (IJRSE)
ISSN 2721-2904 (online)
Volume 7 Number 1 (2025): 30 - 55

Development of a proposed retooled research curriculum framework for the Philippine Science High School

Leo Peter N. Dacumos
Department of Science and Technology, Philippine Science High School
Cordillera Administrative Region Campus, Saint Louis University
ldacumos@carc.pshs.edu.ph

Abstract

The projected transition of the Philippine Science High School (PSHS) system's research curriculum from a three-year to a condensed two-year program. Furthermore, PSHS plans to adopt the Project-based Learning (PBL) approach in the coming years. Positioned ahead of these transitions, the study aims to develop a retooled research curriculum framework aimed at integrating conceptual understanding, procedural skills, and project-based learning (PBL) to optimize student learning outcomes and adapt to changes in pedagogical approaches. The retooled curriculum framework was developed using the 4D Model. The insights and perspectives regarding integrating conceptual, procedural, and project-based learning and the overall experiences within the research curriculum of 22 research teachers and 462 research students from across the eight Philippine Science High School – Luzon campuses were gathered. These insights, perspectives, and experiences led to developing the tripartite research teaching and learning model. Ultimately, the tripartite model serves as the foundation for the proposed retooled research curriculum framework of the Philippine Science High School, particularly in terms of crafted learning outcomes. Overall, the validity results showed a very high level indicating the readiness of the curriculum framework to be deployed and used for its projected transition.

Keywords: *Conceptual and procedural knowledge, curriculum, research education, Science Pedagogy, Project-Based Learning*

INTRODUCTION

Considered the “premier science high school in the Philippines”, the Philippine Science High School System of the Department of Science and Technology (DOST) was established to orchestrate the aim of the state to give priority to “research and development, invention, innovation, and their utilization; and to science and technology education, training and services” (Republic Act No. 8496). For the Philippine Science High School System (PSHSS), a six-year curriculum framework was established as a move to follow the Department of Education’s implementation of the K to 12 Program (Ong & Flores, 2010).

The six-year curriculum of the Philippine Science High School “sets out the essential knowledge, understanding, skills, and capabilities that prepare scholars to be successful in science and technology careers in the future” (PSHS System, n.d.). Through this program, scholars are anticipated to become successful in their chosen STEM courses in the future.

One unique feature of the PSHS curriculum is the research program - a three-year program research course consisting of Research 1, Research 2, and Research 3. The three research courses are offered to Grade 10, 11, and 12 students. The PSHS System Research program aims to prepare the PSHS students “for a career in science or engineering through combined application of the research process with acquired concepts and skills…” (PSHS System, 2020, p.1). Furthermore, the research program strives to develop both creative and

Corresponding author:
Leo Peter N. Dacumos, ldacumos@carc.pshs.edu.ph
DOI: https://doi.org/10.33830/ijrse.v7i1.1710

analytical thinking skills of the students, providing them opportunity for laboratory practical experiences and enabling them to connect their scientific studies to the Philippines' national goal and priorities (Cruz, 1989).

However, during the 2020 COVID-19 pandemic, the Curriculum under Remote or Blended Learning (CRBL) was implemented to ensure the continuity of education at PSHS amidst the restrictions on face-to-face learning (Board of Trustee Resolution No. 2020-11-106). This move provided adjustments to the curriculum, including shortened curricular learning competencies, adoption of online and offline learning and instructional strategies, among the modifications made for the curricular implementation (Gopilan, 2021). Despite the lifting of the COVID-19 pandemic restrictions, the implementation of the CRBL continued through Memorandum number 144, series of 2021. However, the extended implementation also underscored gaps in the research curriculum structure including the delivery of instruction.

An initial evaluation of project-based learning (PBL) implementation within the research curriculum of the PSHS revealed significant challenges as perceived by research teachers (Dacumos & Silva, 2023). These challenges include difficulties in integrating PBL into the curriculum, balancing procedural and conceptual learning, and ensuring that students engage in meaningful, inquiry-driven research projects. Furthermore, many teachers believe that the research curriculum face challenges due to its congested structure. Teachers believe that many of the learning competencies are repeated across the three research courses and other courses, leading to redundancy and inefficiency in curriculum delivery (Dacumos & Silva, 2023; Pecson & Abadiano, 2020).

Underscoring the Organization for Economic Co-operation and Development (OECD)'s "Future of Education and Skills 2030" which emphasizes the integration of disciplinary, interdisciplinary, and procedural knowledge (OECD, 2018), it seeks to ensure that students develop competencies applicable to real-world contexts. This aligns with the prior research projects to strengthen conceptual and procedural, in research education. Similarly, the Next Generation Science Standards (NGSS) advocate for inquiry-driven and project-based learning (VanTassel, 2025), an approach that suited to the intended shift of the Philippine Science High School System in its curriculum.

Given these findings, the need to retool the current research becomes evident. This study, hence, seeks to propose a curriculum framework for the research course to address the gaps in curriculum structure and implementation. Furthermore, the proposed curriculum is positioned ahead as the Philippine Science High School System plans to adopt the Project-based Learning (PBL) approach in the coming years. Recently, Memorandum No. 260, Series of 2023, titled "Nomination for Project-based Learning Champions" was released to identify PBL champions who will lead the integration of subjects in the Specialization Years (Grades 11 and 12). These champions will guide and mentor PSHS scholars toward creating innovative real-world problem-solving projects. The decision of PSHS System to adopt the PBL approach aligns with its commitment to "Future Proofing the PSHS System Curriculum" (PSHS System, n.d.). Moreover, amidst the planned revision of the former PSHS curriculum, which entails transitioning the research course from a three-year duration to a condensed two-year program, there is yet a plan to call for curriculum development to address the need for such transition.

Research Objectives:

This research project aimed to propose a retooled research curriculum framework of the Philippine Science High School System (PSHS). Specifically, this sought to answer the following objectives:

1. To identify the retooling modifications of the current research curriculum,
2. To propose a teaching-learning model to be used to retool the research curriculum framework,
3. To present the different facets of the retooled curriculum framework, and
4. To identify the validity of the retooled curriculum framework.

RESEARCH METHOD

Study Design

A developmental research design was utilized for this study. Particularly, this developmental research incorporated the Four-Door (4D) model. The 4D model is a design model aimed to help the researcher to design a learning product that improves the students' learning process (Irawan, Padmadewi, & Artini, 2018). This model includes four major steps, which include Define, Design, Develop, and Disseminate.

Data Gathering Tool

Qualitative Analysis for Project-based Learning Implementation

A qualitative interview tool was used to delve deeper into the perspectives of the research teachers of PSHS. It aimed to explore their thoughts and opinions regarding the various aspects of project-based learning (PBL) implementation within the PSHS research curriculum. Particularly, the qualitative interview tool focuses on uncovering three key aspects: the benefits or advantages of PBL (referred to as "roses"), the challenges or difficulties associated with its implementation (known as "thorns"), and the opportunities or potential for growth and improvement (termed as "buds").

Quantitative Analysis of Conceptual and Procedural Learning

Two questionnaires were designed to assess the extent of conceptual and procedural knowledge utilization. The Conceptual and Procedural Knowledge Teaching Inventory (CPKTI) and the Conceptual and Procedural Learning Inventory (CPKLI) are questionnaires designed to analyze the extent of teachers' utilization of the two types of knowledge in teaching the research curriculum of the Philippine Science High School as perceived by the research teachers and students, respectively. To guarantee that the instruments were valid, the questionnaires were sent for validation to three STEM educators and curriculum developers. Aiken's V coefficient was used to analyze the collated data of the validators' ratings. Results showed a validity coefficient of 0.96 and 0.96 for the questionnaire for the evaluation of CPKTI and CPKLI, respectively, which indicate that the instruments are valid. Furthermore, to ensure the reliability of the data, the questionnaires for the evaluation of CPKTI and CPKLI were sent for pilot testing to 10 teachers and ten students, respectively. Cronbach's alpha showed reliability coefficients of 0.93 and 0.90, indicating that the questionnaires are reliable.

Procedure

The procedure for this research project was done using the four-door (4D) model. The 4D model is composed of the following steps: Define, Design, Develop, and Disseminate as illustrated in Figure 1.

The output of the define phase was generated from the insights, recommendations, and perspectives from the qualitative and quantitative assessments of the project-based learning implementation and conceptual and procedural learning within the research curriculum of the Philippine Science High School. For the "design" phase, the insights, recommendations, and perspectives of the teachers and were used to develop the tripartite model of research learning which formed the foundation of the proposed retooled curriculum framework. In the "develop" phase, the retooled research curriculum was crafted integrating the three aspects of the tripartite model. The learning outcomes were crafted and categorized based on the three components of the tripartite model, targeting the conceptual learning, procedural learning, and project-based learning outcomes. The fourth phase, the "dissemination" was not performed. However, as part of the aim of the research to be disseminated, the finished curriculum framework was forwarded to curriculum experts of the Philippine Science High School System to ensure the validity and acceptability of the prepared retooled research curriculum framework.

