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Enhancing Grade VI Students' Engagement in Science Through Hands-on Activities: An Action Research Study at Mendrelgang Primary School

Gyeltshen[1], Phuntsho Wangmo[2], Rigzin Thinley[3], Phub Dorji Tamang[4]

[1,3,4]Mendrelgang Primary School, Tsirang

[1]Chokhorling Middle Secondary Secondary School, Sarpang

[2]Gelephu Higher Secondary School, Sarpang

ABSTRACT: This study explored the impact of hands-on science activities on the engagement, interest, confidence, and academic performance of Grade VI students at Mendrelgang Primary School, Tsirang District. It aimed to assess the effectiveness of experiential learning in improving students' attitudes toward science, deepening conceptual understanding, and sustaining interest. A mixed-methods approach—surveys, interviews, and classroom observations—was used to collect both quantitative and qualitative data. Participants were selected through non-probability purposive sampling. Thematic and inferential analyses were conducted to examine the relationships between variables. Following the intervention, students displayed increased curiosity, active participation, and enthusiasm for exploring scientific ideas. Improvements were also seen in confidence, problem-solving skills, independence, and collaborative learning. Academic performance rose, with average science scores increasing from 61.8% in 2023 to 66.3% in 2024. Triangulated data from various sources confirmed these positive changes. The findings highlight the value of hands-on, student-centered learning in making science more engaging, inclusive, and effective. This study provides practical insights for educators, curriculum planners, and policymakers, encouraging the integration of active, inquiry-based strategies into primary science education. Such approaches are essential for nurturing confident, capable, and motivated learners and for promoting deeper and lasting understanding of scientific concepts.

KEYWORDS: Engagement, hands-on experience, interest, Mendrelgang, observation, science

AIMS AND OBJECTIVES

i. To quantify changes in interest levels among Grade VI children in science subjects after exposure to hands-on activities.
ii. To qualitatively explore the experiential aspects of hands-on activities as one of the strategies through interviews and observations, gaining insights into the students' perspectives and experiences.
iii. To provide evidence-based recommendations for educators, policymakers, and curriculum developers regarding the integration of practical, and interactive elements into science education.

Situational Analysis

Mendrelgang Primary School is situated in the southeastern part of Tsirang district, approximately ten kilometers downhill from the diversion along the Tsirang-Sarpang highway, known as Dupi. The school serves a diverse population of students from various cultural and socio-economic backgrounds. In recent years, the school has also begun to accommodate boarding students, particularly those from economically disadvantaged families. This provision has opened up educational opportunities for students who otherwise may not have had access to consistent schooling due to financial or geographic limitations. As a result, more parents are now opting to enroll their children in Mendrelgang Primary School, hoping to provide them with better educational prospects under the guidance of committed teachers.

Despite these positive developments, the school continues to face challenges in improving academic outcomes, particularly in the subject of science. Both teachers and school administrators have observed that many students, especially in Class VI, struggle to perform well in science. It is commonly noted that science is often perceived as a difficult and abstract subject by students, which leads to a lack of interest and motivation. This perception directly affects their engagement levels during lessons and ultimately results in poor academic performance.

This local observation aligns with national trends. According to national data collected in February 2024, the average science score among Bhutanese students stands at 68.06%. Alarmingly, Mendrelgang Primary School reported an even lower average score of 61.3% for the same subject (Dorji, P., personal communication, March 3, 2024). These statistics highlight a pressing need for interventions that can address the root causes of low performance and disengagement in science education at the primary level.

Teachers at Mendrelgang Primary School have identified low student engagement during science lessons as a key area of concern. Many students show minimal enthusiasm during classes, often viewing science as a collection of difficult theories and facts rather than a subject rooted in exploration and inquiry. This lack of interest not only hampers academic performance but also diminishes students' confidence in their ability to learn and succeed in science.

In response to these challenges, this action research seeks to explore the effectiveness of hands-on learning strategies in enhancing student engagement and academic outcomes in science. The study specifically targets Class VI students with the total of 88 students, aiming to understand how interactive, practical activities can foster a more positive and active learning environment. By providing students with experiential learning opportunities—such as experiments, model-making, and real-world applications—the research aims to make science more accessible, enjoyable, and meaningful.

Additionally, the study has collected students' views to assess the impact of these strategies from the learners' perspectives. This input is crucial for designing and implementing more effective, learner-centered teaching approaches that align with the needs and preferences of students. Ultimately, the findings from this study are expected to contribute to improving science education not only at Mendrelgang Primary School but also in similar contexts across the country.

LITERATURE REVIEW

Scope of the Study

This study was found to be significant as it addresses a gap in current literature by specifically examining the impact of hands-on activities in science education for grade VI children. The findings contribute to educational practices and policies, enhancing the quality of science education at the primary school level, guiding the improvement of science education practices.

