Investigating the Effectiveness of Localized Context-Based Stem Approach Using 5e Lesson Plan in Teaching Science 3

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ABSTRACT

This study employed an experimental research design, specifically the one-group pre-test and post-test design, to investigate the effectiveness of the 5E Lesson Plan integrated within a localized context-based STEM approach in improving the conceptual understanding and engagement of the Grade 3 – Plato pupils of Sultan Naga Dimaporo Memorial Integrated School (SNDMIS). The respondents of the study were 34 pupils from Section B, officially enrolled during the Academic Year 2025–2026. A 20-item multiple-choice pretest and posttest aligned with the Science 3 curriculum, together with an engagement survey, were administered before and after the intervention to measure pupils' learning and participation. Data were analyzed using frequency and percentage distribution, weighted mean, Wilcoxon signed-rank test. Results revealed that pretest scores were relatively low, with only a few pupils demonstrating higher achievement, while posttest results showed a remarkable improvement, with most respondents shifting to the "Very Highly Achieved" category. The Wilcoxon signed-rank test confirmed a significant difference between pretest and posttest scores ($p = 0.001$), indicating that the intervention was effective. Furthermore, survey findings showed that learners were highly engaged during the lessons, enjoying the use of local materials, hands-on group activities, and inquiry-based tasks. The study concludes that integrating the 5E instructional model with localized, context-based STEM instruction significantly enhances pupils' conceptual understanding, engagement, and problem-solving skills in Science lessons.

Keywords: 5E Lesson Plan, Localized Context-Based STEM, Conceptual Understanding, Science

INTRODUCTION

Innovative learning strategies have been incorporated into educational procedures more and more in recent years to satisfy the changing needs of the twenty-first century. STEM education, which combines Science, Technology, Engineering, and Mathematics to promote experiential learning, is one notable innovation. To improve pupils' critical thinking, creativity, and teamwork abilities, STEM education places a strong emphasis on learning through practical experiences and problem-solving exercises (Han, Kelley, and Knowles, 2021). Students are supposed to solve practical issues, come up with original ideas, and take part in worthwhile educational activities as a result of this integration. In addition to developing critical academic competencies, STEM education's growing significance as a transformative learning approach gives pupils the tools they need to succeed in the twenty-first century.

Kolb (2014) stated that learning is a process based on concrete experiences resulting from one's interactions with their environment. According to the experiential learning theory put forward by Kolb, individuals use the information obtained from their experiences to solve their daily life problems. According to this theory, individuals learn by including multiple perspectives using their imagination.

The foundation of STEM education is developing learning spaces that provide people with tangible experiences. In STEM activities, people also apply their prior knowledge to solve problems from various disciplines. Thus, experiential learning theory serves as the philosophical cornerstone of this investigation.

Teachers should favor learning models that allow students to gain experience in STEM subjects in order to implement STEM education effectively. Critical thinking abilities can be developed using the 5E learning cycle model. Research by Kuba et al. (2020) supports this claim by showing that pupils' critical thinking abilities are significantly impacted by the 5E learning cycle model.

Consequently, there are five stages in Bybee's (1997) 5E learning cycle model. These phases are as follows: *Engagement*, where students are drawn to the lesson; *Exploration*, where they conduct exploration and make predictions through a variety of activities and experiments; *Explanation*, where they define and clarify the subject's concepts by fostering an environment of discussion in class; *Elaboration*, where they can apply what they have learned thus far to other areas; and *Evaluation*, where the process and the students are assessed.

Additionally, a common tool for teaching concepts and dispelling misconceptions is the 5E learning cycle model. Research indicated that the 5E learning cycle model helps students succeed by giving them the opportunity to learn in a meaningful way. For example, a study conducted in 2024 by Melgarejo et al. investigated how the 5E instructional model affected meaningful learning in Science and technology. The findings showed that by involving pupils in activities that encourage critical thinking and the application of knowledge in practical settings, the model successfully supported meaningful learning.

In light of this, the purpose of this study is to examine how well the 5E lesson plan can be incorporated into the Localized Context-Based STEM Approach for teaching Science to elementary school pupils. Its specific goal is to investigate how well it enhances pupils' conceptual understanding of Science concepts and engagement level in grade 3 Science.

