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Research Experiences of STEM Learners in Science Investigatory Projects and the Level of Support Curriculum Integration

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Abstract

This study aimed to assess the curricular experiences of STEM learners in writing their science investigatory projects as a requirement under the Special Science Class, which served as their basis for supporting the integration of the relevant skill sets in the research curriculum. To do this, the researcher developed and validated a survey questionnaire which was administered in February 2024 during a training workshop, and the data were processed using SPSS. The findings showed that most of the respondents (n=54) had had an experience concerning the 11 skill sets in writing, with three skill sets emerging as experienced by all of them. Further, when asked how they think these skill sets could be formally integrated into a research subject for the Special Science Class, the findings showed Very High support for integrating them. Policy recommendations for STEM education for a sustainable curriculum are provided.

Keywords: STEM Instruction, Research, High School, Sustainable STEM Curriculum

INTRODUCTION

The Philippine educational system has evolved and progressed over the years, with a key milestone being the implementation of the K to 12 Program in 2013. This reform extended basic education to include mandatory kindergarten and an additional two years of senior high school. The system is managed by the Department of Education (DepEd) for basic education, the Technical Education and Skills Development Authority (TESDA) for vocational training, and the Commission on Higher Education (CHED) for higher education. The education sector receives the largest portion of the national budget, with significant allocations for infrastructure, teacher hiring, and instructional materials. This funding is critical for ensuring access to education, particularly through programs like the Alternative Learning System and enhancing educational facilities (Huang *et al.,* 2022).

The Philippines has established policies and frameworks in science education to enhance scientific literacy and inquiry among students. The Science Framework for Philippine Basic Education, developed by the Department of Science and Technology (DOST) through the Science Education Institute (SEI), outlines principles that emphasize depth, relevance, and integrating science with culture and technology. These guiding principles include (1) science is for everyone; (2) science is both content and process; (3) school science should emphasize depth rather than breadth, coherence rather than fragmentation, and use of evidence in constructing explanation; (4) school science should be relevant and useful; (5) school science should nurture interest in learning; (6) school science should demonstrate a commit[1]ment to the development of a culture of science; (7) school science should promote the strong link between science and technology, including Indigenous technology; and (8) school science should recognize that science and technology reflect, influence, and shape our culture. Additionally, the Department of Education's Policy Guidelines on the K to 12 Basic Education Program further supports these objectives by offering specialized programs like the Special Science Elementary School (SSES) and Science, Technology, and Engineering (STE) tracks. These programs cater to students' diverse interests and prepare them for advanced studies and careers in science and technology (Huang *et al.,* 2022).

This focus on science education aligns with global trends that have shifted from merely imparting scientific knowledge to fostering a deeper understanding of the principles underlying scientific inquiry (Ugwu *et al.,* 2015). This shift is increasingly recognized for its broader cognitive benefits, particularly in enhancing problem-solving skills that are applicable across various life contexts (Lakvich, 2021). The COVID-19 pandemic has further underscored the importance of public scientific literacy, highlighting the need for educational approaches that build trust in scientific consensus (Alberts, 2022). The K to 12 Science Curriculum in the Philippines is designed to develop critical thinking and decision-making skills, and it is learner-centered, inquiry-based, and integrates digital resources like DOST Starbooks and DepEd's Learning Resources Management and Development System (LRMDS) to enhance the teaching and learning experience, especially during challenges like the pandemic.

Modern science education, emphasizing inquiry-based instruction, allows students to lead investigations and engage in active learning, significantly improving their understanding and engagement in science (Minner *et al.,* 2010). Science Investigatory Projects (SIPs) are a key platform for this objective, promoting independence and essential skills such as creativity and critical thinking (Ramnarain, 2020). With students at the center of the learning process, SIPs help them deepen their understanding of scientific concepts and prepare them for future scientific endeavors. Globally and in the Philippines, scientific inquiry is increasingly recognized as a fundamental curriculum objective, with frameworks advocating for activities that involve formulating valid questions, conducting investigations, analyzing data, and drawing informed conclusions (Crawford, 2014).

Science research has been integrated into the basic education curriculum in the Philippines. At the Junior High School level, an elective in the Special Science Curriculum (SSC) and STE programs provides a focus on research, while at the Senior High School level, the subject is embedded within the Inquiries, Investigations, and Immersion (3 Is) framework of the Science, Technology, Engineering, and Mathematics (STEM) strand. Incorporating SIPs as a project-based learning strategy within these curricula cultivates curiosity and inquisitiveness, enabling students to make meaningful contributions to their communities while enhancing their scientific understanding (Manalo, 2021).