Identifying Research Gap

Despite ongoing efforts to improve science education, teachers at Mendrelgang Primary School in Tsirang district have observed a persistent lack of student attention and engagement in science classes, particularly among Grade VI learners. This disengagement also extends to a reluctance in participating in assigned science activities. While research suggests that hands-on learning can enhance student interest and performance in science, there is a noticeable gap in localized and practical studies that examine the role of such activities in the context of primary education in Bhutan. Specifically, there is limited action-oriented research that explores how hands-on activities can be systematically integrated to foster sustained engagement, confidence, and academic growth in science. Furthermore, there is a scarcity of studies that assess the long-term cognitive and emotional impact of these interventions on students. This action research seeks to address these gaps by implementing and evaluating hands-on strategies within the Grade VI science curriculum, using both qualitative and quantitative methods. The goal is to generate context-specific insights that inform teaching practices, support student learning, and promote meaningful engagement in science education.

Main Review

Hands-on activities are increasingly recognized as essential pedagogical strategies in educational settings, particularly in science, technology, engineering, and mathematics (STEM) disciplines. These activities not only engage students physically but also stimulate cognitive processes, leading to enhanced learning outcomes. Furtak and Penuel (2018) state learning science should involve active engagement, requiring both physical and cognitive participation. Science education is a cornerstone in fostering critical thinking, curiosity, and problem-solving skills. According to Ekwueme et al. (2015) it is the hands-on approach to instruction that involves guiding students to acquire knowledge through experiential learning in which it is considered as doing science where students become active learners. Nevertheless, Furtak and Penuel (2018) states that hands-on activities are not adequate, minds-on experiences are equally important for the learners.

The concept of hands-on activities encompasses a range of interactive experiences where students manipulate materials and engage in inquiry-based learning. Sadi and Cakiroglu (2011) in Lumpe and Oliver (1991) defines hands-on approach as any science activity which allows the students to handle, observe and manipulate a scientific process where children will be engaged in hands-on rather than a conventional way of learning. Further, Haury and Rillere (1994) defines as a learning experience where participants actively handle and explore objects to deepen their understanding or acquire knowledge. Flick (1993) adds that it involves learning through first-hand experiences and practical engagement.

Hands-on activities facilitate both physical engagement and cognitive exploration, allowing students to discover information and form conclusions through active participation. This dual engagement is crucial, as it aligns with constructivist theories of learning, which emphasize that learners actively construct knowledge through experiences and interactions with their environment (Piaget, 1973; Bruner, 1974). According to Haury and Rillero (1994), hands-on learning supports deeper understanding by encouraging students to manipulate materials, test hypotheses, and learn by doing, which reflects key principles of constructivism.

Additionally, research has shown that hands-on activities can significantly enhance students' emotional engagement and interest in academic subjects. Fredricks et al. (2004) note that emotional engagement, including interest and enjoyment, plays a vital role in student motivation and learning outcomes. Similarly, Bressler and Bodzin (2013) found that experiential, hands-on science instruction increased students' interest and enthusiasm for the subject, contributing to better learning and retention.

This is supported by findings from Adebusuyi et al. (2023), who found that hands-on activities in chemistry not only improved students' performance but also fostered a deeper interest in the subject. Similarly, Ajayi (2017) reported that students taught through hands-on methods demonstrated greater interest and engagement compared to those who received traditional instruction.

The effectiveness of hands-on activities extends beyond mere engagement; they also play a critical role in developing essential skills. Studies have shown that cooperative learning models incorporating hands-on activities significantly enhance students' science process skills and conceptual understanding. For instance, Lord and Orkwiszewski (2006) found that active learning strategies, including hands-on approaches, led to significant improvements in students' performance in biology courses. Similarly, Minner, Levy, and Century (2010) conducted a meta-analysis revealing that inquiry-based and hands-on science instruction positively impacted student achievement and understanding. Moreover, Kolodner et al. (2003) emphasized that problem-based, experiential learning activities foster deeper problem-solving abilities and creativity—skills that are essential for success in STEM fields. In chemistry education, Hofstein and Lunetta (2004) documented how laboratory-based instruction improved student motivation, understanding, and long-term knowledge retention compared to more traditional approaches. Beyond academic benefits, hands-on activities also encourage collaboration and social interaction among students. Vygotsky's (1978) sociocultural theory supports this, noting that learning is a social process, and activities that involve peer collaboration enhance both cognitive and interpersonal development. Cooperative, hands-on tasks create a sense of shared responsibility, which can boost student motivation and foster a stronger classroom community (Johnson & Johnson, 2009).

Despite the clear advantages of hands-on activities, it is essential to consider the context in which they are implemented. Schwichow et al. (2016) caution that the alignment between instructional methods and assessment is crucial for maximizing the benefits of hands-on learning. Additionally, while hands-on activities are beneficial, they should not be viewed as a panacea; alternative instructional methods may be necessary depending on resource availability and specific learning objectives (Schwichow et al., 2016).