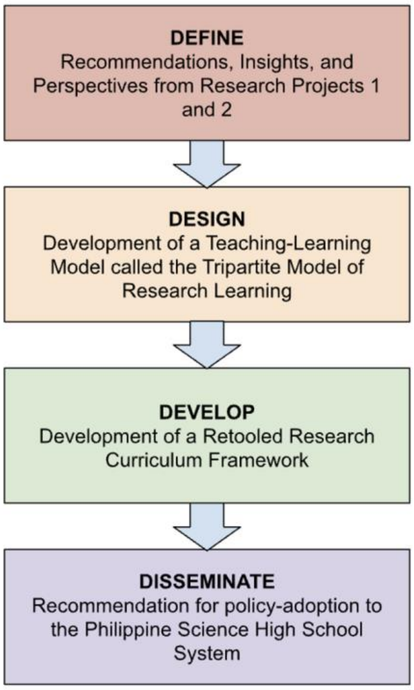

Figure 1. *4D Model for the Current Study*

FINDING AND DISCUSSION

Identified Retooling Modifications of the Current Research Curriculum

Enhanced integration of project-based learning

The current research curriculum consists of learning outcomes that are categorized into cognitive, affective, and psychomotor domains (Curriculum Under Remote or Blended Learning, Revised as of August 11, 2020), and many of these outcomes predominantly emphasize content knowledge. Content knowledge refers to factual information, concepts, principles, theories, and procedures that are central to a particular subject area or discipline (Ball et al., 2008; Shulman, 1987). In the context of the research curriculum, this encompasses a foundational understanding of key scientific concepts, methodologies, and principles. However, while content knowledge is crucial in building a strong research knowledge foundation and will ultimately allow them to develop a research project, they may not adequately prepare students for research - including its structure and organization.

One key characteristic of Project-based learning is its emphasis on providing clear structure and guidance for students as they navigate through the research process (Markula & Aksela, 2022) and effectively implementing a project-based learning approach within the research curriculum. This study proposes the addition of a new set of learning outcomes primarily focused on a structured and supportive approach to engage effectively in project-based learning.

Table 1. *Sample Comparison of Learning Outcomes on Selected Topics between the Current Research Curriculum and the Retooled Research Curriculum*

Selected Topics	Current Research Curriculum *based on CRBL Form 3 Student Learning Outcomes (Cognitive, Affective, and Psychomotor)*	Retooled Research Curriculum *Learning Outcomes for Project-based Learning*
Research 1 Selected Topics		
Introduction to Research	1) Define research 2) Identify characteristics of research 3) Recognize the value of research 4) Grasp the importance of ethical research	1) Group with peers and select research topics based on their common interests 2) Identify topics and/or problems that they see in their immediate community 3) Provide justifications for the selection of their topic/problem based on personal interest, societal relevance, and the potential contribution to knowledge
Literature Search, Topic Selection, & Presentation	1) Identify different sources of related literature 2) Extract relevant information from related literature 3) Recognize the various forms of plagiarism and intellectual dishonesty 4) Identify the knowledge gap in a particular field of interest 5) Identify the characteristics of a good research topic 6) Present a viable solution to the identified knowledge gap both in written and oral form 7) Apply the rules of scientific writing to producing papers (topic proposal)	*On Literature Search* 1) Create a matrix identifying related literature and studies supporting understanding of the identified topic of interest 2) List the details of related literature/studies, including a) Journal details b) Central problem c) Objectives d) Results e) Conclusions and Recommendation 3) Provide a statement of the gap/s based on the details of the relevant literature *On Problem Analysis* 1) Conduct a problem tree analysis of the chosen research problem which includes a) Statement of the Main Problem b) Identified causes and effects relationships with the main problem 2) Provide the basis of the main problem, its causes, and effects, through an extensive literature review
Research 2 or 3 Selected Topics		
Project Implementation	**Cognitive:** 1) Apply learned concepts on research design and methodology protocols 2) Discriminate among activities that need to be documented **Affective:** 1) Practice ethical behavior in the use of resources, taking into consideration implications of actions on man, the environment, and society 2) Contribute to team efforts	1) Implement the proposed research project based on the conceptualized topic from Research 1 through the planned data-gathering procedure 2) Perform tests and measurements necessary to gather data for a research study (as needed) *3) For experimental research:* Collect and record experimental data following established and standardized protocols and control variables *4) For engineering research:* Execute the planned activities, including the creation of prototypes/models, and troubleshoot challenges as they arise. Apply the principles of design thinking and problem-solving.

Selected Topics	Current Research Curriculum *based on CRBL Form 3 Student Learning Outcomes (Cognitive, Affective, and Psychomotor)*	Retooled Research Curriculum *Learning Outcomes for Project-based Learning*
	Psychomotor: 1) Perform tests and measurements necessary to gather data for a research study (as needed) 2) Demonstrate competence in the employment of laboratory skills and techniques needed when conducting a research project (as needed) 3) Competently execute the planned methodology 4) Maintain a logbook/e-journal to record data and progress in the research study.	5) *For non-experimental research.* Utilize suitable non-experimental methodologies such as observational methods, survey tools, etc. 6) Record all collected data in a logbook
Review of Data Presentation and Analysis	**Cognitive:** 1) Choose statistical tool/s appropriate to the generated data 2) Conclude based on the objectives of the study **Affective:** 1) Appreciate the importance of proper data presentation, analysis, and interpretation of results 2) Demonstrate open-mindedness and critical thinking **Psychomotor:** 1) Correlate observed data 2) Interpret data 3) Relate the results to the objectives of the study	1) Formulate a presentation and analysis plan for the data to be presented and analyzed through a data planning matrix: a) Research Objectives b) Type of Data to be collected c) Visual Presentation Plan (with mock tables and/or figures) d) Data Analysis Plan 2) Provide a sample presentation that can be presented both to the scientific panel and the target beneficiaries of their research *If the students are ready with their collected data, they can include their actual table instead of a mock table in the worksheet.*

Table 1 presents a sample of learning outcomes from the current research curriculum and the opposite shows learning outcomes that are primarily focused on the structured nature of project-based learning in acquiring skills in research. The emphasis of this set of learning outcomes is the collaborative learning nature of PBL and to outline the necessary steps to build their research projects from the basic conceptualization of research topics to the presentation of research data.

To include PBL learning outcomes for the retooled research curriculum, it is important to place collaboration (Krajcik et al., 1998) at the forefront of each learning outcome and provide a detailed structure to learning the doing research and achieving to developing one. Placing collaboration at the center of the PBL learning outcomes emphasizes the importance of shared problem-solving in the research process in which the students have identified themselves based on their common interests (Krajcik et al., 1998). Furthermore, another key aspect of retooling the learning outcomes is the provision of a detailed structure not only to develop research skills but to ensure that students navigate the research process with set clear goals, tracking their progress effectively. The International Baccalaureate (IB) framework emphasizes project-based learning as a cornerstone of modern STEM education, enabling students to engage in authentic, inquiry-driven learning to mirror the real-world scientific inquiries.

In the context of the retooled research curriculum, the PBL learning outcomes address its presence not only in the learning objectives but the organization of learning topics or experiences. The PBL learning outcomes are parallel to the learning topics or experiences, that is, with each learning topic set within the research curriculum, a set of PBL learning outcomes is provided to ensure that students of PSHS do not only develop their content knowledge of the research process but apply them in a project-based learning approach.

Decongested research curriculum

Retooling via decongestion of learning topics is needed to address the issues of topic redundancy across the different research courses and complacency among students. According to de Jesus (2023), "...decongesting the curriculum [to] allow more time for the fundamental tool courses…". This means that a decongested curriculum could facilitate a focused and streamlined approach to research education, affording the students more time to understand their topic, plan for their data collection and analysis, and develop more meaningful and utilizable research projects for their community (Lopatto, 2004). Furthermore, decongesting the current research curriculum is timely in anticipation of the projected shift from a three-year to a two-year curriculum at the Philippine Science High School.

