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Enhancing Science Learning Through Hands-On Activities: A Study on Student Engagement and Performance

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Abstract

This study examined the influence of hands-on activities on science performance, student engagement, and learning perceptions among Grade 10 students at PaiMA National High School during the academic year 2024–2025. Using a quantitative, one-group pretest-posttest design and purposive sampling, the research reported 30 students with complete achievement assessments and 31 respondents to the engagement questionnaire. Data were gathered through a researcher-developed, content-validated 30-item science achievement test aligned with the Most Essential Learning Competencies and an adapted 20-item student engagement questionnaire. Descriptive statistics summarized achievement and engagement, while a paired-sample t-test evaluated differences between pretest and posttest achievement scores. Mean achievement increased from 11.27 to 23.47, yielding a gain of 12.20 points. The difference was statistically significant, $t(29) = -11.49$, $p < .001$. Students reported high emotional engagement ($M = 4.15$), behavioral engagement ($M = 4.12$), positive learning perceptions ($M = 4.10$), and cognitive engagement ($M = 4.07$). These findings indicate improved science achievement following hands-on instruction and generally favorable engagement. However, the study did not establish a statistical relationship between engagement and achievement, and its single-group design does not support definitive causal conclusions. The study recommends structured experiments, collaborative activities, inquiry-based instruction, and differentiated support for learners. Its small, purposively selected sample and single-school setting limit generalizability. Aligned with Sustainable Development Goal 4, the findings offer classroom-based evidence for improving student-centered science teaching and encourage further studies using comparison groups, larger samples, and longer assessment periods to examine sustained learning outcomes and understand variations in students' experiences across instructional contexts.

Keywords: Academic Performance, Experiential Learning, Grade 10 Students, Hands-On Activities, Science Education, Student Engagement, Student Perceptions

1. Introduction

Hands-on learning allows students to investigate scientific phenomena through direct experience and active participation. Recent research on practical science work highlights the importance of students' enjoyment, learning environments, and engagement in interpreting achievement outcomes (Cheung & Sonkqayi, 2025; Rogers & Fraser, 2023). Recent evidence connects instructional practices, science engagement, and academic achievement. Bibon (2022) examined teachers' instructional practices in relation to Grade 10 science achievement, while Wong et al. (2024) synthesized evidence linking behavioral, affective, and cognitive engagement with academic outcomes. These studies provide a rationale for examining practical classroom activities without assuming that any single strategy independently causes improvement.

Hands-on science learning involves practical investigation, observation, and the application of scientific ideas. Cheung and Sonkqayi (2025) examined how practical work and clarity of instruction relate to science achievement across cognitive domains. Rogers and Fraser (2023) studied the frequency of practical work in relation to middle-school students' learning-environment perceptions and attitudes. Kelkay (2023) also examined practical work in secondary-school biology. Student engagement includes behavioral, emotional, and cognitive dimensions (Fredricks et al., 2004). Wong et al. (2024) reviewed the association between these engagement dimensions and academic achievement. Haw et al. (2022) examined how science laboratory learning environments and motivation predict engagement in science learning. Recent reviews emphasize both the promise and implementation challenges of inquiry-based science education. Dah et al. (2024) systematically reviewed the impacts of open inquiry on science learning, while Jegstad (2024) synthesized inquiry-based chemistry education. These findings support structured practical activities and careful attention to instructional context.

International research continues to examine inquiry and practical work in secondary-school science classrooms. Gericke et al. (2023) systematically reviewed laboratory work in secondary education and identified the importance of teacher guidance, inquiry design, and clearly defined learning goals. These findings provide a directly relevant basis for examining structured hands-on activities among Grade 10 learners. In the Philippine educational context, improving students' science performance requires diverse instructional strategies that support comprehension, participation, and meaningful application of scientific concepts. At PaiMA National High School, the present study focuses on Grade 10 students and examines hands-on learning as an instructional intervention for improving engagement and academic performance. The investigation is limited to one Grade 10 class and selected science topics appropriate for practical activities. It evaluates changes in learning outcomes through pretest and posttest assessments while examining students' engagement and perceptions of hands-on instruction.

The study draws on experiential learning and a multidimensional view of engagement. Kolb (1984) describes learning through concrete experience, reflection, conceptualization, and experimentation. Fredricks et al. (2004) distinguish behavioral, emotional, and cognitive engagement. Recent syntheses have further examined inquiry-based learning and these engagement dimensions (Dah et al., 2024; Wong et al., 2024). Kolb's (1984) experiential learning model provides a conceptual basis for activities in which students investigate phenomena, reflect on observations, interpret concepts, and apply ideas in subsequent tasks. The intervention also requires attention to task structure and instructional support. Recent reviews of inquiry-based science and chemistry education describe varied implementation approaches and outcomes rather than treating minimally guided practical work as universally effective (Jegstad, 2024; Strata et al., 2024). Together, these foundations explain how hands-on instruction may improve students' engagement and academic performance while emphasizing the importance of instructional support.