Caglak (2017), in his meta-analysis title, "Does hands-on science practices make an impact on achievement in science?" has found out that there is significant improvement and indicated that the hands-on activities had a very large impact on students' science achievement. In line to it, Ekwueme et al. (2015) in their paper title "The Impact of Hands-On-Approach on Student Academic Performance in Basic Science and Mathematics", also demonstrated that there is a positive improvement on both the students' performance and participation on basic science activities. Similarly, the findings of Sadi and Cakiroglu (2011) also demonstrated that instruction enriched with hands-on activities proved to be more effective than conventional instructional methods. Further, Caglak (2017) study reports that engaging in hands-on activities in science classrooms provides a valuable opportunity to enhance students' success and achievements in the subject. Hands-on approach not only improves the performance in general, it does improve the retention rate (Ekwueme et al., 2015). Thus, encouraging active participation and deeper engagement among students, making it a crucial element in science education for fostering interest, conceptual comprehension, and scientific literacy rather than just considering "a time consuming or difficult getting enough apparatus" for all students as stated in Ekwueme et al. (2015).

In conclusion, the literature strongly supports the integration of hands-on activities in educational settings. These activities not only enhance students' engagement, it also increases their interest and attitude towards science and also improve academic performance and the development of critical skills. As educators continue to seek effective teaching strategies, the evidence suggests that hands-on minds-on learning should be a fundamental component of the curriculum, particularly in STEM education.

Research Question

How can I enhance grade VI Students' engagement in science through hands-on activities?

METHODOLOGY

Research site and Participants

The study involved current Grade VI children from Mendrelgang Primary School, located in the Tsirang district. The school has an estimated student population of around 88 individuals in three sections. Utilizing Krejcia and Morgan Table (Krejcia & Morgan, 1970), the sample size for this research has been determined to be 72 students, with confidence level of 95% keeping the real value within ±5 of the measured or surveyed value with 50% population proportion. However, the researchers have not limited to the real value rather included all the grade VI children compulsorily in to this study.

Table 01: Demographic representation of gender

Gender	Frequency	Percent	Valid percent
Male	41	46.6	46.6
Female	47	53.4	53.4
Total	88	100	100

This study used gender distribution of a sample population consisting of 88 individuals of all grade VI students compulsorily throughout this study. Among the participants, 41 are males, which represents 46.6% of the total population. In contrast, there are 47 females, accounting for 53.4% of the population. This indicates a slightly higher proportion of females in the group compared to males.

Data collection and tools

Survey Questionnaires

The study employed survey questionnaire to collect quantitative data on students' interest, confidence, and engagement in science activities using Likert five-point scale. Pre- and post-activity surveys allowed researchers to measure changes in participants' perceptions. The Likert scale format enabled the easy quantification of responses, supporting analysis of how students responded to hands-on science learning.

Semi-structured Interviews

The semi-structured interviews (SSI) were used to collect in-depth qualitative data on participants' experiences with hands-on activities. This method allowed researchers to explore key themes flexibly, encouraging open and detailed responses. Guided by a set of open-ended questions, SSI enabled the researchers to probe deeper into participants' views while maintaining consistency across interviews. This approach aligns with the insights of Creswell (2014), Lhendup (2017), and Kakilla (2021), who emphasize the depth, flexibility, and thematic richness that SSI provides.

Observations

The researchers used classroom observation to qualitatively assess participants' engagement during hands-on activities through recording their specific behaviours, interactions, and expressions related to interest in science.

Reliability and validity

Before collecting data, the survey questionnaires and interview questions underwent thorough testing and re-testing to ensure their reliability. The questionnaire was evaluated using a scale test, and its reliability was assessed through Cronbach's alpha, which measures internal consistency, or how closely related the items in a set are. According to Tavakol and Dennick (2011), a Cronbach's alpha value between 0.70 and 0.95 is generally considered acceptable for indicating good reliability. The questionnaire used in this study just met this criterion, confirming its reliability.

Table 02: Scale Reliability Statistics

	Cronbach's α
Scale	0.701

Data Analyses

The study employed both quantitative and qualitative data analysis methods. Quantitative data were analyzed using SPSS version 22, with descriptive statistics, such as means, percentages, frequencies, and standard deviations were used to interpret changes in students' interest, confidence, and engagement. Additional statistical tests, including t-tests, ANOVA, and correlation analyses, were applied to examine patterns across variables. These tests helped assess the impact of hands-on science activities. For qualitative data, the researchers conducted manual thematic analysis through coding to identify key themes and insights. This mixed-method approach allowed the researchers for a comprehensive understanding of the research findings.

Ethical Considerations

The researchers followed ethical guidelines to ensure the protection of participants' rights, dignity, and welfare. Informed consent was obtained through signed documents that clearly outlined the study's aims and procedures, emphasizing its non-commercial and non-judgmental nature. Participant confidentiality was strictly preserved, with all collected data handled securely. The researchers also respected participants' readiness and perspectives during data collection, providing full transparency about the study's purpose.