Table 2. *Side-by-Side Comparison in the Learning Topics between the Current and Retooled Research Curriculum for Research 1*

Current Research Curriculum	Retooled Research Curriculum	Remarks for Retooling
First Quarter		
1) Introduction to Research 2) The Research Process 3) Literature Search, Topic Selection, and Presentation 4) Writing the Introduction	1) Introduction to Research 2) The Research Process 3) Literature Search, Topic Selection, and Presentation 4) Writing the Introduction	***Current:*** Maintained the content of the learning topics
Second Quarter		
1) Writing the Literature Review 2) Research Design 3) Writing the Proposed Methodology	1) Review of Related Literature (RRL) a) RRL on Research Problem b) RRL on Conceptual Framework c) RRL on Methodology	***Current:*** Overloaded Content in one quarter ***Retooled:*** Shifted emphasis to reviewing literature on three key aspects
Third Quarter		
1) Writing Protocols and Project Planning	1) Research Design a) Identifying and Defining Variables b) Principles of Research Design c) Application of Research Design d) Research Design Write-up 2) Research Methods 3) Project Planning	***Current:*** Redundant/Repeated Topic with Methodology Writing ***Retooled:*** The topic on project planning was merged with Research Methods; Shifted emphasis to Research Design and Research Methods
Fourth Quarter		
1) Writing the Final Proposal 2) Research Presentations and Critiquing	1) Writing the Final Proposal 2) Proposal Presentation and Critiquing 3) Submission of Paper of Ethics Review	***Current:*** Available time to include other research topics ***Retooled:*** Strengthened approach in writing the final proposal; Added paper submission for ethics review

In Research 1 (table 2), it is observed that many of the topics are congested in a singular quarter within the current research curriculum of the Philippine Science High School (PSHS). To address this, curricular topics were organized such that for the second quarter it prioritizes understanding of the three aspects of reviewing the literature. This approach allows the students of PSHS to provide a foundation for understanding the context of their research problem including the current and existing solutions to the problem (Essuman, 2011), the interconnectedness of the variables within their research (Creswell & Creswell, 2017), and the available design and methods to achieve their set research objectives (Ravid, 2016). Additionally, some are redundant such as the methodology writing and project planning. Hence, in order to retool this, these topics were merged to provide continuity of the process of planning for the methods to be used and planning for project implementation. This is to ensure that the students are engaged in comprehensive research planning and addressing ethical issues within their research (Resnik, 2020).

Table 3. *Side-by-Side Comparison in the Learning Topics between the Current and Retooled Research Curriculum for Research 2*

Current Research Curriculum	Retooled Research Curriculum	Remarks for Retooling
First Quarter		
1) Research Proposal Writing 2) Ethics in Research 3) Panel Defense of a Research Proposal 4) Project Planning	1) Research Proposal Presentation (Review of Research Proposals) 2) Project Implementation	***Current:*** Repeated requirements and topics from last research course (Research Proposal Writing, Ethics, Panel Defense, and Project Planning) ***Retooled:*** Included a classroom/peer proposal review by retrieving the previously submitted and presented proposal paper from Research 1 (not a formal panel defense); To start the project implementation proper and presentation of initial data for evaluation of peer, teacher, and panel members
Second Quarter		
1) Conducting Research Seminar 2) Research Paper Writing	1) Project Implementation (Continuation) 2) Review of Data (Presentation and Analysis)	***Current:*** Conduct of a research seminar (involving presentation of the conceptual or technical framework) is already included in the project presentation from previous quarter; Research Paper Writing may be unnecessary since data collection has not commenced yet based in the current curriculum ***Retooled:*** Provided the whole quarter for continuation of project implementation including experimentation, prototyping, etc.; Included a topic discussion for data presentation and analysis
Third Quarter		
1) Project Implementation 2) Review of Data Presentation and Analysis	1) Writing the Results and Discussion	***Current:*** Project Implementation only commences in this quarter and is only limited to one quarter which may be too late and not enough for experimentation, prototyping, and data collection ***Retooled:*** It is expected that at this point, the students have already done with their project implementation having done it in the first two quarters of the academic year and that they have been initially presented and organized. Hence, the third quarter will be dedicated for the writing of the results and discussions
Fourth Quarter		
1) Project Presentation	1) Preparation of Final Full Manuscript 2) Project Presentation	***Current:*** No time given to organize their final manuscript which includes their reformatted proposal and results and discussions sections

Current Research Curriculum	Retooled Research Curriculum	Remarks for Retooling
	3) Preparation of Paper for Journal Submission and/or Intellectual Property Application	***Retooled:*** Added time to organize their final manuscript including retrieval and reformatting of their research proposal and adding the results and discussion sections; Added preparing their manuscript for Journal Submission and, if applicable, Intellectual Property Application

For Research 2 (table 3), the current research curriculum includes a repetition of requirements and topics from Research 1. The repetition includes writing of the final proposal, ethics, and project planning which are already covered in the previous research course. To retool this, a classroom or a peer proposal review is introduced which allows the students to retrieve their prepared paper from Research 1 and present it before their peers, teachers, and panel members. This will prevent them from re-writing their research proposal and focus instead on briefly reviewing their papers and project implementation. Furthermore, two quarters, that is for the first and second quarter) are dedicated for their project implementation in contrast to the original one quarter set for the third quarter. This gives groups ample time for experimentation, prototyping, and data collection, which foster a deeper understanding and exploration of their research projects (National Research Council, 2012).

Lastly, in Research 3 (table 4), as students are expected to finish their research projects in Research 2, the retooled research curriculum does not have a third Research Course in response to the call for streamlining the Research Curriculum and the projected transition from a three-year research program to a two-year research program. Hence, there will be no more categorization of groups into continuing projects, completed projects, or new topics. The requirements and activities set for Research 3 are consolidated into Research 2. This eliminates redundancies, ensuring a seamless progression of research activities from Research 1 to Research 2.

Table 4. *Side-by-Side Comparison in the Learning Topics between the Current and Retooled Research Curriculum for Research 3*

Current Research Curriculum	Retooled Research Curriculum	Remarks for the Retooling
For New Topics 1) Project Review 2) Review of Research Proposal Writing 3) Identification of Topic (Extension or Expansion of Specialized Topic, Collaboration on Multidisciplinary Topics) 4) Proposal Writing 5) Project Implementation in specialization subject **For Continuing Projects** 1) Project Review 2) Project Implementation in specialization subject 3) Conducting a Research Seminar **For Completed Projects** 1) Project Review 2) Project Presentation 3) Final Research Paper Writing (Manuscript and Journal Format)	*The Retooled Research Curriculum does not have a third Research Course in response to the call for streamlining the Research Curriculum and the projected transition from a three-year research program to a two-year research program*	***Current:*** Included topics that are extensions of Research 2; Included topics that are redundant/repeated from Research 2 including Project Review, Proposal Writing, Project Implementation, and Conduct of Research Seminar; No structure for deliverables for the four quarters of the academic year ***Retooled:*** As students are expected to finish their data collection, writing of their final manuscript, and presentations in Research 2, all the topics and activities in Research 3 are placed and organized in Research 2

Current Research Curriculum	Retooled Research Curriculum	Remarks for the Retooling
4) Submission of Paper in Journal Format for Publication 5) Submission to DOST-TAPI for IP Application Processing and Assessment		

Balanced procedural learning and conceptual learning in Research

Levels of knowledge, that is conceptual and procedural knowledge, are often overlooked when discussing about taxonomy used in crafting learning outcomes (Wilson, 2016). These levels of knowledge were "never fully understood or used by teachers because most of what educators were given in training consisted of a simple chart with the listing of levels and related accompanying verbs" (Wilson, 2016; Iowa State University, n.d.).

As observed, student learning outcomes within the current research curriculum are likely to lean towards procedural learning instead of a balanced with conceptual learning (Curriculum Under Remote or Blended Learning, Revised as of August 11, 2020). Many of these learning outcomes are often anchored on taxonomy of learning objectives used in cognitive development that are practically following the procedural knowledge based on Bloom's taxonomy and subsequently revised by Anderson and Krathwohl (Wilson, 2016). Some of these learning outcomes of the current research curriculum are shown in table 5.

The International Baccalaureate (IB) models emphasize conceptual learning by building the courses around big ideas, allowing the students to make meaningful connections across field. IB framework emphasize the balance of these two knowledge to provide stronger foundation for scientific reasoning, hypothesis generation, and insterdisciplinary application.

The retooled research curriculum, henceforth, shifted from the conventional cognitive, affective, and psychomotor domains, to a knowledge dimension approach highlighting particularly the conceptual and procedural learning outcomes. The redirection does not remove the importance of the cognitive, affective, and psychomotor (CAP) domains; rather, these domains are integrated within the new format of learning outcomes. Integrating these two, the bi-directional view of these two types of learning emphasize the need to support the students in developing a holistic understanding of all stages of the research process (Rittle-Johnson & Star, 2007). Combining both types of knowledge equips students to be well-rounded researchers capable of understanding the essence of research, its various processes, and its practical application in the real world.