Although practical work and inquiry have been studied extensively, outcomes may differ across learning contexts and instructional conditions. Cheung and Sonkqayi (2025) examined practical work alongside clarity of instruction, while Dah et al. (2024) synthesized the diverse impacts of open inquiry. These findings motivate context-specific classroom evaluation. Recent literature also examines students' science attitudes, motivation, and learning environments (Haw et al., 2022; Rogers & Fraser, 2023). The present study adds classroom-level evidence from one Grade 10 section, but it does not establish long-term retention or causal effects. Accordingly, this study investigates the effects of hands-on activities on Grade 10 students' science performance and cognitive, behavioral, and emotional engagement. It also examines students' perceptions of experiential learning compared with traditional lecture-based instruction. Through pretest and posttest assessments and engagement measures, the study seeks to provide evidence for improving science teaching practices at PaiMA National High School.

The study primarily aligns with Sustainable Development Goal 4 (Quality Education), which promotes inclusive, equitable, and effective learning opportunities. Hands-on science activities support this goal by encouraging active participation, conceptual understanding, scientific inquiry, and student engagement. By examining instructional strategies that may improve Grade 10 students' academic performance and learning experiences, the research contributes to efforts to strengthen the quality of science education. Its findings may help teachers identify practical approaches that promote meaningful learning and respond to students' different engagement levels.

The study contributes primarily to educational and institutional sustainability by examining an instructional approach that may strengthen student engagement, academic achievement, and science learning experiences. From an educational perspective, hands-on activities encourage active learning, scientific reasoning, and practical application of knowledge. These experiences may support sustained student interest and improve the effectiveness of classroom instruction. From an institutional perspective, the findings may guide teachers and school administrators in refining instructional strategies, developing student-centered learning activities, and incorporating engagement measures into curriculum planning. The study may also serve as a reference for future investigations of experiential learning in other subjects and educational settings. By providing classroom-based evidence on the relationship between hands-on instruction, engagement, and academic performance, the research supports the continuous improvement of science education and the development of effective teaching practices.

2. Material and methods

2.1 Research Design

The study employed a quantitative, one-group pretest-posttest research design to assess changes in students' science achievement following the implementation of hands-on activities, while student engagement, motivation, and perceptions were evaluated descriptively after the intervention. The design involved administering science achievement assessments before and after the intervention to determine changes in academic performance, while a post-intervention questionnaire described students' engagement and learning perceptions.

2.2 Locale of the Study

The study was conducted at PaiMA National High School during the academic year 2024–2025. It focused on one section of Grade 10 students and selected science topics suitable for hands-on learning activities. The investigation was limited to classroom-based instruction and did not account for external factors such as students' prior knowledge and home learning environments.

2.3 Respondents of the Study

The respondents were Grade 10 students enrolled at PaiMA National High School during the academic year 2024–2025. The study examined their science performance, cognitive engagement, behavioral engagement, emotional engagement, and perceptions of hands-on learning. The study reported 30 Grade 10 students who completed both the pretest and posttest science achievement assessments and 31 respondents to the student engagement questionnaire. Accordingly, the analyses were based on the valid responses obtained from each research instrument.

2.4 Sample and Sampling Procedure

Purposive sampling was employed to select Grade 10 students based on the specific objectives and requirements of the study. This nonprobability sampling approach is appropriate for selecting a specific group but limits the generalizability of the findings.

2.5 Research Instrument

The study utilized a researcher-developed, content-validated 30-item multiple-choice science achievement test aligned with the Most Essential Learning Competencies (MELCs) for Grade 10 Science, as prescribed by the Department of Education (2020). The instrument was validated with the assistance of the school's Junior Head Designate and administered before and after the intervention to assess knowledge acquisition and conceptual understanding. Student engagement and motivation were assessed using a 20-item Likert-type questionnaire adapted from the Student Engagement Instrument (SEI) by Appleton et al. (2006). The questionnaire measured cognitive, behavioral, and emotional engagement, alongside academic motivation indicators such as interest, persistence, and perceived value. Responses were rated on a five-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

2.6 Data Gathering Procedure

Data were collected through pretest and posttest science assessments and a student engagement questionnaire. The science achievement test was administered before and after the implementation of hands-on activities to measure changes in students' understanding of selected scientific concepts and skills. The adapted engagement questionnaire was administered after the intervention to assess students' cognitive, behavioral, and emotional engagement. Responses reflected students' interest in science, classroom participation, motivation, and perceptions of their learning experiences. The collected data served as the basis for evaluating changes in science achievement and describing students' engagement and learning perceptions following the instructional intervention.