Data Analysis

Quantitative data interpretation

This section presents a detailed interpretation and analysis of the data collected, focusing on students' engagement to improve their perceptions, interest, and confidence with science learning before and after the hands-on strategy and interventions. Findings are organized thematically based on the research objectives.

i. Students' Perceptions of Hands-on Activities in Science Learning

Table 03: Students' view on whether hands-on activity would make learning science interesting (pre-activity assessment)

		Frequency	Percent	Valid Percent
Valid	Yes	80	90.9	90.9
	No	3	3.4	3.4
	Not sure	5	5.7	5.7

The analysis indicates a strong positive perception among students regarding hands-on activities. A substantial majority, 90.9%, agreed that hands-on activities make learning science more interesting. Only a minimal percentage (3.4%) disagreed, and 5.7% were uncertain. This highlights the perceived value of experiential learning methods in enhancing engagement and curiosity.

ii. Students' Confidence in Learning Science: Pre- and Post-Intervention

Table 04: One-Sample t-Test on children's *Confidence* level in learning science

	Test Value = 0					
					95% Confidence Interval of the Difference	
	T	Df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Pre-activity assessment	45.979	87	.000	3.68182	3.5227	3.8410
Post-activity assessment	36.034	87	.000	4.25000	4.0156	4.4844

Results from the One-Sample t-Test (Table 04) reveal a statistically significant increase in students' confidence following the hands-on intervention. The mean confidence level improved from 3.68 (pre-activity) to 4.25 (post-activity), both of which were significant at the 0.01 level. Confidence intervals showed minimal overlap, supporting the conclusion that this improvement is meaningful.

Table 05: Confidence level in understanding science concepts before the intervention

		Frequency	Percent	Valid Percent
Valid	very not confident	1	1.1	1.1
	Not confident	5	5.7	5.7
	Neutral	22	25.0	25.0
	Confident	53	60.2	60.2
	Very confident	7	8.0	8.0

Table 06: *Confidence level* of students in Understanding Science concept after the intervention

Interest level		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Decreased	4	4.5	4.5	4.5
	Neutral	24	27.3	27.3	31.8
	Increased	60	68.2	68.2	100.0
	Total	88	100.0	100.0	

The descriptive data (Tables 05 and 06) showed that initially, 60.2% were "Confident" and 8.0% "Very Confident". After the intervention, 68.2% reported a perceived increase in confidence. These results affirm the effectiveness of hands-on learning in enhancing confidence.

iii. General Interest in Science Learning: Pre- and Post-Activity

Table 07: Describing Current level of *Interest* in science (Pre)

Pre-activity		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	16	18.2	18.2	18.2
	Interested	49	55.7	55.7	73.9
	Very Interested	23	26.1	26.1	100.0
	Total	88	100.0	100.0	

Table 08: Describing Current level of *Interest* in science (Post)

Post-activity		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	14	15.9	15.9	15.9
	Interested	54	61.4	61.4	77.3
	Very Interested	20	22.7	22.7	100.0
	Total	88	100.0	100.0	

As detailed in tables 07 and 08, most students expressed a pre-existing interest in science prior to the activity. Specifically, 55.7% were "Interested," and 26.1% were "Very Interested." Post-activity responses indicated a slight increase in the "Interested" category (61.4%) and a slight decrease in "Very Interested" (22.7%). Further, one-sample t-test was conducted to compare between pre and post activity on their general interest level in learning science.

Table 09: One-Sample t-Test on general *Interest* level of the children in learning science

	Test Value = 0					
					95% Confidence Interval of the Difference	
	T	Df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Pre activity	57.57	87	.00	4.08	3.93	4.22
Post activity	61.42	87	.00	4.07	3.93	4.20

However, the results from the One-Sample t-Test (Table 09) showed mean interest scores of 4.08 (pre-activity) and 4.07 (post-activity), with both findings statistically significant but nearly identical suggesting that the hands-on activity served to sustain rather than significantly increase this interest.

iv. Changes in Students' Views on Science Learning

Table 10: One-Sample t-Test on the students' view on learning science

	Test Value = 0					
					95% Confidence Interval of the Difference	
	T	Df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Pre-Activity	21.873	87	.000	1.14773	1.0434	1.2520
Post-Activity	13.839	87	.000	1.46591	1.2554	1.6764

Table 10 presents findings from a One-Sample t-Test that explored students' general views on learning science. The results demonstrate a moderate but statistically significant increase in students' perceptions, with the mean score rising from 1.15 (pre-activity) to 1.47 (post-activity). The lack of overlap in confidence intervals suggests a genuine shift in students' views, likely influenced by their experience with the intervention. This improvement indicates that hands-on learning can help students form more positive, meaningful connections to science.

v. Gender-Based Differences in Confidence, Interest, and Views

Table 11: Group t-test (Independent t-test) based on Gender on three variables; interest, confidence and students' view on science

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Describing Current level of interest in science	Male	41	4.07	.65	.10
	Female	47	4.06	.60	.09