Research Objectives

This study aimed to investigate the effectiveness of the integration of the 5E lesson plan alongside the Localized Context-Based STEM Approach in Teaching Grade 3 Science at Sultan Naga Dimaporo Memorial Integrated School. Specifically, it sought to investigate its effectiveness by analyzing pupils' demographic profile in line with analyzing their conceptual understanding by assessing their pretest and posttest performance, determining the significant differences of their pretest and posttest performance, and their engagement level during the instruction.

Hypothesis

This study proposed that there is a significant difference between the pretest and posttest scores of the pupils taught using the 5E Lesson Plan in a Localized Context-Based STEM.

RESEARCH METHODOLOGY

The instructional intervention implemented in this study was deliberately designed to be localized and context-based, with the goal of increasing learners' conceptual understanding and engagement by anchoring Science concepts in their immediate environmental and community experiences alongside the 5E (Engage, Explore, Explain, Elaborate, and Evaluate) lesson. The 5E Localized Context-Based STEM approach fosters curiosity and critical thinking by promoting interactive and meaningful learning experiences (The Grove Center, n.d.), allowing learners to understand the practical applications and significance of scientific concepts in their daily lives. It also strengthened the link between classroom learning and real-life community contexts, consistent with the Constructivist, Experiential, and Inquiry Theories advocating learner-centered and meaningful education.

The study employed an experimental one-group pretest and posttest research design to determine the effectiveness of the 5E Localized Context-Based STEM approach in teaching Science 3. Quantitative data were supported by descriptive observations of learner engagement during the implementation of the intervention. Data were collected through pretest and posttest assessments, engagement survey questionnaires, and prototype evaluation rubrics used to assess pupils' outputs during the evaluation activity.

A purposive sampling technique was utilized in selecting the respondents of the study. The participants consisted of thirty-four (34) Grade 3 pupils under the Plato section of Sultan Naga Dimaporo Memorial Integrated School, who were anticipated to take the specific topic on the Basic Needs of Living Things (code S3LT-IIi-j14), which aligns with the focus of this research, which is relevant to the objectives of the study. This criterion ensured that the respondents were appropriate for evaluating the effects of the intervention.

Data analysis involved both quantitative and descriptive techniques. Pretest and posttest scores were analyzed using frequency, percentage distribution, and the Wilcoxon Signed-Rank Test to determine whether a significant difference existed between learners' performance before and after the intervention. Engagement levels and prototype evaluation results were analyzed using weighted mean with descriptive interpretation.

The investigation was conducted with rigorous adherence to ethical considerations. A parental and school authorization were obtained for the inclusion and publication of learner photographs used solely for academic and documentation purposes. The researchers ensured that all learner information remained confidential and that photographs were used responsibly in accordance with ethical standards for research involving minors.

RESEARCH FINDINGS

Respondents' Profile

Age

Table 4.1.1 presents the frequency and percentage distribution of the respondents according to age. Of the total respondents, eighteen (18) or 52.94% were eight (8) years old, nine (9) or 26.47% were nine (9) years old, three (3) or 8.82% were ten (10) years old, and two (2) or 5.88% were seven (7) years old. Meanwhile, respondents aged eleven (11) and twelve (12) each comprised one (1) respondent or 2.94% of the total sample.

The findings revealed that the majority of the respondents were eight (8) years old, accounting for 52.94% of the total number of participants. The predominance of learners within this age group suggests that the respondents were at an appropriate developmental stage to effectively engage in structured learning tasks and localized STEM-based approaches. This finding aligns with Piaget's Cognitive Development Theory, which identifies learners aged 7 to 11 as being in the Concrete Operational Stage, wherein logical thinking, classification, and problem-solving abilities begin to emerge and develop (Piaget, 1972; McLeod, 2018).

Hewitt and Forcino (2025) also emphasized that introducing STEM activities at this age significantly enhances learners' interest and understanding in Science lessons, as demonstrated by third-grade learners who showed great enthusiasm after participating in STEM lessons. Taken together, these insights underscore the importance of incorporating STEM-based models in elementary classrooms as they are developmentally appropriate and effective in fostering meaningful engagement and lifelong interest in Science, Technology, Engineering, and Mathematics.