Students who engage in SIPs become problem-solvers and critical thinkers by immersing themselves in problem-based tasks, authentic learning activities, and inquiry-based investigations. This approach nurtures their curiosity and empowers them to translate their inquisitiveness into actionable ideas, formulating hypotheses, conducting experiments, and verifying outcomes (Sambeka *et al.,* 2017). Additionally, participating in SIPs enhances students' self-efficacy and develops 21st-century skills such as collaboration, problem-solving, and critical thinking (Gomez, 2013).

With this, the present study aimed to identify the research experiences of STEM learners in writing their Science Investigatory Projects (SIPs) as a requirement under the Philippines' Special Science Curriculum in Senior High School. It also sought to determine their perceived support in integrating these experiences and skills into STEM Research Instruction and Curriculum.

METHOD

Research Design

This study aimed to identify the writing experiences of STEM learners in the teaching of Science Investigatory Projects (SIP) and determine the level at which they perceived these experiences ought to be integrated into STEM Research Instruction. To do this, the researcher used a descriptive design. A descriptive design provides the present status of attributes as manifested by the participants. Insert a content analysis of the outputs here.

Instrumentation

The writing experiences are packaged as a survey questionnaire, which was adopted from the Task-based Areas of the 4AA Model developed by Camara & Tubera (2022). The survey questionnaire was found valid by research teachers. After being approved by respective school officials and/or authorities, it was administered in February 2024 during a training workshop on the Proj. STARTFirst. The lead data collector explained the survey questionnaire to them during the training workshop. Further, in April 2024, the participants were asked to submit their manuscripts (i.e., science investigatory projects). On May 2024, the manuscripts were submitted to three science evaluators for review.

Population

The survey was administered face-to-face among 10th graders enrolled under the Special Science Curriculum in a performing science high school in Pangasinan and is recognized by the Philippines' Department of Education (DepEd). Fifty-four (54) of the target respondents answered (Response Rate: 65.85%). The number of respondents, 54, is the equivalent sample size for an 82-population population with an 8% margin of error for a 95% confidence level. Of the 54 participants, 61.1% did not know about publishing scientific investigatory projects (SIPs). However, all of them 100% wanted to have their SIPs published in the form of a journal article, and 96.2% claimed they had at least seven score in a 10-point scoring system when asked the level of the significance of their role in conducting their SIPs. These attributes were necessary to provide an understanding on the findings.

Data Analysis

The data analyzed in the study included the responses in the survey questionnaire which were collected, tabulated, encoded, and analyzed using SPSS v. 21. Copy of the processed data could be requested from jcamara.lingayen@psu.edu.ph.

RESULTS AND DISCUSSIONS

Curricular Experiences and Level of Support to Integrate in a Research Subject

The respondents were given a set of skills necessary in writing an IMRAD for their science investigatory projects and were asked whether they have experience in performing these skills in their other subjects. Further, they were asked on the level that they think these experiences could be formally integrated in the Special Science Research Curriculum. Results are reported in Table 1 in terms of frequencies, percentages, and means with interpretation.

Table 1. Level to Integrate Research Experiences of Learners in STEM Research Instruction

No	Skill Sets as Experiences *(Camara & Tubera, 2022)*	With Experience		Level of Support to Integrate					
		Y	N	4	3	2	1	WM	DE
1	I searched through the internet the related studies in a research topic.	54 (100%)	0	54	0	0	0	4.00	VH
2	When I have collected raw data, I converted this into a figure.	54 (100%)	0	46	7	0	1	3.81	VH
3	When I have collected raw data, I converted these data into paragraph form or textual form.	54 (100%)	0	48	5	1	0	3.87	VH
4	I wrote an Abstract in my paper.	52 (96.3%)	2 (3.7%)	54	0	0	0	4.00	VH
5	Given a research data, I wrote a possible recommendation of a finding or result.	51 (94.4%)	3 (5.6%)	46	7	1	0	3.83	VH
6	I wrote a possible implication of a finding or result in a paper.	51 (94.4%)	3 (5.6%)	46	8	0	0	3.85	VH

No	Skill Sets as Experiences *(Camara & Tubera, 2022)*	With Experience		Level of Support to Integrate					
		Y	N	4	3	2	1	WM	DE
7	I wrote keywords in the abstract of my research paper.	51 (94.4%)	3 (5.6%)	48	5	1	0	3.87	VH
8	I wrote in the paper a possible conclusion of a finding or result.	50 (92.6%)	4 (7.4%)	54	0	0	0	4.00	VH
9	I wrote the list of references I consulted in my research.	50 (92.6%)	4 (7.4%)	50	3	0	1	3.89	VH
10	Given a research data, I incorporated in my paper the findings of other researchers.	49 (90.7%)	5 (9.3%)	45	9	0	0	3.30	VH
11	When I have collected raw data, I converted these into a tabular form.	44 (81.5%)	10 (18.5%)	44	9	0	1	3.78	VH
	Average Weighted Mean	*50*	*34*	*535*	*53*	*3*	*3*	***3.84***	***VH***

Adopted and utilized with permission from Camara & Tubera (2022). Legend: Very High, VH = 3.25 – 4.00; High, H = 2.51 – 3.25; Low, L = 1.76 – 2.50; Very Low, VL = 1.00 – 1.75

Table 1 shows that all respondents (100%) have curricular experience searching for related studies on the internet for their science investigatory projects and converting raw data into figures or textual forms. Additionally, the table reveals that most respondents have experience with all other skill sets assessed in the study, with "converting raw data into tabular form" having the fewest respondents with experience. The respondents acquired these experiences during their 7th to 10th grade years as part of the Special Science Class curriculum.