Confidence in Understanding Science concept	Male	41	4.09	1.18	.18
	Female	47	4.38	1.03	.15
Views on the importance of science changed	Male	41	1.51	1.08	.17
	Female	47	1.42	.93	.14

Gender comparisons (Table 11) revealed no substantial differences in students' post-activity responses. Both male and female students expressed similar levels of interest (M = 4.07 for males; M = 4.06 for females). Female students showed slightly higher confidence (M = 4.38) compared to their male counterparts (M = 4.09), whereas male students showed a marginally higher mean in changed views on science. To further find out whether differences are statistically significant, we have conducted an independent samples t-tests to validate the data. While gender comparisons in descriptive data (Table 12) showed slight differences in mean scores for confidence and views (female students slightly higher confidence, male students marginally higher view change), independent samples t-tests (Table 13) indicated that none of these gender-based differences were statistically significant. It was concluded that the intervention was equally effective across genders.

Table 12: Independent Samples Test to check whether gender has a difference in current level of interest in science

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Describing Current level of interest in science	Equal variances assumed	.31	.58	.07	86	.94	.01	.13	-.26	.27
	Equal variances not assumed			.07	82.48	.95	.01	.13	-.26	.28
Confidence in Understanding Science concept	Equal variances assumed	2.87	.09	-1.21	86	.23	-.29	.24	-.75	.18
	Equal variances not assumed			-1.20	80.23	.23	-.29	.24	-.76	.19
Views on the importance of science changed	Equal variances assumed	.63	.43	.41	86	.69	.09	.21	-.34	.51
	Equal variances not assumed			.40	79.57	.69	.09	.22	-.34	.52

vi. Correlation Between Confidence, Interest, and Views

Table 13: Correlations of the pre-activity assessment among three variables

Pre-activity Assessment		Confidence level	Interest level	View on learning science subject
Confidence level	Pearson Correlation	1	.304**	-.058
	Sig. (2-tailed)		.004	.592
	N	88	88	88
Interest on learning science	Pearson Correlation	.304**	1	-.107
	Sig. (2-tailed)	.004		.323
	N	88	88	88
View on learning science	Pearson Correlation	-.058	-.107	1
	Sig. (2-tailed)	.592	.323	
	N	88	88	88

**. Correlation is significant at the 0.01 level (2-tailed).

Table 14: Correlations of the post-activity assessment among three variables

Post-activity assessment		Confidence Level	Interest level	View on science subject
Confidence level	Pearson Correlation	1	.376**	.071
	Sig. (2-tailed)		.000	.514
	N	88	88	88
Interest level	Pearson Correlation	.376**	1	-.033
	Sig. (2-tailed)	.000		.757
	N	88	88	88
View on science subject	Pearson Correlation	.071	-.033	1
	Sig. (2-tailed)	.514	.757	
	N	88	88	88

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation analysis (Tables 13 and 14) explored the relationships among students' confidence, interest, and views toward science learning both before and after the activity.

Before the activity, there was a moderate, statistically significant positive correlation between students' confidence in learning science and their interest in the subject ($r = .304$, $p < .01$). This suggests that students who felt more confident also tended to be more interested in science. However, no meaningful connections were found between students' confidence and their views about science learning, nor between their interest and views.

After the activity, the link between confidence and interest became even stronger ($r = .376$, $p < .01$), indicating that the intervention may have helped reinforce the relationship between how confident students felt and how interested they were in science. Despite this improvement, there were still no significant correlations involving students' views, implying that the activity had little effect on changing their overall perspectives toward science learning.

Overall, the results suggest that while the intervention was effective in strengthening the connection between students' confidence and interest, shifting students' broader views about science may require additional or different strategies

Summary of findings from Quantitative Data

Table 15: Summary of Findings

Dimension	Key Change	Statistical Significance	Notes
Interest	Slight internal shift, no overall increase	No (Post t-test & ANOVA)	Some neutrals became interested; "very interested" slightly dropped
Confidence	Clear increase from pre to post	Yes (t-test, CI analysis)	Boosted across the board with no significant group-level variation.
Engagement	High agreement on hands-on value	Mixed (ANOVA p = 0.085)	Strong in-class engagement, out-of-class effect not yet significant.
Views/Perceptions	Perceptions of science improved post-activity	Yes (t-test, CI analysis)	Students viewed science more positively after intervention.

The analysis of students' engagement in science-related activities reveals a shift toward greater interest and participation following the hands-on intervention. While nearly half of the students were already actively involved in science outside the classroom, the post-activity data shows a significant increase in the number of students who are likely or very likely to pursue science-related activities outside of school (80.7%), up from a lower pre-activity level. This suggests that the intervention effectively enhanced students' motivation and engagement. However, while students showed strong preferences for passive learning formats like science videos and reading materials, active engagement in hands-on or extracurricular science activities remains limited, pointing to the potential for educators to capitalize on students' interests by incorporating more interactive and accessible science experiences beyond the classroom

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Qualitative Data Analysis

i. Data analysis and findings of Semi-structured interview

A semi-structured interview was conducted with ten students to explore their perceptions, interest levels, and confidence in participating in hands-on science activities. The purpose of the interview was to gather qualitative insights into students' experiences and attitudes toward science learning through practical engagement, as compared to traditional instructional methods.

