Enhancing Student Performance in Science Learning Through The Implementation of Traditional Natural Pesticides Project

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Abstract. This study aimed to assess the effectiveness of integrating a project focused on traditional natural pesticides into science learning and its impact on student performance. The investigation adopted a pre-experimental research design, utilizing a pretest-posttest non-control group approach. A total of 18 junior high school students participated in the science project, which centered on exploring the utilization of traditional natural pesticides. To evaluate student performance in the project, multiple assessment methods, including performance evaluations and portfolio analysis, were employed. Subsequently, the collected data underwent analysis using the N-gain method, a commonly applied statistical tool to measure student learning gains. The outcomes of the study exhibited consistent improvements in student performance across two consecutive projects. The average performance scores recorded were 61.6 and 78.2, indicating an observable positive trend in student achievement. Although the N-gain values for student performance in the project demonstrated modest increases, registering scores of 0.269, it was evident that the implementation of the traditional natural pesticides project contributed to the amelioration of student performance on carried out the project. Overall, these findings underscore the potential educational benefits derived from integrating real-world, practical projects like traditional natural pesticides into science learning curricula. Such experiential and hands-on learning approaches can foster engagement and deep understanding, leading to meaningful enhancements in student performance and learning outcomes. By exploring and adopting innovative teaching methodologies, educators can effectively cultivate a more impactful and unique educational experience for students.

Keywords: Student Performance, Science Learning, Natural Pesticides.

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1 Introduction

Indonesia was an archipelagic nation brimming with multicultural diversity, a richness that demanded preservation through the upholding of the noble values intrinsic to the Indonesian identity. Back then, one of the primary avenues for safeguarding this diversity lay within the realm of education. It served as the cornerstone of national development, aiming to cultivate students' potential by imparting values and local cultural wisdom. This approach aimed to equip students with the knowledge and skills needed to carry forward and enrich the nation's cultural heritage. Education in the past introduced, explored, and nurtured various cultural elements, molding them into a cohesive cultural fabric that evolved alongside the changing times. The capacity to inherit and shape culture was instilled in students through a foundation of knowledge, intellect, attitudes, and social competencies, allowing them to actively contribute as individuals, community members, citizens, and global citizens (1).

The introduction of traditional knowledge to the younger generation can be facilitated through the educational processes in schools, higher education institutions, and other non-formal education settings. According to (2), local knowledge-based learning represents a conscious and planned effort involving the exploration and utilization of the potentials inherent to the local context in a prudent manner, aimed at creating conducive learning environments and facilitating learning processes wherein learners actively develop their potentials to acquire skills, knowledge, and attitudes necessary for contributing to the nation-building efforts. This perspective aligns with the views of (3), who posit that integrated learning approaches incorporating local potentials are expected to foster regional development and enhance the creativity and character of students. Learning about practices that are already ingrained within the culture or community of the learners can engender enjoyable learning experiences. Additionally, traditional knowledge is crucial for maintaining students' proximity to their schools and for encouraging teachers to engage with the majority of learners (4,5).

In schools, education encompasses a diverse array of subjects aligned with the established curriculum, including the study of science. Science education is designed to foster comprehension of factual knowledge, enhance problem-solving abilities, cultivate proficiency in laboratory techniques, and promote scientific thinking in daily life (6–9). However, in practice, the emphasis on scientific principles within science often leads students to overlook its integration with the broader context of environment, technology, and society, hindering their holistic understanding. Recognizing the significance of culturally oriented learning underscores its pivotal role in education (6).

