

Effect of Gender on Students' Biology Achievement When Taught Using Practical Activity-Based Approach in Secondary Schools in Meru County, Kenya

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ABSTRACT

This study investigated whether gender operates as a moderating variable on students' academic achievement, science process skill acquisition, and learning motivation in biology when instructional delivery is driven by practical activity-based approaches. A quasi-experimental, non-equivalent control group design was executed, utilizing a sample framework of 96 Form Two students purposively sampled from two single-gender County secondary schools in Meru County, Kenya. Empirical data collection was facilitated through three structurally validated instruments: the Biology Achievement Test (BAT), the Observation Checklist for Skills Acquisition (OCFSA), and the Biology Motivation Questionnaire (BMQ). Inferential evaluation via independent samples t-tests and Mann-Whitney U testing revealed no statistically significant post-test differences between male and female cohorts across any of the three measured learning domains ($p > 0.05$). These findings demonstrate the gender-neutral efficacy of experiential learning frameworks, indicating that active pedagogical dimensions benefit learners with equal structural potency regardless of gender. Based on these insights, the study recommends that biology teachers actively integrate hands-on, activity-driven lessons into daily classroom practice to cultivate balanced performance matrices. Furthermore, curriculum designers are urged to engineer gender-responsive experiential frameworks, while educational administrators must prioritize the equitable distribution of foundational laboratory resources to support sustainable science education.

Keywords: Gender, Academic achievement, Science process skills, Motivation, Practical activity-based approach.

INTRODUCTION

The question of gender differences in science education has long been debated. For many years, boys were often assumed to perform better in analytical reasoning and practical manipulation, while girls were thought to struggle with abstract concepts. These stereotypes shaped classroom expectations and sometimes reinforced unequal participation in science subjects. However, recent scholarship increasingly challenges such assumptions, showing that disparities in science learning are more closely linked to instructional pedagogies, teacher attitudes, and classroom environments than to inherent gender differences (Nyongesa, 2023). When learners are exposed to inclusive, learner-centered approaches, gender gaps in academic achievement, science skill acquisition and motivation tend to diminish.

Biology, as a foundational science subject in Kenya's secondary schools, provides a useful lens for examining gender issues. Despite its importance in preparing students for careers in medicine, agriculture, biotechnology, and environmental conservation, achievement in biology has remained consistently low both nationally and in Meru County. According to the Kenya National Examinations Council (KNEC, 2024), national mean scores in biology between 2020 and 2024 ranged from 18.93% to 27.02%, far below the 50% required for a C+ grade. Similarly, Meru County recorded mean scores below 30% during the same period, with the highest being 25.86% in 2024 (Meru County Education Office, 2025). These results highlight persistent challenges in

instructional effectiveness and raise questions about whether gender contributes to the observed underachievement.

The Competence-Based Curriculum (CBC) emphasizes inclusivity and learner-centered approaches, encouraging teachers to adopt strategies that engage all learners actively. Practical activity-based approaches, such as experiments, fieldwork and collaborative projects, are designed to move students away from rote memorization and toward inquiry, discovery and skill development. Oliveira and Bonito (2023) argue that such approaches foster observational and manipulative skills essential for scientific inquiry. By focusing on hands-on experiences, practical activity-based approaches may reduce the influence of gender stereotypes, since both boys and girls are equally involved in tasks that demand observation, experimentation, and interpretation.

Globally, countries such as the United Kingdom, United States, and Ireland have prioritized practical activity-based approaches in science curricula to boost scientific literacy and critical thinking (Ntawuhiganayo & Nsanganwimana, 2022). Frequent exposure to practical tasks in these systems correlates with improved student motivation and sustained interest in science-related careers. In Africa, similar pedagogical shifts are evident. Studies in Ghana, Nigeria, and Rwanda have linked practical activities to improved academic achievement, science process skills, and student motivation (Mukasa & Namusoke, 2024; Azode & Okoli, 2024). However, challenges such as limited resources and large class sizes hinder consistent implementation. In Kenya, despite curriculum emphasis on student-centered learning, practical work is inconsistently applied due to overcrowded classrooms, inadequate laboratory facilities and insufficient teacher training (Wambasi, 2023).

Motivation is another critical dimension of learning where gender differences have been observed. Intrinsic motivation, driven by curiosity and interest, and extrinsic motivation, fueled by grades or rewards, both play vital roles in sustaining effort (Anwer, 2019). Practical activities often enhance intrinsic motivation by making learning enjoyable and relevant. Musyoka and Wambua (2021) note that discovery-based tasks encourage active participation and foster stronger engagement. Importantly, such motivation is not inherently gendered; rather, it depends on how lessons are structured and delivered. When both boys and girls are equally engaged in inquiry-based tasks, they are more likely to persist and succeed.