Awareness and Initial Understanding of Hands-on Activities

The majority of participants indicated that they had heard the term *"hands-on activity"* for the first time during this intervention. While a few students attempted to pronounce or interpret the term, they lacked an accurate understanding of its meaning. Most associated the term with actively using physical materials or equipment during science lessons.

"I did not get chance to handle the science materials last year, But this year I had an opportunity to use and do activity by myself". This indicates that, in their previous learning experiences, they rarely had the opportunity to physically engage with science materials. Instead, science lessons typically involved teacher demonstrations, while students remained passive listeners or mere observers.

Perceptions of Traditional vs. Hands-on Learning

Respondents consistently expressed that traditional "chalk and talk" or teacher-centered approaches limited their involvement and made science less engaging. Respondent 4 said, *"I have seen my science teacher demonstrate in the class but I knew nothing but became a passive listener",* and conversely the respondent 5 said, *"I have learned comparatively more than what I was taught last year".* These responses acknowledged that observing teachers conduct experiments did not provide the same level of understanding or enthusiasm as when they were allowed to carry out the activities themselves.

Respondent 1 remarked that if he had been given the opportunity to conduct experiments on his own in the past, he might have developed greater confidence and improved his learning outcomes. Similarly, Respondent 2 shared that hands-on activities sparked his interest in science and added that he still had time to adapt and learn through practical engagement. He expressed hope that the foundational skills learned now could be applied in future science education.

Emotional and Cognitive Impact of Hands-on Activities

Many students reported an initial reluctance to handle science equipment, primarily due to fear of damaging the materials. This hesitation stemmed from their lack of prior exposure and confidence. However, as they were given the opportunity to directly interact with equipment during the intervention, their enthusiasm and comfort levels increased notably.

Respondent 3 and 6 reflected on missed opportunities in earlier grades (IV and V), expressing regret that he did not have access to such facilities and teaching methods at that time. Nevertheless, he acknowledged that it is not too late for him to learn and is now motivated to engage actively in hands-on experiments.

Effectiveness and Enjoyment of Hands-on Learning

A significant number of participants emphasized that hands-on activities greatly enhanced their understanding of scientific concepts. *"I liked the activity when I was made to do by myself, and I did not know how the time was spent",* this described that activities given to them were as enjoyable, immersive, and highly engaging—so much so that they often lost track of time while performing them.

Students overwhelmingly agreed that learning by doing was more effective than passive listening. They appreciated being able to repeat experiments until the desired result was achieved, which deepened their conceptual understanding and boosted their confidence. Moreover, several students expressed a strong preference for teachers to adopt this method more consistently in the future, as it fostered active participation and enthusiasm for science.

ii. Data Analysis and interpretation of classroom Observation

Perception of Science Learning

Observers noted a marked shift in how students perceived science when it was presented as a hands-on endeavour rather than a teacher-centered lecture. Prior to these activities, many learners viewed science class as passive—merely watching demonstrations. During the sessions, however, students repeatedly described the work as "real," "meaningful," and "connected to everyday life." Their willingness to take charge of materials, consult checklists, and even improvise tools (using paper clips and rubber bands) underscores a new perception of science as an accessible, practical discipline. In post-activity discussions, students referred to science as "something I can do myself," reflecting an internalized sense that science is not just theoretical but a hands-on craft.

Interest in Science

Interest levels soared as students moved from observers to active experimenters. Small-group debates "What if we change the angle?" or "Let's try a different resistor"—and the animated energy in the room signalled genuine curiosity. Rather than merely completing tasks, students pursued "what-if" scenarios, extended experiments with creative twists, and eagerly shared discoveries with peers. Observers consistently described clusters of students "lost track of time" and "leaning forward" over their apparatus, clear indicators that interest had grown from mere compliance to enthusiastic investigation.

Confidence in Science Skills

Hands-on engagement fostered tangible gains in student confidence. Students who had previously hesitated to handle equipment—fearing breakage or error—became self-assured, carefully donning safety goggles and skilfully using test-tube holders. One observer highlighted how an once-reluctant student, stood upright and explained voltage readings to peers without prompting. In their self-reflections, many students noted, "I can do this now," or "I knew I could figure it out," revealing a newfound belief in their capacity to design, conduct, and troubleshoot experiments independently.

iii. Students' performance in science (2023 Vs. 2024)

Table 16: Comparison of 2023 and 2024 result, class VI

Number of students		**Subjects**	**2023 mean marks**	**2024 mean marks**	**Remarks**
2023	**2024**				
51	87	Science	61.8%	66.3%	Improved

The data presented in Table 16 highlights an improvement in the average science marks of Class VI students from 2023 to 2024. The mean marks in 2023 were 61.8%, while the mean in 2024 increased to 66.3%. This represents an improvement of 4.5 percentage points, which, in terms of relative improvement, equates to a 7.3% increase from the previous year's baseline. While this improvement appears to be significant, it is important to understand its implications more deeply.