In the realm of science education within schools, it is imperative to enact pedagogical strategies conducive to fostering Sustainable Development Education. This entails the adoption of a comprehensive approach integrating both theoretical and practical dimensions, along with the incorporation of diverse perspectives to ensure contextual relevance. Educational interventions should elucidate the dynamics of change grounded in historical experiences, current realities, and future projections, thereby equipping students with the requisite adaptability for forthcoming challenges. Moreover, pedagogical methodologies must undergo continual refinement to remain responsive to societal dynamics, educational system evolution, and technological advancements, as underscored by extant literature (10–12). Furthermore, educational delivery mechanisms should be characterized by reliability, encompassing aspects such as competency-based learning, experiential activities, empirical discoveries, and rigorous assessment protocols (12)

Exploring topics related to natural materials provides an ideal platform for project-based learning, as highlighted by (13). Engaging in investigative and exploratory activities with natural materials holds the promise of enhancing process skills, as indicated by research conducted by (14), and fostering critical thinking, as demonstrated by (15). Nevertheless, there remains a gap in development research concerning the utilization and exploration of natural materials in enhancing students' scientific performance. It is imperative to conduct further studies to validate and design teaching materials, as well as to evaluate the effectiveness and reliability of implementing such learning approaches on students' scientific performance. The way to bring it is through learning traditional natural pesticides project. This research study aimed to assess the effectiveness of integrating a project focused on traditional natural pesticides into science learning and its impact on student performance.

2 Methods

The investigation employed a pre-experimental research design, employing a pretest-posttest non-control group methodology. Eighteen junior high school students were engaged in a science project focused on investigating the application of traditional natural pesticides. The assessment of student performance throughout the project involved the utilization of various evaluation techniques, including performance assessments and portfolio analyses. Following data collection, statistical analysis was conducted using the N-gain method, a widely recognized statistical approach for quantifying student learning progress. The results of the study revealed consistent enhancements in student performance across successive project iterations. Learning process that attempt in learning is shown in figure 1. The learning takes place in April to May 2023. The activities carried out consist of three themes as presented in Tabel 1.

Table 1. Laboratory activities theme.

Code	Theme
Project 1 (P1)	Herbicides
Project 2 (P2)	Pesticides

The pedagogical process spanning P1 and P2 entailed a series of integrated learning activities. These encompassed the phases of Experimenting experience (A), Attempt direction (B), Design and execution of new projects (C), Discussion (D), and final phase is Formative test (E). Indicator items developed to assess student performance in the laboratory as presented in Table 2.

Table 2. Students performance assessment indicators.

Indicator	Activities assessed	
	Observation	Portfolio
Students gather information from a variety of sources.		B
Students make a summary		B
Students set investigative / research variables	A	A, C
Students raise the background of the importance of conducting an investigation/research		B
Students formulate investigation/research objectives		A, B
Students make hypotheses.		A, B
Students select appropriate variables, collect relevant data, and select a form of presentation of results appropriate for a chosen investigative procedure		A, B, C
Students document pictures of observation objects.		C
Students present observations in a chart, graph, or histogram.	D	A, C
Students compile and complete an investigative procedure.	A, C	A, C
Students take measurements according to the measurement scale	A, C	A, C
Students use the appropriate measuring instruments correctly.	A, C	
Students choose laboratory equipment that is in accordance with the task at hand.	A, C	
Students adopt laboratory procedures by minimizing risk.		A, C
Students move materials/materials/equipment using the right way/container	A, C	
Students separate substances based on their form.	A, C	
Students do sample preparation.	A, C	
Students make observations and collect data using the five senses	A, C	A, C
Students recognize objects based on their characteristics.	A, C	A, C
Students identify objects to match with specific references/reading sources.	A, C	A, C
Students identify similarities/differences between objects	A, C	A, C
Students make reasonable generalizations/conclusions based on observations.		A, C
Students use observations to confirm or prove errors/refute existing hypotheses.		A, C
Students distinguish between observations and references/literature sources.		C, D
Students generating idea and conduct investigations related to everyday life.		D
Students formulate the benefits of investigation for the environment and social and promote innovation		B, D
Students present observations in group discussions	D	D

In Formative test, Students complete 10 essay questions related to the activities that have been carried out.

