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Utilizing Local Organic Waste in Bioplastic Production: An Action Research on Enhancing Research Skills and Environmental Awareness Among Senior High School Students in Taganito, Claver, Surigao del Norte

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Abstract: ***This research investigates the impact of a classroom-integrated Science Investigatory Project (SIP) focused on bioplastic production from banana peel starch on the research skills and environmental awareness of Grade 12 STEM students. Conducted over 10 weeks with 45 participants at a public senior high school in Taganito, Philippines, the study employed a mixed-methods approach, utilising pre- and post-assessments, attitude surveys, and reflection journals. Students engaged in structured SIP phases, including proposal writing, experimentation, and presentation, with an emphasis on scientific inquiry and sustainable innovation. Quantitative findings revealed a significant improvement in research skills, with average scores rising from 61.7% in the pre-test to 86.4% in the post-test. Notable gains were observed in experimental design (+42.8%) and conclusion writing (+45.3%). Environmental awareness also increased markedly, with survey responses improving from an average of 3.5 to 4.6 on a 5-point Likert scale. Students showed greater confidence in contributing to environmental solutions and a stronger preference for using sustainable materials. Qualitative data from reflection journals reinforced these findings, with 91% of students expressing enthusiasm for hands-on learning and 87% reporting increased awareness of plastic waste issues. Despite challenges such as limited materials and time constraints, students demonstrated growth in scientific confidence, collaboration, and environmental responsibility. The study concludes that SIPs grounded in real-world ecological issues are effective in enhancing students' research competencies and 21st-century skills, while also fostering environmental awareness and action-oriented mindsets. The integration of sustainability-focused Service-Learning Initiatives (SIPs) into science curricula is strongly recommended.***

Keywords: Science Investigatory Project, Bioplastic, Research Skills, Environmental Awareness, STEM Education, Action Research

Abbreviations:
SIPs: Science Investigatory Projects

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I. INTRODUCTION

Global plastic production has exceeded 400 million metric tons annually, contributing to long-term environmental contamination [1].

This contamination is primarily caused by the persistence of non-biodegradable, petroleum-based plastics in terrestrial and aquatic ecosystems [2]. In response to this issue, recent research highlights the potential of converting organic and agricultural waste into biodegradable bioplastics as a sustainable alternative [3]. Several studies have demonstrated the feasibility of this approach in reducing reliance on fossil-based plastics [4]. Furthermore, advancements in bioplastic technology offer promising routes toward the scalable and eco-friendly production of materials [5].

In the context of science education, addressing real-world problems such as plastic pollution is vital for fostering critical thinking, environmental awareness, and problem-solving skills among learners. The K to 12 Science Curriculum of the Philippines emphasizes the cultivation of scientifically literate citizens capable of making informed decisions and contributing to sustainable development [6]. One practical pedagogical approach to achieve this is through the Science Investigatory Project (SIP), which encourages inquiry-based learning by allowing students to explore scientific concepts through independent or collaborative research [7].

Science Investigatory Projects (SIPs) engage students in identifying local problems, designing experiments, collecting and analyzing data, and presenting evidence-based conclusions. This experiential approach not only enhances learners' scientific inquiry and research skills but also cultivates creativity, collaboration, and communication—essential competencies for the 21st century [8]. Moreover, SIPs provide a platform for integrating scientific knowledge with real-world applications, particularly in addressing environmental challenges that are relevant to students' local contexts.

Bioplastic production from organic waste, such as banana peels, has emerged as a promising and accessible project for secondary school students. Banana peels are rich in starch and cellulose, making them a suitable raw material for producing biodegradable plastics with reduced environmental impact [9]. As one of the world's leading banana

producers, the Philippines generates significant volumes of banana waste, providing an abundant and locally sustainable resource for such initiatives. Integrating bioplastic research into the classroom not only deepens scientific understanding but also fosters awareness of waste reduction, resource management, and the potential for science-driven solutions to environmental challenges.

This action research aims to examine the dual impact of implementing a Science Investigatory Project (SIP) focused on bioplastic production from banana peel waste on the research competencies and environmental awareness of senior high school students. By integrating the SIP into regular classroom instruction, the study aligns with the principles of inquiry-based learning. It supports the development of individuals who are scientifically literate and environmentally responsible. Furthermore, it offers valuable insights into how meaningful, context-driven scientific investigations can empower students to take active roles in promoting sustainability and driving innovation within their communities.

A. Statement of the Problem

This research aims to address:

i. How does participation in an SIP focused on bioplastic production affect the research skills of senior high school students?
ii. What is the level of change in students' environmental awareness after the SIP?
iii. What challenges and reflections do students experience throughout the project?