Cohort Size and Comparability:

The cohort sizes in the two years are notably different, with 51 students in 2023 and 87 students in 2024. The larger cohort in 2024 could potentially introduce more variability into the results. Larger groups often show a greater spread of marks, and the average can shift more significantly as a result. Therefore, the increase in mean marks should be viewed with caution, as the differences in cohort size may contribute to the apparent improvement. That said, despite this larger and potentially more diverse group in 2024, the average mark still rose, which suggests that the shift could reflect a real change in student performance.

Potential Impact of the Hands-On Intervention:

The timing of this improvement is also worth noting. The increase in mean marks coincides with the implementation of a hands-on action research intervention in 2024. The hands-on activities likely played a role in enhancing student engagement and learning. However, while the timing suggests that the intervention might be responsible for this improvement, it would be premature to attribute the entire 4.5-point gain solely to this factor. Other variables, such as changes in the curriculum, teaching methods, or even differences in teacher performance, could have contributed to the improvement. To draw a more definitive conclusion, additional research would be needed to control for these potential confounding factors and to isolate the specific impact of the hands-on intervention.

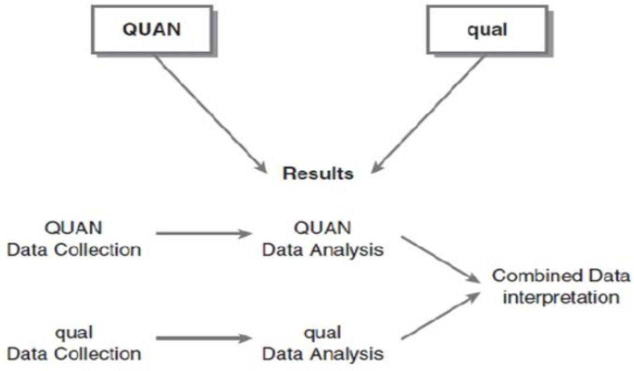
Summary of the findings from the Qualitative data

Based on the sources, the findings highlight a significant positive impact of hands-on science activities on students' engagement, perception, confidence, and performance. Initially, many students were unfamiliar with the term "hands-on activity" but quickly associated it with using physical materials. Students consistently found traditional teaching methods less engaging compared to hands-on learning, which they described as enjoyable, immersive, and effective, often causing them to lose track of time. While some students initially hesitated to handle equipment due to fear, their enthusiasm and comfort increased with practice. This practical engagement fostered a new perception of science as "real," "meaningful," and "something I can do myself," rather than just a passive observation. Interest levels soared, with students actively pursuing investigations and sharing discoveries. Tangible gains in confidence were observed, as students became more self-assured in handling equipment and explaining concepts. Furthermore, coinciding with the hands-on intervention in 2024, the average science marks for Class VI students improved from 61.8% in 2023 to 66.3%. While this 4.5-point increase should be viewed with caution due to differences in cohort size and other potential factors, the rise despite a larger group suggests the intervention likely played a role in enhancing student performance. Students overwhelmingly preferred this active learning approach and hoped for its more consistent adoption.

Data Triangulations

Data triangulation involves using multiple data sources to examine a phenomenon, thereby enhancing the credibility and validity of research findings (Denzin, 1978; Patton, 1999). In action research—where practitioners seek to understand and improve their own teaching practice—triangulating data ensures that conclusions are not based on a single perspective or method, but rather reflect a richer, more nuanced picture of classroom reality. The researchers have used Methodological Triangulation; Combining surveys, semi-structured interviews, and observation checklists to balance breadth (surveys) with depth (interviews) (Patton, 1999).

The use of triangulation in this study significantly enhances the credibility, validity, and depth of the findings. By drawing on multiple data sources—semi-structured interviews, classroom observations, and pre-post survey results—a consistent narrative emerged, confirming the effectiveness of the hands-on science intervention. Below is a synthesis of findings across the three data sources, organized around the key themes of perception, interest, and confidence. The researchers have used the concurrent data triangulation designed by Creswell et al. (2003).



Creswell et al. (2003)

Creswell et al. (2003)

The implementation of hands-on science activities led to notable improvements in students' perception, interest, confidence, and performance in science learning. Initially unfamiliar with the concept, many students began to view science as tangible and engaging after participating in the intervention. Interviews revealed a shift from seeing science as abstract theory to something "real" and "doable," while classroom observations showed students confidently handling materials, engaging in inquiry, and using scientific vocabulary accurately. Survey results supported this, showing increased agreement that science is fun, important, and relevant. Interest in science also rose significantly. Students expressed excitement about using real equipment and showed a clear preference for active experimentation over passive learning. Observations confirmed high levels of engagement, curiosity, and collaboration, while surveys reflected growing enthusiasm, with more students looking forward to science lessons and exploring science outside of school. Perhaps most significantly, students reported greater confidence in their scientific abilities. Many overcame initial hesitation and began working independently, troubleshooting problems, and supporting peers. Observers noted increased autonomy, and survey data indicated improved self-efficacy. Triangulated data from interviews, observations, and surveys strongly suggest that hands-on learning fostered a deeper connection to science, enhancing students' perception, interest, and confidence in meaningful and lasting ways along with the improvement in performance.