Additionally, participants generally reported a very high level of integration (WM=3.84) for these skill sets in the Special Science Class research curricula. The table illustrates the frequency of participants who rated the integration level of each skill. Out of 11 skills, three were rated at a 100% Very High level of integration: searching related literature and studies, writing an abstract, and drafting a conclusion from findings. Furthermore, the table highlights the diversity of participant responses concerning skills such as converting data into figures, paragraphs, and tables and writing keywords, implications, recommendations, references, and corroborations. Despite this variation, each skill was considered highly important for integrating into research classes. Among these skills, "searching related studies on the internet" was experienced by 100% of participants in their previous subjects and was rated at the highest score of '4' on the Likert scale for its integration variable.

Table 2. List of Scientific Investigatory Projects submitted as Proj. WB4 Outputs

No	**Title of Submitted Science Investigatory Projects**	Researchers
1	Assessing the Adsorption Potential of Coconut *(Cocos nucifer* L.) Shell Biochar Composites for the Remediation of Algae-Infested H_2O	CMME, RHAI
2	Exploring the Potential of Malabar Spinach *(Basella alba)* as a Natural Biofilter for Rainwater Purification	*

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No	Title of Submitted Science Investigatory Projects	Researchers
3	Development and Assessment of Lantana *(Lantana camara)* Flower Extract as a Mosquito-Killing Spray	EB
4	Lubigan *(Acorus calamus* L.) as a Hypoglycemic Agent for Diabetic-Induced Winstar Albino Rats	EGCDS NCL
5	The Effectiveness of Latundan *(Musa acuminata x M. balbisiana)* Banana Peel as an Alternative Ingredient for Deodorant	*
6	Bio-Burner: Alcohol Burner Powered by Cogon Grass *(Imperata cylindrica)* as a Biomass Fuel and Alternative Fuel Source	*
7	The Hypolipidemic Property of Black Beans *(Phaseolus vulgaris)* Extract Tested among Wistar Albino Rats	SJB
8	Nutritional Profiling and Sensory Evaluation of Electrolyte-Enriched Coconut *(Cocos nucifera* L.) Water-based Sports Gel: Optimizing Performance and Palatability	KAL
9	Shrimp *(Penaeus vannamei)* Shells and Oyster *(Crassostrea iredalei)* Shells as an Alternative Battery Electrolyte	YSKM
10	Exploring the Potential of Guava *(Psidium guajava)* Fruit Extract Gelatin as a Withdrawal Therapy for Nicotine Addiction	JAA
11	Sea Grapes *(Caulerpa lentillifera):* A Potential Nutritious Salt Alternative for Enchanced Health and Palatability	EMP
12	Shredded Plastic Seawall: Production and Physical Examination of Sea Wall Made from Shredded Disposable Plastics	*
13	Dried Bamboo Shoots as a Potential Ingredient for Polvoron	*
14	Talong *(Solanum melongena)* Extract: A Nephroprotective Agent Against Gentamicin-Induced Nephrotoxicity in Sprague Dawley Rats	SSES HCM JFHR
15	Enhancing Supplementary Feeds to Chickens *(Gallus gallus domesticus):* The Potential of Carabao Grass *(Paspalum conjugatum)* and Banana Stalk *(Musa acuminata)*	*
16	Exploring the Potential of Using Tawa-Tawa *(Euphorbia hirta)* Herbal Gummy for Effective Flu Symptoms Alleviation	FR
17	Utilizing Mango Peels *(Mangifera indica)* as an Innovative Ingredient in Cavatelli Pasta Production	JV HKD BLV

*Note: *opted not to indicate the name in the raw draft when sent for peer review*

Table 2 displays the list of science investigatory projects submitted by the cohort of participants as an initial output of the Proj. Write-By-Four. These manuscripts reflect the STEM learners' curriculum experiences and, therefore, are a fit source of observable strengths and weaknesses in writing. Each manuscript is subjected to a plagiarism check, and the results generally indicate they are not written through artificial intelligence (AI).