Science process skills, such as observing, classifying, measuring, experimenting, and interpreting data, are equally central to biology education. Studies in Nigeria and Ethiopia show that inquiry-based instruction significantly improves these skills and fosters scientific attitudes (Tsobaza & Njoku, 2021; Dagnew & Sitotaw, 2019). Yet, many classrooms still rely on teacher-centered approaches that emphasize content delivery over skill development (Nyaga & Gitonga, 2023). Even when practical components are included, they often lack structure and depth. Indoshi (2021) observes that KCSE practical assessments tend to focus on procedural recall rather than conceptual understanding, leading to superficial learning. This gap underscores the need for pedagogical innovation that benefits all learners equally, regardless of gender.

Against this backdrop, the present study sought to examine whether gender significantly influences students' academic achievement, science process skills and motivation in biology when taught using a practical activity-based approach. By focusing on Meru County, where biology achievement has remained low, the study provides insights into whether gender disparities persist under effective innovative teaching approaches or whether practical approaches can serve as a leveling force, ensuring equitable outcomes for all learners.

METHODOLOGY

Location of the Study

The research was conducted in Meru County, located in the Eastern region of Kenya. Geographically, the county lies on the northeastern slopes of Mount Kenya and extends toward the eastern lowlands, offering a diverse ecological and educational setting. Meru was selected as the study site not only because of its persistent low achievement in biology but also because it represents the broader challenges faced by many counties across Kenya in science education. Analysis of Kenya Certificate of Secondary Education (KCSE) results between 2020 and 2024 consistently indicates that Meru County, alongside several other counties, recorded mean scores below 30% in biology (KNEC, 2024; Meru County Education Office, 2025). These

results mirror the national trend of underachievement in science subjects and underscore the urgency of identifying effective instructional strategies. Consequently, Meru County provides a representative case for examining the efficacy of practical activity-based approaches in improving students' motivation and performance in biology.

Research Design

This study adopted a quasi-experimental research design, specifically utilizing a non-equivalent group framework. This methodological approach is particularly well-suited for educational research environments where the restructuring of established institutional class streams via individual randomization is neither feasible nor pedagogically desirable (McCoy, 2025). By utilizing intact, pre-existing school cohorts, the study safely preserved the naturalistic classroom environment while systematically isolating the outcomes associated with the instructional intervention. The research configuration involved two distinct experimental streams, comprising one all-male and one all-female class, both of which were exposed to the practical activity-based instructional treatment for a continuous duration of six weeks on the topic of Gaseous Exchange. Baseline metrics were established via a pre-test prior to the intervention, and subsequent changes were determined through a post-test administered at the end of the instructional period. The operational layout of this quasi-experimental design is illustrated in Figure 1.

Group	Pre-test	Treatment	Post-test
Experimental Group E1	O1	X	O3
Experimental Group E2	O2	X	O4

Figure 1: Non-equivalent Group Design

Where:

X represents the instructional treatment using the practical activity-based approach.

E₁ and E₂ represent the male and female intact experimental groups, respectively.

O₁ and O₂ represent the pre-test diagnostic baselines for the male and female groups.

O₃ and O₄ represent the corresponding post-test outcome for each gender group.

In classroom execution, the experimental groups were drawn from separate single-gender County secondary schools. The intervention was conducted entirely within normal school operating hours and delivered by the students' regular biology teachers, ensuring that the participants remained unaware of the experimental observations, thereby eliminating potential Hawthorne effects and safeguarding the internal validity of the study.

Target Population and Sampling Procedures

The target population comprised 20,166 Form Two students across 192 public secondary schools in Meru County (Meru County Education Office, 2024). The accessible population comprised 4,872 Form Two students in 63 County secondary schools. Two single-gendered County schools were purposively selected, giving a study sample of 96 students. The distinction is therefore made explicit: 20,166 students and 192 schools refer to the target population, whereas 4,872 students and 63 schools refer to the accessible population from which the two sampled schools were drawn.

Public secondary schools in Meru County are classified as National, Extra County, County, and Sub-County schools. For this study, County schools were purposively selected because of their academic performance in biology, accessibility, and laboratory status. The selected schools were stratified by gender to ensure that the study included male and female learners.

The study comprised two Experimental groups (E1 and E2). All groups completed pre-tests at the beginning of the study. Where a school had more than one biology stream, the streams used the same teaching approach, but one stream was selected for analysis through a random draw. The intervention lasted six weeks, after which post-tests were administered.