CONCLUSION

By integrating qualitative insights (interviews and observations) with quantitative survey data, the study confirms that hands-on science interventions have a multi-dimensional impact—reshaping how students perceive science, increasing their enthusiasm, and building confidence in their own scientific abilities.

Implementation of the hands-on science intervention brought about notable improvements across various aspects of students' learning experiences. One of the most prominent outcomes was the enhancement of students' confidence in their ability to understand and engage with science concepts. The interactive and practical nature of the activities allowed learners to approach science with greater assurance and enthusiasm. In terms of interest, the intervention successfully maintained—if not slightly elevated—students' enthusiasm toward the subject. Although many students already demonstrated a strong interest in science prior to the activity, the experience helped to reinforce and sustain this positive disposition. Students also developed a more favourable perception of science as a subject. They began to see it not merely as a collection of facts and theories, but as a dynamic and engaging discipline that can be explored through real-life applications and interactive learning.

Importantly, the impact of the intervention was consistent across both male and female students. This suggests that hands-on, experiential learning methods offer an inclusive approach that supports diverse learners equally. The analysis further revealed a strengthened relationship between students' confidence and their interest in science following the intervention. As students became more confident in their scientific abilities, their curiosity and enthusiasm for the subject also increased—highlighting a positive feedback loop between self-assurance and engagement. Lastly, the experience appeared to encourage more students to take an active interest in science outside the classroom. Many expressed a greater willingness to participate in science-related activities in their personal time, indicating that the intervention not only enhanced classroom learning but also inspired continued exploration beyond the school environment. Collectively, these findings underscore the value of incorporating hands-on, experiential approaches in science education. Such methods not only deepen conceptual understanding but also cultivate lasting motivation, curiosity, and engagement among students.

Similarly, the findings from the *semi-structured interviews* suggest that hands-on science activities significantly improve students' perceptions of science learning, enhance their interest, and build confidence. Students demonstrated a clear preference for experiential learning and expressed a desire for more opportunities to engage in such methods. This shift from passive to active learning appears to have had a profound impact on their attitude toward science and their willingness to participate in scientific inquiry. The *classroom observations* demonstrate that transforming science lessons into hands-on experiences can profoundly reshape students' perceptions, elevate their interest, and bolster their confidence, turning passive listeners into active, self-assured learners.

The observed improvement in *student performance* from 2023 to 2024 is promising, with a 7.3% relative gain in average marks. While the larger cohort in 2024 must be taken into account, the increase in mean marks suggests a positive shift in student outcomes. The hands-on intervention may have contributed to this, but further analysis is needed to confirm its specific impact, controlling for other factors that could have influenced the results.

This triangulated approach strengthens the validity of the conclusion that hands-on, experiential science teaching is not just engaging—it is transformative. It promotes active, inclusive, and meaningful learning experiences that equip students to become curious, capable, and confident young scientists.

RECOMMENDATION

Recognizing that hands-on activities significantly enhance student engagement by improving their perception, interest, attitude, and confidence, the researchers strongly recommend that science teachers adopt this strategy, as supported by the learners themselves. To ensure the effectiveness of such activities, it is essential that all necessary materials and resources are readily available, enabling students to fully immerse themselves in practical tasks. Additionally, educators are encouraged to incorporate well-curated YouTube videos related to the lesson topics. These visual aids have proven effective in capturing students' attention and can be followed up with individual or group experiments. This approach not only increases student engagement but also fosters greater focus and determination to complete tasks, ultimately strengthening their skills and enhancing cognitive understanding of scientific concepts.

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LIMITATION:

The study compared the average science marks of Class VI students from 2023 to 2024, noting an improvement from 61.8% to 66.3%. While this increase coincided with the implementation of the hands-on intervention in 2024, the cohort sizes in the two years were notably different, with 51 students in 2023 and 87 students in 2024. The researchers explicitly state that the larger cohort size in 2024 could introduce more variability into the results and that the increase in mean marks should be viewed with caution, as differences in cohort size may contribute to the apparent improvement. Furthermore, while the timing suggests the intervention might be responsible, the authors note that it would be premature to attribute the entire gain solely to this factor. They point out that other variables, such as changes in the curriculum, teaching methods, or differences in teacher performance, could also have contributed to the improvement.

Therefore, the study acknowledges that additional research would be needed to control for these potential confounding factors and to isolate the specific impact of the hands-on intervention on academic performance. This indicates that the observed improvement in academic performance cannot be definitively and solely attributed to the hands-on activities based on this study alone.

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