2.7 Data Analysis Techniques

The collected data were analyzed using descriptive and inferential statistics with Microsoft Office Excel. The mean, standard deviation, and mode were used to summarize students' pretest and posttest performance and engagement scores, describing central tendencies and variations in their responses. A paired-sample t-test was employed to determine whether a statistically significant difference existed between students' pretest and posttest science achievement scores. Student engagement and perceptions were analyzed using descriptive statistics. The paired-sample t-test assessed changes in science achievement, while descriptive statistics summarized students' engagement and perceptions following the instructional intervention.

3. Results and Discussion

3.1 Student Engagement and Perceptions of Hands-On Science Activities

Students demonstrated generally high engagement across the assessed dimensions. Emotional engagement recorded the highest mean ($M = 4.15$, $SD = 0.92$), followed by behavioral engagement ($M = 4.12$, $SD = 0.78$), student perceptions ($M = 4.10$, $SD = 0.85$), and cognitive engagement ($M = 4.07$, $SD = 0.89$). These findings indicate favorable student responses to hands-on science instruction. Dap-og and Orongan (2022) examined science achievement and engagement through computer-assisted instruction, while Wong et al. (2024) identified

behavioral, emotional, and cognitive engagement as important dimensions of learning. Haw et al. (2022) also examined science laboratory environments and motivation as predictors of engagement.

3.1.1 Cognitive Engagement in Hands-On Science Learning

Cognitive engagement recorded a mean of 4.07 (SD = 0.89), with responses ranging from 3.00 to 5.00. Students generally demonstrated cognitive involvement through connecting scientific concepts with real-life experiences and seeking clarification during activities, although engagement varied among learners. The findings align with the broader discussion of engagement and academic achievement by Wong et al. (2024). Dap-og and Orongan (2022) examined cognitive engagement in computer-assisted science instruction, providing a related but distinct instructional context. Differences in cognitive engagement suggest that some learners may require additional instructional support.

3.1.2 Behavioral Engagement in Classroom Science Activities

Behavioral engagement obtained a mean of 4.12 (SD = 0.78), with scores ranging from 3.00 to 5.00. It showed the lowest variability among the assessed dimensions, indicating relatively consistent participation, task completion, and adherence to classroom instructions. Behavioral engagement encompasses attention, effort, persistence, and classroom participation (Fredricks et al., 2004). Wong et al. (2024) reported associations between student engagement and academic achievement. The relatively consistent behavioral scores indicate favorable participation but do not establish a causal effect on achievement.

3.1.3 Emotional Engagement and Motivation in Science Learning

Emotional engagement achieved the highest mean of 4.15 (SD = 0.92), with responses ranging from 3.00 to 5.00. Students generally expressed interest, enthusiasm, and enjoyment during hands-on activities. However, this dimension also exhibited the greatest variability. Emotional engagement reflects students' affective responses and interest in learning (Fredricks et al., 2004). Wong et al. (2024) examined its association with academic achievement and well-being. The variation in emotional engagement suggests differences in students' learning experiences and responses to practical activities.

3.1.4 Student Perceptions of Hands-On Science Instruction

Student perceptions obtained a mean of 4.10 (SD = 0.85), with responses ranging from 3.00 to 5.00. Students generally viewed hands-on activities positively, particularly opportunities for participation, supportive learning experiences, and expressing their ideas. These findings are relevant to Rogers and Fraser (2023), who examined practical-work frequency in relation to students' science attitudes and learning-environment perceptions. Haw et al. (2022) also investigated science motivation and engagement. The positive perceptions suggest favorable experiences with hands-on instruction, although the factors responsible were not independently established.

3.2 Effects of Hands-On Activities on Science Academic Performance

3.2.1 Pretest and Posttest Science Performance

Among 30 students, the mean science achievement score increased from 11.27 in the pretest to 23.47 in the posttest, representing a mean gain of 12.20 points. Score variance increased slightly from 15.99 to 18.33. These findings demonstrate improved academic performance following the implementation of hands-on activities. The improvement is consistent with literature examining instructional practices and science learning. Kurt and Sezek (2021) investigated teaching methods and scientific process skills, while Bibon (2022) examined instructional practices and Grade 10 science achievement. Cheung and Sonkqayi (2025) also explored practical work and instructional clarity in relation to science performance. However, the absence of a comparison group prevents attributing the improvement exclusively to hands-on instruction.