Table 4.1.1 Frequency and Percentage Distribution of the Respondents of the Demographic Profile in terms of Age (n=34)

AGE	FREQUENCY	PERCENTAGE
7	2	5.88
8	18	52.94
9	9	26.47
10	3	8.82
11	1	2.94
12	1	2.94

Gender

Table 4.1.2 presents the frequency and percentage distribution of the respondents according to their gender. The result revealed that male learners comprise the majority of the respondents, representing 52.94% or eighteen (18) of the total class, while females account for 47.06% or sixteen (16). Given that gender distribution may have an impact on classroom participation and engagement patterns, this slight predominance of boys should be taken into account when interpreting the study. Regardless of gender, middle childhood students are in the Concrete Operational Stage, where they acquire the logical thinking and problem-solving skills required for structured learning, according to Piaget (1972).

This finding is consistent with the study of Hewitt and Forcino (2025), which showed that during pre-instruction of STEM lessons, boy learners demonstrated greater interests in Science and Engineering than their female counterparts. Additionally, a 2023 study by the National Center for Science and Engineering Statistics (Emembolu, 2020) reveals that men make up a greater share of the STEM workforce than women, showing that women are less likely to enter the STEM field. The study also suggests that young students getting exposure to STEM can have a positive impact on their interest in the subjects, leading to an increase in the possibility of students pursuing STEM careers in the future.

This finding highlighted that early exposure to STEM education can positively impact students' interest in the subjects and should therefore be incorporated in elementary school classrooms. It also suggests a pre-existing gender difference in interest in Science and engineering among the respondents.

Table 4.1.2 Frequency and Percentage Distribution of the Respondent of the Demographic Profile in terms of Gender (n=37)

GENDER	FREQUENCY	PERCENTAGE
Male	18	52.94
Female	16	47.06

Pretest and Posttest Score Results of the Respondents

Table 4.2 presents the results of the pretest and posttest administered to the respondents. As reflected in the pretest results, twenty (20) respondents, representing 58.82% of the total class, obtained scores ranging from 11 to 15, which were interpreted as Highly Achieved. Ten (10) respondents or 29.41% obtained scores ranging from 6–10, corresponding to the interpretation of Moderately Achieved. Furthermore, three (3) respondents or 8.82% attained scores ranging from 16–20, interpreted as Very Highly Achieved, while one (1) respondent or 2.94% obtained a score ranging from 1–5, categorized as Not Achieved.

These findings indicate that only a limited number of respondents demonstrated high academic performance before the integration of the 5E Lesson Plan within the Localized Context-Based STEM Approach.

In contrast, the posttest results presented in Table 4.3 revealed a marked improvement in the respondents' performance. Twenty-eight (28) respondents, representing 82.35% of the total class, obtained scores ranging from 16–20, interpreted as Very Highly Achieved, while six (6) respondents or 17.65% attained scores ranging from 11–15, corresponding to the interpretation of Highly Achieved. Notably, none of the respondents fell under the categories of Moderately Achieved or Not Achieved in the posttest results.

The improvement observed in the pupils' posttest scores suggests that the localized context-based STEM approach integrated with the 5E learning cycle may have supported deeper conceptual understanding among Grade 3 learners through inquiry-driven and experiential learning activities. The findings support Constructivist Theory, which emphasizes that learners develop understanding through active engagement, exploration, and interaction with meaningful experiences. Through the localized STEM activities, learners were able to connect scientific concepts to familiar community-based situations, thereby supporting meaningful learning.

This finding is consistent with the study of R. V. Mendaño and R. J. T. Laceda (2025), who found that inquiry-based instructional models improve conceptual understanding through active learner participation, guided inquiry, and experiential learning activities.