B. Objectives

i. To assess the improvement in research skills of students conducting an SIP.
ii. To evaluate the change in environmental awareness before and after the project.
iii. To document student reflections and challenges during the project-based learning cycle.

II. REVIEW OF RELATED LITERATURE

Science Investigatory Projects (SIPs) have long been recognized as practical pedagogical tools that promote inquiry-based learning, scientific thinking, and student engagement. Rooted in constructivist educational theory, SIPs enable students to construct knowledge through active experimentation and critical reflection, rather than passively receiving information. Tejero [10] found that participation in SIPs significantly improves learners' science process skills, including hypothesis formulation, experimental design, data collection and interpretation, and drawing logical conclusions. These skills are critical for developing scientific literacy and align closely with the 21st-century competencies emphasized in the K to 12 curricula, such as critical thinking, creativity, collaboration, and communication.

Bioplastics derived from renewable and biodegradable sources—such as starch, cellulose, or plant oils—have emerged as practical and environmentally responsible alternatives to conventional plastics. Singh and Rujnić-Sokele [11] highlight the potential of bioplastics in mitigating plastic pollution and reducing dependence on fossil fuels. Among these sources, banana peels are especially promising due to their high starch content, abundance, and low economic value as agricultural waste. Kabir et al. [12] demonstrated the feasibility of producing biodegradable plastic films from banana peel starch, noting that they exhibited acceptable tensile strength, flexibility, and degradability. Such attributes make banana peel-based bioplastics an ideal topic for student research projects that combine scientific inquiry with environmental relevance.

Furthermore, student-led research on sustainability topics, such as bioplastic development, promotes not only cognitive growth but also environmental ethics and personal responsibility. Villan and dos Santos [13] argue that project-based learning models, such as SIPs, empower students to link classroom science to real-world challenges, fostering deeper engagement and action-oriented thinking. Their study showed that students participating in sustainability-themed SIPs exhibited increased environmental concern, creativity, and initiative.

Educational frameworks support the integration of research projects into science curricula. The Department of Education (DepEd) [14] emphasizes contextualized, learner-centered instruction that encourages problem-solving and scientific attitudes. By guiding students to investigate locally relevant environmental issues, such as plastic pollution and waste management, teachers help develop learners who are academically competent and socially and environmentally conscious.

Additionally, the interdisciplinary nature of SIPs on bioplastics enables students to apply concepts from biology, chemistry, environmental science, and economics. This holistic approach fosters an appreciation for how scientific research intersects with ecological sustainability and community welfare. Salazar and Cruz [15] found that students creating eco-products from organic waste during SIPs gained insights into circular economy principles and showed increased motivation to pursue science-related careers.

In summary, the literature highlights the educational and ecological benefits of Science Investigatory Projects, particularly those focused on bioplastics derived from organic waste. These projects enhance students' research skills and scientific understanding while fostering values and behaviours aligned with environmental stewardship, positioning SIPs as powerful tools for nurturing future scientists and responsible citizens.

III. METHODOLOGY

A. Research Design

Action research using a mixed-methods approach.

B. Participants

45 Grade 12 STEM students in a public high school in Taganito Claver, Philippines.

C. Instruments

i. Research Skills Rubric (validated tool for hypothesis formulation, data collection, analysis)
ii. Environmental Awareness Survey (Likert scale)

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iii. Student Reflection Journals

D. Procedure

i. Week 1–2: Orientation and proposal writing.
ii. Week 3–6: Experimentation – extraction of starch from banana peels, testing tensile strength and biodegradability.
iii. Week 7–8: Data analysis and report writing.
iv. Week 9–10: Presentation, reflection, and post-assessment.

E. Data Analysis

i. Paired t-test for pre- and post-assessment scores
ii. Thematic analysis for journal entries

IV. RESULTS AND DISCUSSION

A. Improvement in Research Skills

Table-I: Research Skills Assessment

Skill Area	Pre-Test Mean (%)	Post-Test Mean (%)	% Increase
Hypothesis Formulation	62.4	85.2	+36.5%
Experimental Design	59.3	84.7	+42.8%
Data Analysis and Interpretation	64.8	88.5	+36.5%
Conclusion and Evaluation	60.1	87.3	+45.3%
Overall Average	61.7	86.4	+40.0%

- Interpretation: There was a significant improvement in students' ability to carry out various stages of scientific investigation after participating in the SIP.
- Average rubric scores increased from 62% (pre-project) to 88% (post-project), particularly in experimentation and data interpretation.