Table 5. *Sample Comparison of Learning Outcomes on Selected Topics between the Current Research Curriculum and the Retooled Research Curriculum*

Selected Topics	Current Research Curriculum *based on CRBL Form 3 Student Learning Outcomes (Cognitive, Affective, and Psychomotor)*	Retooled Research Curriculum *Learning Outcomes for Conceptual and Procedural Learning Outcomes*
Introduction to Research	1) Define research 2) Identify characteristics of research 3) Recognize the value of research 4) Grasp the importance of ethical research	**Conceptual Learning Outcomes** 1) Define the foundational principles underlying research through exploration of sample research studies: a) Its definition b) Nature and Purpose c) Key characteristics 2) Articulate the importance of principles surrounding ethical research practices, including those that guide responsible conduct of research 3) Identify the qualities that define a good research topic, considering its relevance, significance, and feasibility based on sample research studies related to the chosen topic of interest **Procedural Learning Outcomes** 1. Engage in structured activities (such as brainstorming) and exercises to identify the research interest, including that of the central problem they wish to pursue in their study
Literature Search, Topic Selection, & Presentation	1) Identify different sources of related literature 2) Extract relevant information from related literature 3) Recognize the various forms of plagiarism and intellectual dishonesty Identify the knowledge gap in a particular field of interest 4) Identify the characteristics of a good research topic 5) Present a viable solution to the identified knowledge gap both in written and oral form 6) Apply the rules of scientific writing to producing papers (topic proposal)	**Conceptual Learning Outcomes** 1) Explore various sources for related literature reading, including academic journals, books, and reputable online resources 2) Deduce the need to identify gaps in existing knowledge within a specific field and recognize areas where research is needed 3) Recognize the importance of providing citations and referencing the literature used in developing the study **Procedural Learning Outcomes** 1) Apply the skills to extract pertinent information from various related literature sources 2) Utilize the three-pass approach in reviewing related literature to the selected research topic 3) Evaluate and analyze sections of research journals/articles important in reviewing literature based on set criteria 4) Apply APA 7th edition formatting in writing literature citations and reference listing
Writing the Introduction	1) Apply the rules of scientific writing to producing papers (Background, Objectives, Significance, Scope, and Limitations)	**Conceptual Learning Outcomes** 1) Rationalize the distinct purposes of the major sections of the Introduction: a) Background of the Study b) Research Objectives c) Significance of the Study d) Scope and Delimitation of the Study 2) Critically analyze research journals highlighting the fundamental principles of scientific writing, including: a) clarity, precision, and objectivity

Selected Topics	Current Research Curriculum *based on CRBL Form 3 Student Learning Outcomes (Cognitive, Affective, and Psychomotor)*	Retooled Research Curriculum *Learning Outcomes for Conceptual and Procedural Learning Outcomes*
		b) Use of voice and tense c) Formatting styles d) Plagiarism **Procedural Learning Outcomes** 1) Assess sample studies related to the selected research topic based on: a) Principles of scientific writing b) Major sections of the introduction 2) Apply scientific writing principles to articulate a clear and cohesive introduction of the research paper for the selected research topics
Research 2 or 3 Selected Topics		
Review of Data Presentation and Analysis	**Cognitive:** 1) Choose statistical tool/s appropriate to the generated data 2) Conclude based on the objectives of the study **Affective:** 1) Appreciate the importance of proper data presentation, analysis, and interpretation of results 2) Demonstrate open-mindedness and critical thinking **Psychomotor:** 1) Correlate observed data 2) Interpret data 3) Relate the results to the objectives of the study	**Conceptual Learning Outcomes** 1) Recognize the theoretical underpinnings of data analysis methods and their assumptions, mainly by asking these questions: a) What are the objectives of this analysis? b) What statistical techniques are appropriate? How do they answer the objectives set for the study? c) What data are you using? Are there any limitations to the analysis methods for the data collected? 2) Differentiate commonly used statistical tools for experimental, non-experimental, and engineering studies and how they are used and selected based on the formulated research objectives in the study: a) Descriptive statistics (Measures of Central Tendency, Measures of Variability, and frequency distribution b) Inferential statistics i) Comparative (t-test, ANOVA, Mann-Whitney U, Kruskall-Wallis, etc) ii) Correlational (Pearson correlation, Spearman rho, Chi-square, etc) iii) Regression Analysis (Linear and Multiple Regression Analysis) 3) Discriminate the uses of various visual presentations for the data collected: a) Tabular Presentation b) Graphical Presentation c) Differentiate the various graphical presentations of data according to their uses and applicability of data to be presented. **Procedural Learning Outcomes** 1) Choose the appropriate statistical tool/s for the collected data based on guided standards for the: a) Type of data to be analyzed, i.e. descriptive or inferential analysis

Selected Topics	Current Research Curriculum *based on CRBL Form 3 Student Learning Outcomes (Cognitive, Affective, and Psychomotor)*	Retooled Research Curriculum *Learning Outcomes for Conceptual and Procedural Learning Outcomes*
		b) Assumptions on the use of parametric or non-parametric tests for inferential analysis 2) Choose the appropriate type of visual presentation for the data collected and justify their use in the study

Teaching-Learning Model in Retooling the Research Curriculum Framework of the Philippine Science High School System

Integrating conceptual understanding, procedural skills, and project-based learning (PBL) in research education is rooted in recognizing the multifaceted nature of scientific inquiry. This approach has been informed by findings from two research projects to evaluate and retool the research curriculum. These projects revealed the importance of integrating theoretical knowledge, practical skills, and hands-on experience to foster a deeper understanding of scientific research among students. By adopting a holistic approach encompassing conceptual, procedural, and experiential learning, educators aim to equip students with the comprehensive skill set necessary for success in scientific research.

Building upon the findings of these projects, Research Project 3, aimed to develop this re-tooled curriculum framework that integrates conceptual knowledge, procedural knowledge, and project based learning to enhance student learning outcomes, hence, the "Tripartite Framework of Research Teaching and Learning" (figure 2).

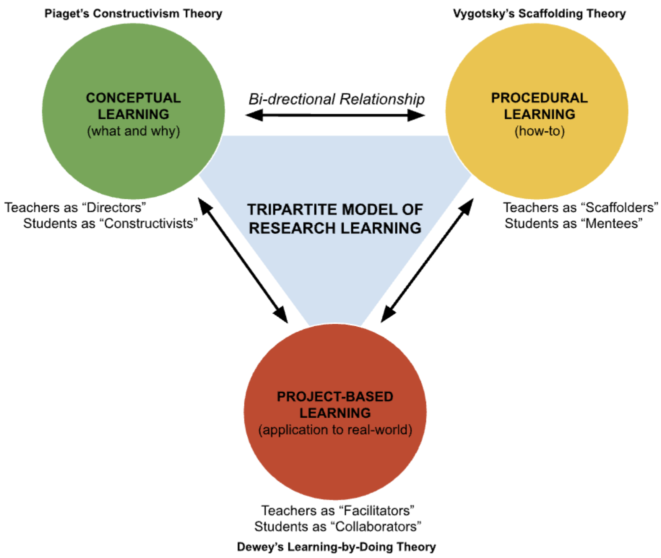

Figure 2. *Tripartite Model of Conceptual, Procedural, and Project-based Learning in Research Curriculum*

In research education, as the previous research projects proposed, conceptual and procedural learning are intertwined in a bi-directional relationship, where each informs and enriches the other component. Bi-directionality of these two types of knowledge has been proposed for its optimal effect on students' learning

(Rittle-Johnson et al., 2015). This bi-directionality in research emphasizes the dynamic interaction between understanding theoretical underpinnings and principles behind stages of the research process and acquiring practical skills through a series of guided approaches from the teacher.

Conceptual knowledge refers to a deep understanding of the fundamental concepts, principles, and underlying theories within a particular subject area or field (Rittle-Johnson et al., 2015), answering the "what" and "why" questions. In research, conceptual learning allows learners to explore research concepts, theories, and frameworks while enabling them to construct their learning. Procedural knowledge, known as "how-to" knowledge, is the ability to follow procedures and understand how to perform specific tasks (Canobi, 2009; Miller & Hudson, 2007; Rittle-Johnson & Schneider, 2015). Procedural learning allows students to gain skills in performing research tasks such as planning for the methodological approaches, implementing the research plan, and writing the manuscript, among others.

Project-based learning then integrates both by emphasizing the application of knowledge and skills in real-world contexts, answering the question "application" or "doing." Project-based learning (PBL) applies the bi-directional view of conceptual and procedural learning (Blumenfeld et al., 1991). PBL allows students to engage in authentic, inquiry-driven projects requiring conceptual and procedural learning to solve real-world problems (Thomas, 2000).