Creswell and Creswell (2018) emphasize that sample size depends on research design and objectives. Campbell and Stanley (2015) recommend at least 30 participants per group in quasi-experimental studies, though larger samples enhance validity and reduce bias. To ensure representativeness, the ministry's guideline of 45 students per class was adopted, yielding an expected sample size of 96 students across the two selected County schools, as shown in Table 1.

Table 1: Sampling Grid for Schools and Students

	Schools	Students
Accessible Population	63	4,872
Sample	2	96

Data in Table 1 shows the sampling frame used for the accessible population and the final school and student sample size. The accessible population was 4,872 students in 63 County secondary schools, from which two schools and 96 students were selected.

Research Instruments

Three instruments were used: the Biology Achievement Test (BAT), Biology Motivation Questionnaire (BMQ), and Observation Checklist for Skills Acquisition (OCFSA). The instruments were aligned to the three study outcomes: academic achievement, motivation, and science process skills. Measured using Kuder-Richardson Formula 20 (KR-20), the BAT had a reliability coefficient of 0.710. The motivation scale yielded a Cronbach Alpha value of 0.901 for the BMQ. The OCFSA instrument for science process skills recorded a high alpha value of 0.975. These high alpha values indicate acceptable internal consistency in evaluating students' achievements. According to Creswell and Creswell (2018), a reliability coefficient of 0.7 or higher is considered acceptable for educational research. Therefore, the instruments were highly dependable for the study.

Data Analysis

Data were analyzed using SPSS version 27.0. Descriptive statistics (means, standard deviations, and, where appropriate, mean ranks) were used to summarize the outcome variables. Independent-samples t-tests were used for the reported achievement comparisons, while Mann-Whitney U tests were used for the reported science process skills and motivation comparisons. Statistical significance was assessed at $\alpha = 0.05$.

RESULTS AND DISCUSSION

A total of 96 students participated in the study. The sample included male and female learners in their distinct groups. Table 2 presents the gender distribution used for the study.

Demographic Distribution and Participation Frameworks

Information in Table 2 presents the gender distribution of the 96 student participants.

Table 2: Gender Distribution by Group

	Gender		Total
	Male	Female	
Experimental Groups	49	47	96
Total	49	47	96

Data in Table 2 show that both male and female students were nearly equally represented in the Experimental groups. This balance ensured that gender was adequately accounted for in the study, allowing fair comparisons across teaching approaches. Based on the data in Table 2, the response rate was tabulated in Table 3.

Table 3: Response Rate by Group

Category	Number targeted	Number that responded	Percentage
Experimental Group 1	45	49	108.89%
Experimental Group 2	45	47	104.44%
Total	90	96	106.66%

The results indicate that Experimental Group 1 achieved a response rate of 108.89%, while Experimental Group 2 recorded 104.44%. Overall, 96 out of the 90 targeted students participated, yielding a 106.66% response rate. Since the overall response rate exceeded the commonly accepted threshold of 70% for educational research, it was considered both adequate and excellent. This high level of participation provided a strong basis for valid statistical analysis and reliable inferences regarding the impact of the practical activity-based approach on student motivation and achievement.

Gender Comparison in Academic Achievement

Beyond practical activity-based effects, this section explores whether gender influenced students' academic achievement, science process skills, and motivation. Table 4 employs an independent samples t-test to examine gender-based differences in academic achievement prior to the pedagogical intervention.

Table 4: Independent Samples t-Test of Pre-test Academic Achievement by Gender

Group	N	Mean (%)	Std. Deviation	T	df	p-value
Male	49	4.28 (14.25)	2.25306	2.089	94	0.040
Female	47	5.35 (17.85)	2.53897			

The mean achievement score was 4.28 (14.25%) for male students and 5.35 (17.85%) for female students. The reported independent-samples t-test indicated a statistically significant baseline difference, $t(94) = 2.089$, $p = 0.040$. Using the reported raw-score means and standard deviations, the standardized mean difference is approximately Cohen's $d = -0.44$ (male minus female), indicating a moderate baseline difference. This baseline difference is important when interpreting post-test outcomes because a simple post-test gender comparison does not by itself account for initial group differences.

Table 5: Independent Samples t-test of Post-test Academic Achievement by Gender

Group	N	Mean (%)	Std. Deviation	T	df	p-value
Male	49	21.39 (71.29)	4.15740	0.071	94	0.944
Female	47	21.45 (71.49)	4.04221			

In the post-test, male students had a mean score of 21.39 (71.29%), while female students had a mean score of 21.45 (71.49%). The independent-samples t-test showed no statistically significant difference, $t(94) = 0.071$, $p = 0.944$. The corresponding standardized mean difference based on the reported raw-score means and standard deviations is approximately Cohen's $d = -0.01$, indicating a negligible difference.