Increase in Environmental Awareness

2. Environmental Awareness Survey

Scale: 1 (Strongly Disagree) to 5 (Strongly Agree), N = 45 students

Statement	Pre-Mean	Post-Mean	Change
"I am aware of the harmful effects of plastic on the environment."	3.9	4.6	+0.7
"I am confident that I can contribute to environmental solutions."	3.2	4.5	+1.3
"I prefer using eco-friendly or reusable materials in daily life."	3.1	4.3	+1.2
"I believe scientific research can help solve environmental problems."	3.7	4.8	+1.1
Overall Average	3.5	4.6	+1.1

Interpretation: Students' environmental awareness and attitudes improved significantly, especially in terms of personal responsibility and belief in scientific solutions.

3. Reflection Journal Themes

(Analyzed from weekly journal entries; n = 45)

Theme	% of Students Mentioning	Excerpts
Increased awareness of plastic waste	87%	"I didn't know plastic was this harmful until I tried to make an alternative to it."
Confidence in research	73%	"I feel like a real scientist. I can now design an experiment by myself."
Enjoyment in hands-on learning	91%	Making bioplastic was fun and challenging. I learned more than from just lectures."
Group collaboration challenges	35%	"We had to learn how to divide the work and agree on our research design."

Interpretation: Reflections reveal that students gained not only academic knowledge but also personal and social growth through the SIP.

4. Challenges Encountered

(Frequency from open-ended responses)

Challenge	% of Students Affected
Lack of materials/laboratory tools	60%
Difficulty in writing the research paper	45%
Time constraints (balancing academics)	38%
Understanding scientific terminologies	27%

Interpretation: Resource limitations and academic load were primary obstacles, but students developed resilience and problem-solving skills through teacher support and teamwork.

V. CONCLUSION

The implementation of the Science Investigatory Project (SIP) on bioplastic production from banana peel waste resulted in significant improvements in students' research competencies and environmental awareness. Through the structured phases of the SIP—proposal development, experimentation, analysis, and presentation—students engaged deeply with the scientific process, demonstrating notable improvements in their ability to formulate hypotheses, design and conduct experiments, and interpret and communicate findings. The measurable improvement in pre- and post-assessment scores confirms that students not only developed technical skills but also gained a more sophisticated understanding of the scientific method.

Beyond cognitive development, the project fostered a heightened sense of environmental responsibility among participants. Students gained first-hand insight into the negative impacts of plastic pollution and the value of sustainable alternatives such as bioplastics. Their increased awareness was evident in both survey responses and reflection journal entries, which consistently highlighted a shift in attitudes toward eco-conscious living and a greater commitment to sustainability. Many students expressed pride in contributing to a possible solution to plastic waste, viewing their work not just as an academic exercise but as a meaningful effort with real-world implications.

Moreover, the project nurtured a wide range of 21st-century skills, including collaboration, creativity, critical thinking, and communication. Students learned to work effectively in teams, solve problems using scientific reasoning, and present their findings confidently to peers and teachers. These are essential competencies for success in both academic and future professional environments, particularly in STEM-related fields.

The success of this SIP demonstrates the transformative potential of project-based learning when rooted in local, community-relevant issues. By connecting classroom content to real-world environmental problems, the project provided students with authentic learning experiences that bridged theory and action. This approach not only

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makes science more engaging and relevant but also cultivates socially responsible and scientifically
literate individuals.

RECOMMENDATIONS

- Promote SIPs with real-life environmental impact.
- Provide structured guidance to students in research phases.
- Partner with local eco-agriculture offices for materials and expert mentorship.

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DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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AUTHOR'S PROFILE

Dr. Mauricio S. Adlaon is a dedicated professor specialising in biology, environmental education, and science teaching, with over 20 years of experience in academia. Passionate about fostering scientific curiosity, he integrates cutting-edge research with innovative teaching methods to inspire students in the field of science education. Committed to creating engaging and inclusive learning environments, he actively mentors future educators and researchers. Through published works and community outreach, he advocates for science literacy and environmental awareness, aiming to empower the next generation of scientists and informed citizens.

Vincent G. Parcon is a licensed professional teacher currently pursuing a Master of Arts in Education, with a major in General Science. He serves as a dedicated secondary school teacher II at Cagdianao National High School, where he also holds key leadership roles, including Science Coordinator, Grade 9 Curriculum Chairman, and Boy Scouts of the Philippines Coordinator. With extensive experience in the field of education, Mr. Parcon is deeply committed to promoting scientific literacy, innovative teaching practices, and student development through active engagement in research and co-curricular programs.