As research students engage in their research projects, they, in turn, immerse themselves in the research process, which includes designing, implementing, and revising, which continuously utilizes their conceptual and procedural learning. Furthermore, challenges encountered during implementation can prompt students to revisit, construct, and deepen their conceptual learnings, and practical learnings allow them to acquire procedural skills and insights. With PBL, a dynamic environment for students in research enables them to integrate and apply their conceptual and procedural learning in an authentic research context (Hung, 2006).

Role of PSHS Teachers and Students in the Tripartite Model

In this new learning environment for research, PSHS teachers and students will play distinct but complementary roles (table 6). A PSHS teacher will don three hats in implementing the retooled research curriculum, that is, as an "Director" for conceptual learning, as a "Mentor" for procedural learning, and as a "Facilitator" in the implementation of project-based learning. A PSHS student, on the other hand, will play the role of a "constructivist" for conceptual learning, a "mentee" for procedural learning, and a "collaborator" in project-based learning.

Conceptual learning anchors itself to the principles of constructivism - a learning theory that emphasizes the student's active role in constructing or building their understanding and knowledge (Badie, 2016). Hancer (2007, as cited in Ahmad et al., 2020) concurs with this as he claims, "constructivist principles also accompany the improvement of students' conceptual learning and elimination of misunderstanding" (p.24). Within the constructivist framework, learners actively engage in sense-making activities, connecting new information to existing knowledge frameworks, identifying patterns and relationships, and generating their understanding of concepts.

Table 6. *Roles in the teaching-learning process in the retooled curriculum*

Tripartite of Learning Outcomes	Roles in the Teaching-Learning Process	
	PSHS Research Teacher	**PSHS Student**
Conceptual Learning	Teacher as “Director”	Student as “Constructivist”
Procedural Learning	Teacher as “Scaffolder”	Student as “Mentee”
Project-based Learning	Teacher as “Facilitator”	Student as “Collaborator”

Hence, within conceptual learning, teachers can be a “director”. Sianipar (2019) defines “directors” as imparting knowledge or skills through various methods. However, instead of simply imparting information, the “director” encourages active engagement by creating opportunities for students to explore concepts, pose questions, and construct their own understanding. On the other hand, the PSHS students are actively engaged in the learning process. Hence, they will take on the “constructivist” role as they are not passive recipients of knowledge but actively construct knowledge for themselves, hence developing their conceptual knowledge (Bruner, 1961; Piaget, 1970).

Procedural knowledge aligns with the principles of Vygotsky’s scaffolding theory. Scaffolding focuses on developing procedural knowledge by providing structured support and guidance to learners as they acquire new skills and strategies (Skeen & Zafonte, 2015). Educators scaffold learning experiences by breaking down complex procedures into smaller but more manageable chunks, providing demonstrations, modeling, and giving feedback to help learners develop their procedural competence. In procedural learning, teachers can adopt the role of “scaffolders”. At the same time, the students are positioned as “mentees.” “Scaffolders” guide their students to master a particular field, providing them guidance, feedback, and resources (Main, 2021). Through explicit instruction, demonstration, and constant feedback, “scaffolders” demonstrate the “how-to” of the research process, from the conceptualization process, formulation of research questions, and designing the experiments to analyzing data and communicating findings. As “mentees”, the research students engage in the learning process under the guidance of their “scaffolders” - providing explicit instruction, practical demonstration, and constructive feedback. In research, these “mentees” can perform the procedural skills in the different facets of the research process, such as formulating research questions, designing experiments, conducting literature review, and analyzing data, among others, through the mentorship approach that teachers provide them.

Project-based learning (PBL), as discussed in the earlier section, is the culminating phase and the application of the bi-directional relationship between the conceptual and procedural learning process of research education (Blumenfield et al., 1991). John Dewey’s learning-by-doing theory emphasizes hands-on, experiential learning as a central tenet of education. This theory is often regarded as the founder of project-based learning as it advocates life-long learning that allows students to interact with real-life tasks - the essence of project-based learning (Wahbeh et al., 2021). In PBL, students are now enabled to conduct the research project, navigate through the steps of the research process, and ultimately solve their identified problem from the community. Hence, teachers transform into “facilitators” of student researchers as they go through this research process. Davis (2014) defined “facilitators” as those who manage and maintain a group process, primarily focusing on the process students have agreed to use to get some end results, allowing them to explore and venture into research projects that could potentially be used to solve a community problem. Students become active “collaborators” in the research process as they collaborate with peers to apply their conceptual and procedural understanding in their research projects. As collaborators, the students take ownership of their learning as they apply their conceptual understanding and procedural skills in various aspects of the research process.

Proposed Retooled Research Curriculum Framework of the Philippine Science High School

Salient Features of the Proposed Retooled Research Curriculum Framework

Streamlined Learning Competencies. The projected transition of the Philippine Science High School (PSHS) research curriculum from a three-year program to a condensed two-year program necessitates a strategic approach to curriculum design. The newly proposed retooled research curriculum framework prioritizes the development of essential skills in conceptual understanding, procedural skills, and project-based learning while also addressing the need to streamline the curriculum.

The retooled curriculum simplifies the focus on salient competencies essential for the research process based on relevant literature, including the current curriculum guide of PSHS with the aid of the suggested research course framework of Australian Curriculum on Science Research Project and Kurashiki Amaki High School (Designated Super Science High School). Emphasis is placed on conceptualizing the research topic based on real-world problems, problem tree analysis, writing the introduction, literature review, planning for methodological approaches, and submission for ethical review for Research 1 (Grade 11). For Research 2 (Grade 12), the focus was on project implementation, mini presentation of data, processing of data, writing the entire manuscript, project presentation and submission for journal publication, and intellectual property registration.

This decongestion of the curriculum stems from these relevant sources and the invaluable experience of research teachers at the center of curriculum development (Alsubaie, 2016). Drawing from the research teachers' experiences as implementers of the current curriculum, their insights and expertise play a pivotal role in shaping or re-shaping the curriculum.

Redirection of Learning Objectives and Integration of Conceptual Knowledge, Procedural Knowledge, and PBL Approach. A key aspect of the retooled research curriculum is the redirection from the traditional cognitive, affective, and psychomotor domains to prioritizing knowledge dimension learning outcomes in conceptual understanding, procedural skills, and project-based learning (PBL) approach (table 7). This shift acknowledges the evolving needs of education in the 21st century, where students must be equipped with conceptual and procedural knowledge and practical real-world application through project-based learning (OECD, 2018).

Table 7. *Focus in the teaching-learning process in the retooled curriculum*

Tripartite of Learning Outcomes	Focus in the Teaching-Learning Process
Conceptual Learning	This emphasizes the development of conceptual understanding, including the theories and principles behind the different research processes.
Procedural Learning	This emphasizes the development of procedural skills from the developed understanding of concepts of the different research processes. Furthermore, this allows concepts to be practiced through rules and procedures.
Project-based Learning	This emphasizes the application of the learned concept and procedure through assessment tasks, enabling them to develop a cohesive project from the problem they identified in their community.

Fluid Implementation of the Research Course through the PBL Approach. The assessment flow in Research for the SYP students (Grades 11 and 12) progresses seamlessly through a series of worksheets aimed at developing their skills in the research process (table 8). These worksheets will scaffold PSHS students' learning of each stage of the research process.

Major Course Topics/Content

Research 1 Course. For Research 1 topics (table 8), the curriculum will commence in the first quarter with an introduction to the fundamental principles of research, emphasizing its definition, nature and purpose, key characteristics, the ethical practices in doing research, and the general stages of the research process. Understanding these facets of research establishes the mindset of learners of the importance of research in various contexts and disciplines (Leedy & Ormrod, 2019). Students will then progress to modules focused on literature search and topic selection, emphasizing the importance of effectively locating relevant literature and sources (Creswell & Creswell, 2017).

Table 8. *Suggested Research 1 Learning Topics and Assessment Flow*

Learning Topics	Assessment Flow
First Quarter	
1) Introduction to Research	Worksheet I.1 Selection of Research Interest
2) The Research Process	
3) Literature Search, Topic Selection, and Presentation	Worksheet I.2 Literature Search Worksheet I.3 Problem Tree Analysis
4) Writing the Introduction	Worksheet I.4 Writing the Introduction and Presentation (Research Colloquium 1)
Second Quarter	
1) Review of Related Literature	
a) RRL on Research Problem	Worksheet I.5 The Research Problem
b) RRL on Conceptual Framework	Worksheet I.6 Conceptual Framework
c) RRL on Methodology	Worksheet I.7 Methodology Review
Third Quarter	
1) Research Design	Worksheet I.8 Identifying and Defining Variables
2) Research Methods	Worksheet I.9 Principles of Research Design Worksheet I.10 Application of Research Design Worksheet I.11 Process Flowchart Worksheet I.12 Research Design and Methods Write-up
	Worksheet I.13 Process Specification & Gantt Chart
Fourth Quarter	Worksheet I.14 Organizing the Research Proposal
1) Project Planning	Research Colloquium 2
2) Writing the Final Proposal	Ethics Review Application
3) Proposal Presentation and Critiquing	
4) Submission of Paper of Ethics Review	

Upon firming up their understanding of the identified topic and research problem, students will learn the facets of writing a good introduction, including the significant sections (Background of the Study, Research Objectives, Significance of the Study, and Scope and Delimitation of the Study). With their finalized topics, the students will now be assigned with a research adviser who, with the facilitation of the research teacher, will guide the students through the research process.