The list of scientific investigatory projects showcases a diverse range of innovative research focused on utilizing natural and readily available resources to address environmental, health, and sustainability challenges. For instance, several projects explore the potential of various plants and organic materials for environmental remediation and health benefits. The projects include assessing the adsorption potential of coconut shell biochar composites for water remediation, utilizing Malabar spinach as a natural biofilter for rainwater purification, and testing the effectiveness of lantana flower extract as a mosquito-killing spray. Other research highlights the hypoglycemic properties of Lubigan for diabetes treatment, the hypolipidemic effects of black beans on cholesterol levels, and the nephroprotective potential of talong extract against kidney toxicity.

Additionally, the projects investigate innovatively using agricultural waste and natural products, such as developing alternative deodorants from banana peels, creating biomass fuel from cogon grass, and exploring the nutritional value of electrolyte-enriched coconut water-based sports gel. Some studies also focus on alternative energy sources and materials, including shrimp and oyster shells as battery electrolytes and shredded plastic for seawall construction. Other unique projects involve exploring the culinary applications of dried bamboo shoots in polvoron production, utilizing mango peels in pasta production, and the potential of guava fruit extract gelatin as a therapy for nicotine addiction. This diverse collection of projects strongly emphasizes sustainability, health, and the practical application of natural resources.

Evidence of Integration in WRITE-BY-FOUR Outputs: A Triangulation

Table 3. Percentage of Learners with Curriculum Experiences and the Level of Evidence that

No	Skill Sets as Experiences	Percentage of		Level of Evidence					
		N	Y	4	3	2	1	WM	DE
1	I searched through the internet the related studies in a research topic.	54 (100%)	0	54	0	0	0	4.00	VH
2	When I have collected raw data, I converted this into a figure.	54 (100%)	0	46	7	0	1	3.81	VH
3	When I have collected raw data, I converted these data into paragraph form or textual form.	54 (100%)	0	48	5	1	0	3.87	VH
4	I wrote an Abstract in my paper.	52 (96.3%)	2 (3.7%)	54	0	0	0	4.00	VH
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7	I wrote keywords in the abstract of my research paper.	51 (94.4%)	3 (5.6%)	48	5	1	0	3.87	VH
8	I wrote in the paper a possible conclusion of a finding or result.	50 (92.6%)	4 (7.4%)	54	0	0	0	4.00	VH
9	I wrote the list of references I consulted in my research.	50 (92.6%)	4 (7.4%)	50	3	0	1	3.89	VH

No	Skill Sets as Experiences	Percentage of		Level of Evidence					
		N	Y	4	3	2	1	WM	DE
10	Given a research data, I incorporated other researchers' findings in my paper.	49 (90.7%)	5 (9.3%)	45	9	0	0	3.30	VH
11	When I have collected raw data, I converted these into a tabular form.	44 (81.5%)	10 (18.5%)	44	9	0	1	3.78	VH
	Average Weighted Mean	*50*	*34*	*535*	*53*	*3*	*3*	***3.84***	***VH***

Adopted and utilized with permission from Camara & Tubera (2022). Legend: Very High, VH = 3.25 – 4.00; High, H = 2.51 – 3.25; Low, L = 1.76 – 2.50; Very Low, VL = 1.00 – 1.75

Table 3 shows that the findings of this study are significant as they provide localized insights into how the Special Science Curriculum in the Philippines integrates the skills necessary for writing an IMRAD format using science investigatory projects (SIP). Conducting a SIP differs from writing it; thus, research teachers need to understand how beginning researchers experience the essential skills in scientific writing. This understanding will enable teachers to adjust their instruction and enhance their curriculum. The study reveals that 81.5% (n=44) of the respondents have experienced 100% of the assessed skills, indicating that beginning researchers in the K to 12 Basic Education Curriculum (BEC) are well-prepared for science research writing.

CONCLUSION

The experiences of STEM learners in writing offer valuable insights that instructional designers can use to tailor differentiated instruction and improve the specialized curriculum for science learning. The list of science investigatory projects The researcher believes that students with hands-on research experience can reliably indicate if these experiences should be included in a formal high school research subject.

SUGGESTIONS

With these findings, the researcher suggests the following: (1) locate the writing skills in the curriculum of Special Science Class, and (2) identify the outputs required from the students to understand how they have had an experience in each of this skill.

LIMITATIONS

Due to budget constraints, data collection was conducted during a training workshop for STEM learners at a school in Binalonan, Pangasinan, which included two sections from the Special Science Class. As a result, the data presented here may differ from those obtained from other types of schools (small, medium, large, mega) and other special interest programs (STEM vs. non-STEM). To address this, the research teacher facilitated data collection, and an education program supervisor from the Philippines' Department of Education was requested onsite to monitor both the training workshop and survey administration. It should be noted, however, that the school is one of the top-performing high schools in the country with a special science class, boasting division, regional, national, and international achievements in research.

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