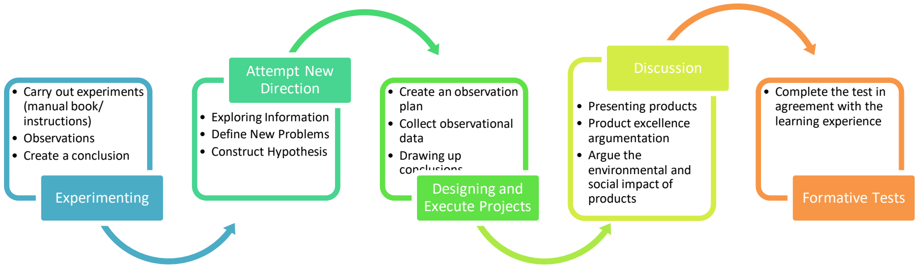

Fig. 1. Scheme of traditional natural pesticides project-oriented learning

Student performance was analyzed using percentage, average, and N-gain techniques. The score and N-gain are interpreted consecutively by category as presented in Table 3 and Table 4.

Table 3. Students performance category.

Score	Category
80.00-100	Excellence
60-79.99	Good
40-59.99	Poor
20-39.99	Fail

Table 4. N-gain category.

N-gain	Category
g>0.7	High
0.3≤g≤0.7	Medium
G<0.3	Low

3 Results and Discussion

In the realm of science education, evaluating student performance involves examining both processes and concepts, reflecting the intricate nature of the field. Chemistry explores numerous complexities surrounding matter and its transformations, alongside observable phenomena (16). Active participation, particularly through hands-on experiences like laboratory work, is crucial for deep comprehension, known as "minds-on" learning (17,18). The ultimate goal of chemistry education is to clarify natural phenomena through systematic inquiry, tailored to students' perspectives and abilities (17,19,20). As a result, assessing students' performance in science education is closely tied to developing their science process skills.

In understanding the natural world, science process skills are indispensable tools for gathering and synthesizing information. These skills not only cultivate a scientific mindset but also nurture creative thinking, which is fundamental to scientific exploration. The emphasis on these skills underscores their crucial role in education, providing students with the means to think scientifically and tackle complex problems (17,20,21). Science process skills are organized into a hierarchical taxonomy, dividing them into elementary, intermediate, and advanced levels. This categorization ensures a structured approach to skill development, gradually exposing students to more intricate cognitive challenges and fostering their ability for nuanced scientific inquiry (22,23).

Figure 2 provides a comprehensive overview of students' performance throughout the science learning sessions through traditional natural pesticides project, covering activities such as experimenting experience, attempt direction, project design, execution, and discussion. The data reveals a significant improvement in students' overall performance across these learning aspects, likely due to their increasing familiarity with the teaching methods utilized throughout their studies. Additionally, students demonstrated more positive attitudes during the practicum sessions, which aligns with previous research indicating that ethnoscience-oriented learning enhances student interest, motivation, and learning outcomes in science education (24–26). This increased interest and motivation are likely influential factors contributing to the observed enhancement in performance (27,28).