3.2.2 Statistical Significance of Science Performance Improvement

The paired-sample t-test revealed a statistically significant difference between pretest and posttest scores, $t(29) = -11.49$, with a two-tailed $p = 2.58 \times 10^{-12}$. The one-tailed p-value was 1.29×10^{-12}, and the corresponding critical values were 1.699 and 2.045. The results indicate significant improvement in science achievement following the intervention. The significant difference demonstrates measurable improvement during the study period. Research on practical science instruction provides relevant context for interpreting these findings (Cheung & Sonkqayi, 2025). Nevertheless, the one-group design does not establish that hands-on activities alone caused the improvement.

3.3 Relationship Between Student Engagement and Science Performance

The study recorded high engagement across all dimensions alongside a 12.20-point improvement in mean science achievement. Emotional engagement was highest (M = 4.15), followed by behavioral engagement (M = 4.12), student perceptions (M = 4.10), and cognitive engagement (M = 4.07). The findings showed improved science achievement and generally high student engagement following hands-on instruction. However, the available results do not establish a statistically significant relationship between student engagement and academic performance because no correlation analysis was reported. Existing literature identifies associations between

engagement and academic achievement (Wong et al., 2024). Research also emphasizes the relevance of instructional clarity, laboratory environments, and motivation (Cheung & Sonkqayi, 2025; Haw et al., 2022).

3.4 Implications of Hands-On Activities for Science Education

The findings demonstrated improved science achievement and generally high student engagement following hands-on instruction. Emotional engagement showed the greatest variability, whereas behavioral engagement demonstrated the most consistent responses. These results indicate favorable learning experiences alongside differences in students' engagement levels. Recent studies provide relevant instructional context. Dah et al. (2024) reviewed open-inquiry learning outcomes, while Huang (2022) examined inquiry-based laboratories and students' teamwork and problem-solving skills. Lazaro and Paglinawan (2025) investigated laboratory resources and engagement, and Agravante-Destacamento (2025) examined hands-on biology activities among Grade 11 students. Panergayo et al. (2026) also investigated micro-laboratory demonstrations and science engagement. These studies support further examination of structured practical instruction, particularly through larger samples, comparison groups, and longer assessment periods.

4. Conclusion & Recommendations

The study concludes that hands-on science activities were associated with improved academic performance and generally high student engagement among Grade 10 learners at PaiMA National High School during the academic year 2024–2025. The statistically significant difference between pretest and posttest scores indicates meaningful improvement in students' understanding of the selected science concepts following the instructional intervention. Engagement findings revealed positive responses across cognitive, behavioral, and emotional dimensions, with emotional engagement obtaining the highest mean and behavioral engagement demonstrating the greatest consistency. Students also expressed favorable perceptions of interactive learning experiences, suggesting that practical activities supported their interest, participation, and appreciation of science instruction. However, variations in engagement scores indicate that students experienced these activities differently and may require varying levels of instructional support. Collectively, the findings provide classroom-based evidence supporting the value of hands-on learning as a student-centered instructional approach for strengthening science achievement and engagement within the study's specific educational context.

Based on the findings, science teachers are encouraged to integrate structured hands-on activities, practical experiments, collaborative discussions, and inquiry-based tasks into classroom instruction to sustain student engagement and support academic achievement. Particular attention should be given to learners demonstrating moderate cognitive or emotional engagement through differentiated instructional strategies and appropriate learning support. Teachers should regularly gather student feedback to identify learning difficulties, evaluate instructional experiences, and refine classroom activities according to learners' needs. School administrators are encouraged to support student-centered teaching practices and incorporate engagement indicators into instructional planning and assessment. Given the greater variability in emotional engagement, schools may strengthen positive classroom environments through inclusive practices, mentorship, and regular classroom check-ins. Future researchers are encouraged to investigate hands-on learning across different grade levels, science topics, and instructional settings. Additional qualitative investigations, including interviews and focus group discussions, may provide deeper insights into students' experiences, motivation, and perceptions of interactive science instruction.

The study was limited to one Grade 10 section at PaiMA National High School during the academic year 2024–2025, using purposive sampling and a one-group pretest-posttest design. The small sample and absence of a comparison group limit the generalizability of findings and prevent definitive causal conclusions. The investigation covered selected science topics and did not account for external factors, including students' prior knowledge and home learning environments. Future studies may include larger samples, comparison groups, additional learning contexts, and longer assessment periods to examine sustained learning outcomes.

5. Compliance with ethical standards

The study involved Grade 10 students at PaiMA National High School and required appropriate ethical safeguards to protect participants' rights, privacy, and welfare. Institutional permission, parental or guardian informed consent, student assent, voluntary participation, confidentiality measures, and conflict-of-interest declarations are essential ethical considerations. The researcher must verify and document compliance with these requirements before publication to ensure transparency, accountability, and adherence to accepted ethical standards in educational research.

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