The second quarter will engage students in the value of literature review and critically analyzing and synthesizing them. Furthermore, the scaffolded approach of the literature review will emphasize three aspects of the literature: the research problem, the conceptual framework, and the methodology. In this manner, the learners will have a comprehensive understanding of the novelty of their research based on their literature review of the research problem (Essuman, 2011), a hypothesis/es from their conceptual framework (Creswell & Creswell, 2017), and a view of methodological approaches before the planning stage of their research (Ravid, 2016).

The third quarter will firm up their understanding of their research design. Mainly, they will acquire the necessary skills to identify their research variables and apply the principles of research design. Students' in-depth understanding of variables and the principles of research design will be crucial in their selection of the appropriate research methods and integration of methodological principles such as randomization, replication, and local control in their collection process of data (Creswell & Creswell, 2017). Dedicating one whole quarter of research design allows the students to have a deeper exploration of their research and preparation for the planning process of the method.

Finally, the fourth quarter will explore the research methods, including the principles and skills to be developed and used for the research implementation and the project planning phase, which will be important in their research activity for the following research course. This quarter will also involve writing a manuscript of their research proposals to be presented to a scientific panel and submitted for ethics review.

By the end of Grade 11, students will have acquired a solid foundation in research methodology and project planning, laying the groundwork for advanced research projects in Grade 12 and beyond.

Research 2 Course. Research 2 (table 9), for grade 12, builds upon the foundational concepts and skills acquired in grade 11. This will guide students through the advanced stages of research project development, particularly on implementing their planned research project.

During the first quarter, students will be engaged in refining their research proposals from the previous quarters based on the insights and suggestions gained from the last course. Project implementation will then commence, enabling the groups to experiment, observe, or prototype for their studies. Project implementation is an essential and critical phase in the research process as student researchers translate their plans into gathering data (Denzin & Lincoln, 2011). This will be regularly consulted with their mentors (teacher and adviser), and documented through research logs. One feature particularly added in this retooled curriculum is the conduct of mini-presentations to allow the students to present their initial data to their panel and peers.

In this way, their presented data will be assessed on the correctness and validity of their collected data based on the solicited feedback and suggestions (Umanath & Vessey, 1994). This will help students to identify potential flaws in their data collection process, and refine them for the validity of the collected data (Nosek et al., 2015). In the second quarter, students will continue their project implementation.

All groups are expected to be in their final stage of data collection this quarter. Hence, with the data already collected, students will learn the aspects of data review, presentation, and planning for data analysis. This will allow the students to critically evaluate their findings, identify patterns and trends, and prepare to articulate their results to their peers and mentors.

The third quarter will transition to the writing phase of their results and discussions. This crucial step allows the student researchers to transform their collected data, analyses, and findings into a coherent and comprehensive manuscript (Day & Gastel, 2012). They are expected to synthesize their findings, contextualize them within the literature review, and draw meaningful conclusions and implications from their analyzed data.

The final quarter will focus the students towards communication of their research output through presentation, publication, and/or intellectual property registration. As future scientists, PSHS students are expected to go beyond mere gathering of procedures and preparing their research manuscripts. The goal is for these students to communicate their research to their target beneficiaries from where they identified their research problem through journal publication. By publishing their work in reputable journals, researchers gain recognition for their contributions and facilitate the exchange of ideas and the replication of experiments by other scholars (Björk, 2017).

Furthermore, students are expected, if applicable, to submit their papers for intellectual property application. With IP protection, student researchers will see the value of controlling the use and exploitation of their inventions (Mazzoleni & Nelson, 2007).

Table 9. *Suggested Research 1 Learning Topics and Assessment Flow*

Learning Topics	Assessment Flow
First Quarter	
1) Research Proposal Presentation (Review of Research Proposals)	Worksheet II.1 A Refined Research Proposal
2) Project Implementation a) Design Execution/ Experimentation b) Regular Consultations c) Regular Updates d) Documentation (includes maintenance of laboratory journal/ e- Journal and drafting of research paper)	Worksheet II.2 Logbook Entries Worksheet II.3 Progress Report (with Mini Presentation of Progress and Initial Data)
Second Quarter	
1) Project Implementation (Continuation)	Worksheet II.4 Progress Report (with Mini Presentation of Final Phase of Data) Research Colloquium 3
2) Review of Data (Presentation and Analysis)	Worksheet II.5 Plan for Data Presentation and Analysis
Third Quarter	
1) Writing the Results and Discussion	Worksheet II.6 Results and Discussion Write-Up
Fourth Quarter	
1) Preparation of Final Full Manuscript 2) (Formatting)	Final Full Paper Manuscript
3) Project Presentation a) Poster Presentation (in a research exhibit, open to the public) b) Oral Presentation (in a school symposium webinar/ or any online platform conferences and seminars, open to the public	Research Colloquium 4
4) Preparation of Paper for Journal Submission and/or Intellectual Property Application	Worksheet II.7 Journal Format/IP Application

Validity of the Retooled Research Curriculum Framework

Results showed that all curriculum framework domains got average scores beyond 4.20, indicating a very high level of validity. This implies that the formulated learning objectives, the identified learning experiences and their organization, and the evaluation methods set at the retooled research curriculum can readily be used without the need for revision. These domains set by Tyler's objective centered model collectively serve as the backbone of a curriculum, guiding the design and implementation of the educational activities (Anh, 2018; Darrin, 2014) for research education at the Philippine Science High School System.

The very high validity rating in the formulated learning objectives in the developed retooled research curriculum framework for the Philippine Science High School signifies the clear and measurable student learning outcomes. Tyler's objective-centered model identified the importance of a well-articulated learning objective as it serves as the very foundation of curriculum development, providing its implementers a guide for instructional planning and assessment (Tyler, 1949; Darrin, 2014).

Experts evaluated the identified learning experiences very highly. This rating indicates the comprehensiveness, variety, relevance to life, suitability, interesting, and validity of the learning topics and instructional activities integrated into the developed retooled curriculum framework. Tyler (1949) emphasized that properly selected learning experiences contribute directly to the attainment of learning objectives. Hence, with the very high validity of the identified learning experiences in the retooled curriculum framework for research can enable a successful holistic learning of research competencies among students of the Philippine Science High School.

The third domain, organization of learning experiences, of the curriculum framework, was rated very highly by the experts. This indicates that the learning experiences set in the research curriculum have continuity, is sequential, and is integrative. Tyler (1949) advocates a systematic organization of learning experiences as it ensures logical progression and seamless transition between instructional activities and learning competencies. The very high rating in this domain reflects the careful planning and alignment with the overarching goals and learning outcomes of the research education at the Philippine Science High School.

Lastly, the evaluation methods were rated with very high validity by the curriculum experts. This rating indicates that the evaluation methods, which include the worksheets, identified and crafted for the retooled research curriculum framework affirm the appropriateness, variety, and effectiveness of the assessment strategy. According to Tyler (1949) and Darrin (2014), the alignment of evaluation methods with the identified learning objects ensures proper measurement of desired learning outcomes. In the case of the retooled research curriculum, the designed assessment flow through the seamless worksheets to be implemented across the two research courses can comprehensively and reliably assess the students' research learning through its scaffolded approach.

Table 10. *Recapitulation of the Retooled Curriculum Framework Validation Results*

Curriculum Framework Domains	Validator Scores (V)				Average Score	Level of Validity
	V1	V2	V3	V4		
Formulated Learning Objectives	4.75	4.63	4.75	4.625	4.69	VHV
Identified Learning Experiences	4.83	4.67	4.67	4.67	4.71	VHV
Organization of Learning Experiences	5.00	4.67	5.00	4.33	4.75	VHV
Evaluation Methods	4.67	4.00	5.00	4.67	4.58	VHV
Overall Rating	**4.81**	**4.49**	**4.85**	**4.57**	**4.68**	**VHV**

VHV – Very High Validity

Recommended Steps for the Adoption Process of the Retooled Research Curriculum

The successful integration and implementation of the retooled research curriculum for the Philippine Science High School requires a systematic approach. Figure 3 summarizes the recommended steps for the adoption process of the retooled research curriculum.