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Table 4.2 Pretest and Posttest Score Results of the Respondents (n=34)

Score	Pretest		Posttest		Verbal Interpretation
	f	%	F	%	
16-20	3	8.82	28	82.35	Very Highly Achieved
11-15	20	58.82	6	17.65	Highly Achieved
6-10	10	29.41	0	0.00	Achieved
1-5	1	2.94	0	0.00	Not Achieved

Figure 4.1 presents the line graph illustrating the comparison between the respondents' pretest and posttest results in the Science lesson using the 5E Lesson Plan integrated into a Localized Context-Based STEM Approach. As reflected in the graph, the respondents generally obtained lower scores in the pretest, with only a few learners classified under the Very Highly Achieved category, while some respondents fell under the Not Achieved category.

In comparison, the posttest results showed higher scores across most respondents. A greater number of learners were classified under the Very Highly Achieved category, while no respondents remained in the Not Achieved category. The comparison between the pretest and posttest results indicates an improvement in learners' performance following the implementation of the intervention. The consistently higher posttest scores suggest that the integration of the 5E Lesson Plan within a Localized Context-Based STEM Approach may have contributed to learners' improved conceptual understanding in Science lessons.

This finding is consistent with the study of Holmes et al. (2021) which suggest that the contextual and localized application of lessons can support learners' retention and facilitate the transfer of knowledge across different situations, particularly when learning experiences are connected to meaningful real-world contexts.

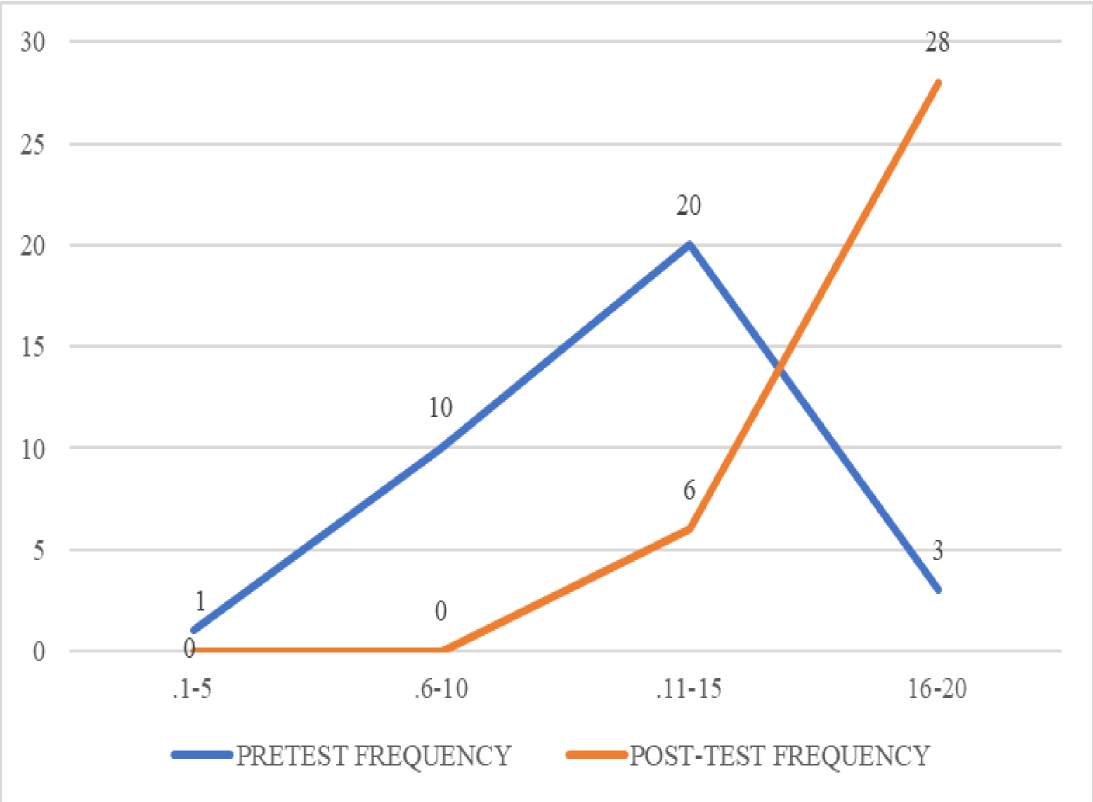

Figure 4.1 Line Graph of the Respondents' Pretest and Posttest Scores

Difference Between the Pretest and Posttest Scores of the Respondents

Table 4.3 presents the results of the Wilcoxon Signed-Rank Test conducted to determine the difference between the respondents' pretest and posttest scores. The computed Z-value of -5.10 exceeded the critical value of ±1.96