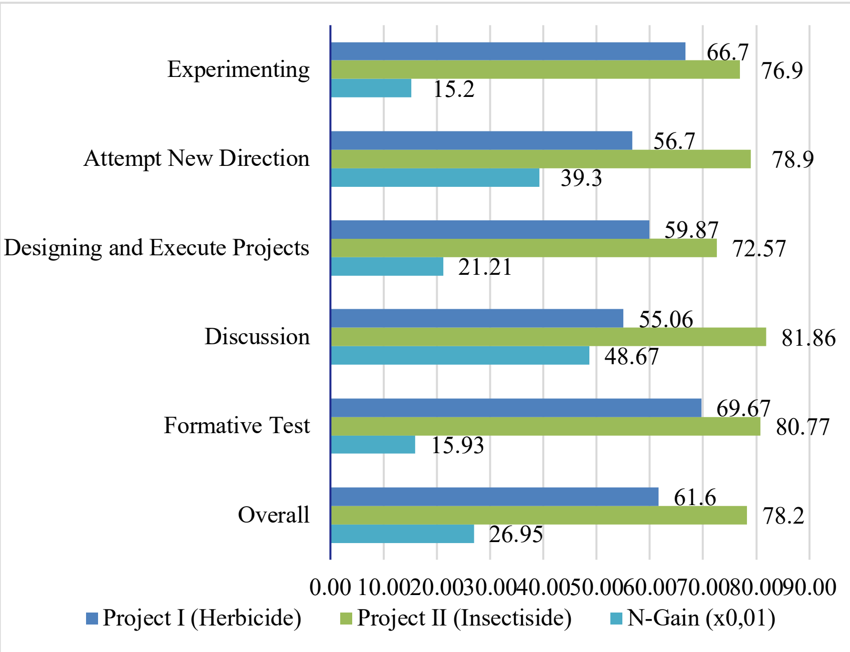

Fig. 2. A figure caption is always placed below

Overall, there is an improvement in students' performance in experimenting, exploring new directions, designing and executing projects, discussing, and taking formative tests, from their initial learning experience to the second one, specifically the insecticide project. The most significant improvement occurs in the discussion activity, with an N-gain value of 0.4867. The performance enhancement in discussions may be attributed to the increasing self-confidence of students as they discuss their experiences in the project. Students' motivation to successfully complete the project is also increasing. Overall, there is an improvement with an N-gain value of 0.2695. Its indicating a transition from good to excellent performance. During this phase, students are responsible for presenting their projects, advocating for their project's excellence, and critically evaluating the environmental and social impacts of their creations. This surge underscores growing confidence among students in presenting their experiment outcomes and reflects a shift towards innovative product outcomes, along with an enhanced ability to explain product development concepts and their broader societal implications. Discussion activities are acknowledged for their potential to boost student motivation and critical thinking skills in science education (29). When supported by investment and inquiry experiences, such discussions have been shown to enhance student motivation and improve their perceptions of science learning (30,31).

On the contrary, an interesting observation arises from the slight decrease in experimenting experience between the initial and subsequent project sessions, with average scores of 66.7 and 76.9, respectively, both falling within the "good" performance range. This decline is attributed to students' initial struggles in devising investigative plans that effectively utilize laboratory equipment and measuring instruments. Despite the second practicum assignment being theoretically less complex, it presented practical challenges as students found it difficult to optimize laboratory resources (32,33). Previous studies have highlighted the positive relationship between active involvement in practical laboratory tasks and increased motivation, as well as improved learning outcomes in science education (34,35).

Furthermore, the findings elucidate the potential for implementation of traditional natural pesticides project as a catalyst for improving science education on a broader scale. As educators and policymakers seek to reform science curricula and teaching methods, the implementation of traditional natural pesticides project offers a compelling model. It showcases how a contextualized and culturally relevant approach can not only enhance student performance but also reignite interest in science among students of diverse backgrounds (36,37). One of the key takeaways from this study is the importance of sustained engagement and continuity in ethnoscience-oriented learning. While the observed performance improvements are significant, it is noteworthy that they register within the "low" category when assessed using the N-gain technique. This implies that there is room for further refinement and optimization of the pedagogical approach.

In conclusion, the integration of ethnoscience-oriented practicum learning, implementation of traditional natural pesticides project represents a transformative paradigm within science education. It’s not only the positive impact on student performance but also emphasize the potential for enhanced attitudes and critical thinking skills. This pedagogical approach aligns with contemporary trends in education that prioritize interdisciplinary and culturally relevant learning experiences. It bridges the gap between traditional knowledge and scientific inquiry, enriching the educational journey for students (38–40).

4 Conclusion

The outcomes of the study exhibited consistent improvements in student performance across two consecutive projects. The average performance scores recorded were 61.6 and 78.2, indicating an observable positive trend in student achievement. Although the N-gain values for student performance in the project demonstrated modest increases, registering scores of 0.269, it was evident that the implementation of the traditional natural pesticides project contributed to the amelioration of student performance on carried out the project. Overall, these findings underscore the potential educational benefits derived from integrating real-world, practical projects like traditional natural pesticides into science learning curricula. Such experiential and hands-on learning approaches can foster engagement and deep understanding, leading to meaningful enhancements in student performance and learning outcomes. By exploring and adopting innovative teaching methodologies, educators can effectively cultivate a more impactful and unique educational experience for their students.

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