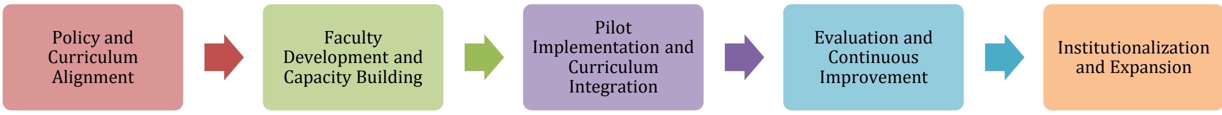

Figure 3. *Steps in the Adoption Process of the Retooled Research Curriculum*

Before the implementation of the retooled research curriculum, it will be important to conduct first a review of the alignment of the new retooled curriculum with the curriculum goals of the Philippine Science High School System under the Department of Science and Technology. The review process must make sure that the revised framework continuity of the existing policies of the department and the system.

Next is the faculty development and capacity-building. As teachers play a crucial role in the adoption of the retooled curriculum, faculty training and professional development must be conducted to equip educators with the knowledge and skills in implementing project-based learning (PBL), and balancing of conceptual and procedural learning. Since suggested flow of learning topics and assessment structure has been established (table 8 and 9), the faculty development program also need to focus on enhancing the ability of teachers to implement the revised framework effectively. Workshops and mentorship program can be conducted to familiarize faculty with the progression of topics and assessment methodologies of the retooled research framework.

Before full-fledged adoption, pilot implementation in selected campuses is recommended to test the feasibility of the retooled curriculum. The pilot need to focus on the implementation of the decongested topics and assessment methodology to ensure implementation of the revised learning outcomes which focused on PBL and balance of conceptual and procedural learning. After its pilot implementation, a comprehensive evaluation focusing on student performance, level of engagement, and students' and teachers' feedback must be conducted. Based this, if necessary, curriculum adjustments must be made bridge identified gaps and optimize implementation of the curriculum.

Lastly, once the retooled curriculum has been successfully piloted and adjusted, the Philippine Science High School System can implement it full scale. This steps need to ensure that the revised curriculum is integrated within the system's official academic program and policy to ensure consistency of implementation across the different campuses.

CONCLUSIONS

Based on the findings of the study, the following conclusions are hereby advanced:

1. The identified retooling modifications of the current research curriculum at the Philippine Science High School include the enhanced integration of project-based learning to foster hands-on, inquiry-driven learning, the decongestion of the research curriculum to ensure depth over

breadth for a more focused and meaningful learning experience, and balancing of procedural and conceptual learning to strengthen both acquisition of concept and procedure.

2. The tripartite learning model is the foundational framework that can be used to develop the retooled research curriculum framework of the Philippine Science High School.

3. The retooled curriculum framework features a redesigned and revamped curriculum, including a revised unit/subject area program description, new salient features, revised course description, and general course objectives, and re-organized major course topics/content.

The retooled curriculum framework, across its four domains (learning objectives, learning experiences, organization of learning experiences, and evaluation methods), is valid for implementation.

RECOMMENDATIONS

Based on the abovementioned conclusions, the following are hereby recommended:

1. Continuously identify areas or aspects of the current curriculum that can be retooled;
2. Adoption of the tripartite learning model as a framework to continuously improve and retool the research curriculum and other related curricula;
3. Adoption and implementation of the retooled research curriculum framework for the Grade 11 and 12 students of the Philippine Science High School;
4. Others:
    a. Continuous improvement through evaluation and feedback of the developed research curriculum framework to address the needs of the students of Philippine Science High School;
    b. Teacher training with demonstration teaching on how to utilize the proposed retooled research curriculum of the Philippine Science High School; and
    c. Adoption of the tripartite model for the other subject areas.

Acknowledgements

The author would like to thank the members of the review panel for this research, Dr. Stephenie O. Busbus, Dr. Paulina A. Bawingan, Dr. Precelita Osillos, Dr. Miriam A. Janeo, Dr. Evelyn E. Oda, Dr. Gaudelia A. Reyes, and Dr. Dorothy D. Silva. The author would also like to thank the Philippine Science High School System for the accommodation to conduct the study.

REFERENCES

Ahmad, S., Sultana, N., & Jamil, S. (2020). Behaviorism vs constructivism: A paradigm shift from traditional to alternative assessment techniques. *Journal of Applied Linguistics and Language Research, 7*(2), 19-33. https://doi.org/10.20935/AcadQuant7627

Alsubaie, M. A. (2016). Curriculum Development Teacher Involvement in Curriculum Development. *Journal of Education and Practice, 7*, 106-107. https://scirp.org/reference/referencespapers?referenceid=3210893

American Psychological Association. (2020). *Publication manual of the American Psychological Association* (7th ed.). https://doi.org/10.1037/0000165-000

Anderson, L. W. & Krathwohl, D.R., et al (2001) A taxonomy for learning, teaching and assessing: A revision of Bloom's taxonomy of educational objectives. New York: Longman.

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., ... & Wittrock, M. C. (Eds.). (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Addison Wesley Longman.

Australian Curriculum, Assessment and Reporting Authority. (n.d.). General capabilities (Version 8.4). https://www.australiancurriculum.edu.au/f-10-curriculum/general-capabilities/

Badie, F. (2016). Towards concept understanding relying on conceptualisation in constructivist learning. *13th International Conference on Cognition Learning in Digital Age.* http://teachinghistory.org/teaching-materials/teaching-guides/25184

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching. Journal of Teacher Education, 59(5), 389–407. https://doi.org/10.1177/0022487108324554

Baues, F. (2023, June 26). *Scientific writing: Make your papers write themselves*. StudySmarter UK. https://www.studysmarter.co.uk/magazine/scientific-writing/

Biggs, J., & Tang, C. (2011). Teaching for quality learning at university. McGraw-Hill Education.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating Project-based learning: Sustaining the doing, supporting the learning. Educational Psychologist, 26(3/4), 369-398. https://psycnet.apa.org/doi/10.1207/s15326985ep2603&4_8

Björk B. C. (2017). Open access to scientific articles: a review of benefits and challenges. *Internal and emergency medicine*, *12*(2), 247–253. https://doi.org/10.1007/s11739-017-1603-2

Bruner, J. (1961). The act of discovery. Harvard Educational Review, 31(1), 21-32. https://doi.org/10.4324/9780203088609-13

Calamlam, J. M., & Gamboa, G. (2021). Practical Research worksheets for Senior High school. *ResearchGate.* https://doi.org/10.13140/RG.2.2.34834.68802/1

Canobi, K. H. (2009). Concept-procedure interactions in children's addition and subtraction. *Journal of Experimental Child Psychology, 102*(2), 131-49. https://doi.org/10.1016/j.jecp.2008.07.008

Chi, M. T. (2006). Two approaches to the study of experts' characteristics. Mahwah, NJ: Lawrence Erlbaum Associates. https://psycnet.apa.org/doi/10.1017/CBO9780511816796.002

Comparing facilitation, coaching, mentoring and teaching. (n.d.). Scrum.org. https://www.scrum.org/resources/comparing-facilitation-coaching-mentoring-and-teaching

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Karolinska Institutet. (n.d.). Course syllabus - Scientific Research Methods. https://education.ki.se/course-syllabus/5HI022

Dacumos, L. (2023). Reflection in teaching: Conceptual and procedural knowledge in teaching and learning the research curricula of the Philippine Science High School. *Unpublished manuscript.*

Data analysis and presentation. (2009, October 5). https://www150.statcan.gc.ca/n1/pub/12-539-x/2009001/analysis-analyse-eng.htm

Davis, S. (2014). Facilitator as coach, teacher, trainer, and mentor. https://facilitatoru.com/training/facilitator-as-coach-teacher-trainer-and-mentor/

Day, R. & Gastel, B. (2016). How to write and publish a scientific paper (8th edition).

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11(4), 227-268. https://psycnet.apa.org/doi/10.1207/S15327965PLI1104_01

De Jesus, E. C. (2023, July 6). Chasing comprehensive curricular change | Inquirer Opinion. INQUIRER.net. https://opinion.inquirer.net/164554/chasing-comprehensive-curricular-change

Denzin, N. K., & Lincoln, Y. S. (2011). The Sage Handbook of Qualitative Research (4th ed.). Sage Publications.