at the 0.05 level of significance. The negative direction of the Z-value indicates that the posttest scores were generally higher than the pretest scores. Furthermore, the obtained p-value of 0.001 ($p < 0.05$) indicates that the difference between the two sets of scores was statistically significant. Based on these results, the null hypothesis stating that there was no significant difference between the pretest and posttest scores was rejected.

The findings indicate that the respondents obtained relatively higher scores in the posttest compared to the pretest following the implementation of the 5E Lesson Plan integrated into a Localized Context-Based STEM Approach. This suggests that the intervention may have contributed to improvements in learners' conceptual understanding of Science concepts.

This finding is consistent with the study of Putra et al. (2020), which examined the implementation of the 5E learning cycle strategy in enhancing pupils' conceptual understanding and learning motivation in Physics. The study reported that the instructional model encouraged active learner participation through a sequence of learning stages, which supported learners' understanding of the subject matter.

Additionally, beyond the use of a learning model such as the 5E learning cycle, effective instructional approaches are essential in fostering scientific attitudes and improving pupils' science learning outcomes. Research shows that both 5E-based instruction and contextualized STEM approaches significantly enhance students' conceptual understanding and engagement in science (Eroğlu & Bektaş, 2022; Montero & Geducos, 2022).

One such approach is STEM, which integrates Science, Technology, Engineering, and Mathematics as a key component of the 21st-century education.

Table 4.3 Difference between the Pretest and Posttest Results of the Respondents. (n=34)

p-value	**Z-value**	**Level of Significance**	**Discussion**
0.001*	-5.10	0.05	$H_{\circ}$. Rejected

Note: **significant

Evaluation Result of the Water Filter Prototype.

Table 4.4 presents the evaluation results of the Water Filter prototype of the respondents according to their group. The Water Filter prototype is a self-made water filtration system that uses readily available materials to remove impurities and contaminants from water. DIY water filters can be a cost-effective and creative way to purify water, especially in emergencies or areas with limited access to clean water. The respondents were divided into two groups, where each group drew their own design of a water filter using local and recyclable materials. Using their design, each group made its own version of a water filter.

The prototype of the two groups was evaluated by four (4) Science teachers from Sultan Naga Dimaporo Memorial Integrated School, together with six (6) invited visitors who served as guest judges. The projects were assessed based on three significant factors: creativity and relevance, use of local, recyclable, and affordable materials, and teamwork and presentation. The groups had the opportunity to present their work, explain how it functioned, and respond to questions from the panel. This gave the evaluators a clearer view of how well the students understood and applied their concepts.

Following the demonstrations, the judges shared their feedback. They were impressed by the creativity and effort that went into the projects, the collaboration between group members, and the effective utilization of recycled and low-cost materials. However, they offered recommendations for improvement, including simplifying the explanation for ease of understanding, enhancing confidence during presentation, and developing the design for better function and appearance.

When the scores were tallied, Group 2 came out on top with a total of 118 points or 98.33%, showing excellent creativity and teamwork, while Group 1 followed closely with 115 points or 95.83%, also performing very well.

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Both groups were praised for their hard work and were reminded that the main goal of the activity was not only competition but also learning, collaboration, and improvement.

The localized and hands-on STEM activities may have enhanced learners' engagement and conceptual understanding by allowing pupils to apply scientific concepts to real-world and community-based situations. This supports the findings of J. C. R. Bolanio and R. V. Mendaño (2025), who emphasized that contextualized STEM activities and experiential tasks strengthen learners' problem-solving skills and active participation.