Elsevier Author Services. (2023, August 4). How to submit a paper for publication in a journal. Elsevier Author Services - Articles. https://scientific-publishing.webshop.elsevier.com/publication-recognition/how-to-submit-a-paper-for-publication-in-a-journal/

Essuman, I. K. (2014). Reflective Practice in teaching and learning of Science. Keb. https://www.academia.edu/7480150/Reflective_Practice_in_teaching_and_learning_of_Science

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). Educational Research: An Introduction (6th ed.). White Plains, NY: Longman.

Hariapsari, K. W., TukiRan, T., & Sudibyo, E. (2018). Validity of teaching materials based on Socio-Scientific Issues approach on the topic of Vibration, waves, and Sound. Journal of Physics: Conference Series, 1108, 012034. https://doi.org/10.1088/1742-6596/1108/1/012034

Hayes, A. (2023, March 21). *Descriptive statistics: Definition, overview, types, example*. Investopedia. https://www.investopedia.com/terms/d/descriptive_statistics.asp

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235-266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*(2), 99-107. https://doi.org/10.1080/00461520701263368

How to use a Gantt chart for project Management. (n.d.). https://www.wrike.com/project-management-guide/faq/how-to-use-a-gantt-chart-for-project-management/

Iowa State University (n.d.). A model of learning objectives based on a taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiehqWP1JaFAxVWU2wGHS_HDg4QFnoECBkQAQ&url=https%3A%2F%2Fwww.celt.iastate.edu%2Fwp-content%2Fuploads%2F2015%2F09%2FRevisedBloomsHandout-1.pdf&usg=AOvVaw03_cAZVemSd9UAUvZjifvV&opi=89978449

IPOPHL (n.d.). *E-services.* https://www.ipophil.gov.ph/online-filing/

Justice, M. (n.d.). *Research Methodology Course Syllabus.* https://inside.tamuc.edu/academics/cvSyllabi/syllabi/201440/40503.pdf

Klahr, D., & Dunbar, K. (1988). Dual space search during scientific reasoning. *Cognitive Science, 12*(1), 1-48. https://doi.org/10.1016/0364-0213(88)90007-9

Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *The Journal of the Learning Sciences, 7*(3-4), 313-350. https://www.jstor.org/stable/1466790

Kusmawan, U. (2024). Beyond Traditional Practicums: Exploring the Potential of Scalable Practicum in Science Courses. *Studies in Learning and Teaching*, *5*(3), 622-637. https://doi.org/10.46627/silet.v5i3.505

Larkin, M. (2002). Using scaffolded instruction to optimize learning. https://www.vtaide.com/png/ERIC/Scaffolding.htm

Leedy, P. D., & Ormrod, J. E. (2019). Practical research: Planning and design. Pearson.

Liu, C. H. & Matthews, R. (2005). Vygotsky's philosophy: Constructivism and its criticisms examined. *International Education Journal 6*(3), 386-39. https://doi.org/10.20935/AcadEnvSci7515

Lopatto, D. (2004). Survey of undergraduate research experiences (SURE): First findings. Cell Biology Education, 3(4), 270-277. https://doi.org/10.1187/cbe.04-07-0045

Main, P. (2023, January 25). *Scaffolding in Education: A Teacher's guide. Structural Learning.* https://www.structural-learning.com/post/scaffolding-in-education-a-teachers-guide

Markula, A., & Aksela, M. (2022). The key characteristics of project-based learning: how teachers implement projects in K-12 science education. Disciplinary and Interdisciplinary Science Education Research, 4(1). https://doi.org/10.1186/s43031-021-00042-x

Mazzoleni, R., & Nelson, R. R. (2007). The benefit and costs of strong patent protection: A contribution to the current debate. *Research Policy, 36*(3), 387–398. https://doi.org/10.1016/S0048-7333(98)00048-1

Miller, S.P., & Hudson, P.J. (2007). Using evidence-based practices to build mathematics competence related to conceptual, procedural, and declarative knowledge. *Learning Disabilities Research and Practice, 22*(1), 47-57. https://doi.org/10.1111/j.1540-5826.2007.00230.x

Nosek, B. A., Alter, G., Banks, G. C., Borsboom, D., Bowman, S., Breckler, S. J., Buck, S., Chambers, C., Chin, G., Christensen, G., Contestabile, M., Dafoe, A., Eich, E., Freese, J., Glennerster, R., Goroff, D. L., Green, D. P., Hesse, B. W., Humphreys, M., . . . Yarkoni, T. (2015). Promoting an open research culture. Science, 348(6242), 1422–1425. https://doi.org/10.1126/science.aab2374

OECD (2018). The future of education and skills. *Education 2030.* https://www.oecd.org

Philippine Science High School System (12 November, 2023). Nomination for project-based learning champions. *Memorandum No. 260, Series of 2023.*

Piaget, J. (1970). Science of education and the psychology of the child. Orion Press.

Project-Based Learning Strategies – Center for Excellence in Learning and Teaching. (n.d.). https://www.celt.iastate.edu/instructional-strategies/teaching-strategies/problem-based-learning/project-based-learning-strategies

Ravid, R. (2016). Practical statistics for educators. Rowman & Littlefield.

Research guides: Organizing your Social Sciences Research Paper: 5. The Literature review. (n.d.). https://libguides.usc.edu/writingguide/literaturereview#:~:text=A%20literature%20review%20surveys%20prior,the%20research%20problem%20being%20investigated.

Resnik, D. B. (2020) What is ethics in research and why is it important?. National Institute of Environmental Health Sciences. https://www.niehs.nih.gov/research/resources/bioethics/whatis

Ritchie, S. M., Rigano, D. L., Leach, M. J., & de Beer, W. (2013). A systematic literature review of pharmacy students' approaches to learning and implications for pharmacy education. *American Journal of Pharmaceutical Education, 77*(4), 76. https://doi.org/10.5688/aj7406106

Rittle-Johnson, B., Schneider, M., & Star, J. R. (2015). Not a One-Way street: Bidirectional relations between procedural and conceptual knowledge of mathematics. *Educational Psychology Review, 27*(4), 587–597. https://doi.org/10.1007/s10648-015-9302-x

Rittle-Johnson, B., & Star, J. R. (2007). Does comparing solution methods facilitate conceptual and procedural knowledge? An experimental study on learning to solve equations. *Journal of Educational Psychology, 99*(3), 561-574. https://doi.org/10.1037/0022-0663.99.3.561

Science Curriculum Guide_with tagged sci equipment.pdf. (n.d.). Google Docs. https://drive.google.com/file/d/1veFq-Q4MRP6fi_MGUcHtlwk0ElhizlPs/view

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57, 1-22. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Skee, T. & Zafonte, M. (2015). Teaching APA style documentation: Discovery learning, scaffolding, and procedural knowledge. *Journal of Instructional Research, 4*, 69-75. *SSH – 岡山県立倉敷天城高等学校. (n.d.).* https://www.amaki.okayama-c.ed.jp/wordpress/?page_id=1339

Thomas, J.W. (2000). A review of research on project-based learning. Autodesk Foundation.

Tuckman, B.W. & Harper B.E. (2012). *Conducting Educational Research* (6th ed). Lanham, MD: Rowan & Littlefield Publishers.

Tyler, R. W. (1949). Basic principles of curriculum and instruction. University of Chicago Press.

Umanath, N. S., & Vessey, I. (1994). Multiattribute data presentation and Human Judgment: a Cognitive fit perspective*. *Decision Sciences*, *25*(5–6), 795–824. https://doi.org/10.1111/j.1540-5915.1994.tb01870.x

Wajnah, W., Kusmawan, U., Arifin, S., Muhammadiyah, M., & Arsyad, M. (2025). Technology-Based Learning Innovation in Community Service: Impact on Improving Education Access in Remote Areas. *Journal Of Human And Education (JAHE)*, *5*(2), 137–144. https://doi.org/10.31004/jh.v5i2.2320

Wahbeh, D. G., Najjar, E. A., Sartawi, A. F., Abuzant, M., & Daher, W. (2021). The role of Project-Based Language Learning in developing students' life skills. *Sustainability*, *13*(12), 6518. https://doi.org/10.3390/su13126518

Wiggins, G., & McTighe, J. (2005). Understanding by design. ASCD. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://files.ascd.org/staticfiles/ascd/pdf/siteASCD/publications/UbD_WhitePaper0312.pdf

Wilson, L. O. (2016). Anderson and Krathwohl Bloom's taxonomy revised: Understanding the new version of Bloom's taxonomy. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiGvfSo4JaFAxUiS2wGHV8WBxsQFnoECBoQAQ&url=https%3A%2F%2Fquincycollege.edu%2Fwp-content%2Fuploads%2FAnderson-and-Krathwohl_Revised-Blooms-Taxonomy.pdf&usg=AOvVaw3eOY7ZB6DnLfW-wmPqMq1J&opi=89978449