Table 4.4 Evaluation Result of the Water Filter Prototype

Group	Percentage	Description	Verbal Interpretation
Group 1	98.33	Excellent	Outstanding
Group 2	95.83	Excellent	Outstanding

Group 1

Figure 4.7 Water Filter Prototype of Group 1

Group 2

Figure 4.8 Water Filter Prototype of Group 2

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When the scores were tallied, Group 2 came out on top with a total of 118 points or 98.33%, showing excellent creativity and teamwork, while Group 1 followed closely with 115 points or 95.83%, also performing very well. Both groups were praised for their hard work and were reminded that the main goal of the activity was not only competition but also learning, collaboration, and improvement.

Respondents' Level of Engagement Based on the Survey Questionnaire.

Table 4.5 presents the results of the respondents' level of engagement during the intervention. The findings revealed that all indicators obtained weighted mean scores ranging from 2.34 to 3.00, with corresponding interpretations of Highly Engaged. The highest weighted mean of 3.00 indicated that the respondents generally demonstrated positive engagement during the implementation of the 5E Localized Context-Based STEM lesson, particularly in activities involving local examples, group work, and experiments, which also appeared to support learners' attention throughout the Science lesson.

Meanwhile, the indicator related to sharing ideas obtained the lowest weighted mean of 2.90, which was likewise interpreted as Highly Engaged. This indicates that all measured aspects of learner engagement remained at a relatively high level during the intervention.

The observed level of learner engagement may be associated with the integration of localized and inquiry-based STEM activities that encouraged participation, collaboration, experimentation, and the application of concepts to real-life situations. The incorporation of familiar community contexts and locally available materials may have contributed to learners' interest and participation, as these enabled pupils to relate the Science lessons to their own experiences and environment.

This finding is consistent with the study of Mendaño and Laceda (2025), which reported that inquiry-based instructional models can support learner engagement through opportunities for exploration, questioning, and collaborative interaction. The study also noted that experiential STEM activities and contextualized engineering tasks may contribute to learners' participation, creativity, and problem-solving skills. In the present study, the prototype-making activity provided learners with opportunities to engage with scientific concepts through hands-on experiences, which may have supported their participation throughout the intervention.

Overall, the findings suggest that the integration of a Localized Context-Based STEM Approach within the 5E learning cycle may provide a learning environment that supports learner participation and conceptual understanding in Science lessons.

Table 4.6 Respondents' Level of Engagement Based on the Survey Questionnaire (n=34)

Indicators	Weighted Mean	Interpretation
I enjoyed the Science lessons that used local stories or examples.	3.00	Highly Engaged
The hands-on activities helped me understand Science better.	2.97	Highly Engaged
I felt excited to join group work and experiments during the Science lessons.	3.00	Highly Engaged
The lessons made me curious and ask more questions about Science.	2.97	Highly Engaged
I was able to focus and pay attention during the whole Science lesson.	3.00	Highly Engaged
I liked using things from our community or environment in our Science activities.	3.00	Highly Engaged
I shared my ideas and helped my classmates during Science activities.	2.9	Highly Engaged
The steps of the lesson (Explore, Explain, etc.) helped me learn Science well.	2.91	Highly Engaged
I felt confident to do the experiments or activities by myself.	3.00	Highly Engaged

I look forward to Science lessons like this again.	2.97	Highly Engaged
Grand Weighted Mean **2.97**		**Highly Engaged**

Legend: 1:00-1.66 Not Engaged 2.34-3.00 Highly Engaged 1.67-2.33 Engaged

DISCUSSION

The 5E Localized Context-Based STEM education model produced positive results in terms of student academic performance, engagement, and application of scientific concepts. The respondents, who were primarily 8-year-old Grade 3 students, who are in a developmental stage, based on the data results of the Level of Engagement survey, said that the 5E Localized Context-Based STEM Approach allowed them to participate successfully in structured learning activities and regional STEM-Based activities. This result is in line with Piaget's Cognitive Development Theory, which places students between the ages of 7 and 11 in the Concrete Operational Stage, which is when logical reasoning, categorization, and problem-solving abilities start to emerge (Piaget, 1972; McLeod, 2018).

Following the use of the localized STEM method, learners' science achievement clearly improved, according to the pretest and posttest results. The majority of students had already shown a basic grasp of science topics before to the intervention, although one respondent received a score in the "Not Achieved" range. However, posttest findings indicated a change toward higher achievement levels following the implementation of the 5E Localized Context-Based STEM education. Every student received ratings in the "Highly Achieved" to "Very Highly Achieved" ranges, demonstrating increased comprehension of the course material. This improvement implies that scientific concepts were better understood and retained when science training was contextualized using well-known environmental challenges.

The results of the Wilcoxon Signed-Rank Test, which was used to compare the respondents' pretest and posttest scores, further supported the intervention's efficacy. At the 0.05 level, the calculated Z-value of -5.10 is greater than the critical value of ‡1.96. The Z-value's negative sign suggests that the posttest results were often better than the pretest results. The result is statistically significant because the test's p-value was 0.001 ($p < 0.05$). This implies that the respondents' conceptual grasp of the science findings had improved as a result of the intervention.

According to the findings, students were very involved in the localized STEM programs during their implementation. A "Highly Engaged" level of engagement was indicated by the total weighted mean of 2.97. Students showed great focus throughout class discussions, enthusiasm for practical tasks like designing and building prototypes, and active participation in group activities. These results demonstrate how including collaborative STEM activities and real-world environmental challenges in the 5E class successfully piqued students' interest and maintained their involvement. Even the indication with the lowest rating-sharing ideas obtained a weighted mean of 2.9 (Highly Engaged), suggesting that students were still highly engaged in even the least-rated facet of engagement. However, the 5E Localized Context-Based STEM method produced an interesting and learner-centered classroom environment, as evidenced by the overall high level of engagement.

Through project-based learning, the STEM lesson exemplar's execution also led to the meaningful application of information. Using locally sourced and recyclable materials, students successfully designed and built a prototype water filter. With percentage ratings ranging from 95.83 to 98.33, the examination of the prototypes revealed exceptional performance in every group. These findings show how students may apply STEM (science, technology, engineering, and mathematics) concepts to solve environmental issues in the real world while utilizing recyclable and local resources.

This suggests that learners' academic performance, engagement, and practical application of science concepts may possible improve by the 5E Localized Context-Based STEM teaching strategy. Inquiry-based learning, practical STEM projects, and local environmental challenges were integrated to create meaningful learning opportunities that encouraged environmental stewardship, critical thinking, and teamwork. These results confirm that 5E Localized and Context-Based STEM instruction is a successful method for teaching Science 3 and helping elementary students achieve relevant and meaningful learning objectives.

CONCLUSION

The majority of Grade 3 respondents were 8 years old, and male pupils marginally outnumbered female pupils, according to an analysis of the data from the use of 5E Localized Context-Based STEM Approach. Learners' achievement and engagement were positively impacted by the intervention, which included incorporating 5E Localized Context-Based STEM activities into classroom instruction. The comparison of pretest and posttest results showed a statistically significant improvement, indicating that the approach effectively enhanced pupils' conceptual understanding of scientific concepts. Learners actively participated in contextualized learning activities that connected science concepts to real-world experiences, including a DIY Water Filtration system prototype using recyclable materials, educational posters, and group reporting that emphasized the value of water as a means of survival.

These activities improved pupils' understanding of applied science in their everyday lives while also encouraging creativity, critical thinking, and teamwork. With posttest scores considerably higher than pretest scores and notable improvements in conceptual understanding and science process skills, quantitative data validated the approach's efficacy. Increased motivation, engagement, and enjoyment in studying science through hands-on activities were noted in the learners' survey responses.

In summary, the findings of the study indicate that integrating the 5E lesson model within a localized context-based STEM approach may support the development of conceptual understanding and learner engagement in Science 3. The inquiry-oriented and experiential nature of the intervention provided opportunities for pupils to actively construct knowledge through hands-on activities, collaboration, and contextualized problem-solving tasks.

The significant improvement observed between pretest and posttest scores suggests that the intervention holds promise as a learner-centered instructional approach for elementary Science education. However, considering the limitations associated with the one-group experimental design, the findings should be interpreted with caution and should not be viewed as definitive evidence of causality.

Future research employing larger samples, comparison groups, and longer intervention periods is recommended to further examine the effectiveness of localized context-based STEM instruction integrated with inquiry-driven learning models.

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