The findings of the current study are consistent with a range of studies that have examined gender dynamics in science education. Nwuba and Osuafor (2021) investigated the effects of experiential learning on biology achievement in Nigeria Awka Education Zone and found no appreciable gender influence. Similarly, Chabari et al. (2018) reported that a hands-on teaching approach using graphic organizers had no significant impact on achievement or chemistry self-concept across genders, implying that such approaches could reduce gender disparities in science achievement.

Similarly, the results of the present study are consistent with those of Nneji et al. (2024) in Nigeria, who explored the effect of practical work on biology achievement using a pretest/posttest quasi-experimental design

with 219 students. The results indicated that students taught using practical activities significantly outperformed those taught conventionally, and practical activities were equally effective across genders. The conclusion that both male and female students benefitted equally from practical work agrees with the present study evidence that practical activity-based instruction eliminates gender disparities in achievement.

Moreover, the findings of the current study are also in agreement with those of Olayinka *et al.* (2024) in Nigeria, who examined how practical activities influence biology achievement among senior secondary students using a quasi-experimental design with pretest and posttest groups. The results revealed significant improvement in achievement for both male and female students in the practical activity group compared to conventional instruction. The demonstration that practical activities foster equal achievement across genders aligns with the present study conclusion that practical activity-based instruction benefits all students regardless of gender.

The study findings are also consistent with those of Kambaila *et al.* (2019) in Zambia, who investigated the impact of practical work on biology achievement using a quasi-experimental design with 90 students. The results showed that students in the experimental group achieved significantly higher scores than those in the control group, with no significant difference between male and female students. The evidence that practical work benefits both genders equally supports the present study result that practical activity-based instruction bridges gender gaps in achievement.

The results of the present study are congruent with those of Enohuen (2015) in Nigeria, who examined the effect of instructional materials on biology achievement and retention. The findings indicated no significant gender differences in achievement when instructional materials were used. Similarly, Ghumdia (2016) in Borno State found no significant interaction between gender and the acquisition of science process skills when inquiry-based teaching strategies were employed. These conclusions reinforce the present study evidence that instructional approaches, rather than gender, determine achievement outcomes when practical activities are integrated.

In addition, the findings of the present study are also in line with those of Bizimana, Mutangana, and Mwesigye (2022) in Rwanda, who explored concept mapping and cooperative mastery learning in photosynthesis. The results indicated that concept mapping facilitated equal retention among male and female students, while cooperative mastery learning favored female students. The evidence that instructional approaches can balance gender disparities supports the present study conclusion that practical activity-based instruction provides equal opportunities for both male and female students in biology. Similarly, the gender-neutral efficacy established in the current study, concluding that the Practical Activity-Based Approach benefits male and female students equally, is heavily reinforced by Hagos (2026). The meta-analytical findings of that study revealed that student-centered, inquiry-based instructional frameworks yield no significant academic achievement variance based on gender, supporting the current study conclusion that practical activity-based pedagogy acts as an equitable tool for all learners.

The results of the present study are also consistent with those of Osotsi *et al.* (2025) in Kenya, who examined the integration of basic science process skills in biology practical work using a quasi-experimental design with 384 students. The findings revealed that students in the experimental group performed significantly better in biology practical tasks, though the study did not explore gender differences. The evidence that practical activities enhance achievement supports the present study conclusion; while the absence of gender analysis highlights the need for further investigation into whether practical activity-based instruction benefits both male and female students equally.

In Rwanda, Bizimana, Mutangana, and Mwesigye (2022) found that concept mapping led to equal retention of photosynthesis content among male and female students. However, they noted that cooperative mastery learning favored female students, highlighting how instructional strategies can differentially affect gender outcomes. This nuanced finding underscores the importance of selecting pedagogical models that promote equity. The current study findings are consistent with those reported by Giso and Mugwiria (2024), whose investigation into experiential learning in Maara Sub-County, Tharaka Nithi, revealed no statistically significant gender differences in biology achievement. The study outcome reinforces the conclusion that

practical activity-based pedagogies are broadly effective across gender lines. Likewise, Nneji *et al.* (2024) in Nigeria observed that practical activities significantly improved achievement for all students, regardless of gender, and recommended increased investment in hands-on learning resources.

Olayinka *et al.* (2024) also confirmed that practical activities led to higher achievement among both male and female students in Ekiti State, Nigeria. The study emphasized the need for professional development to help teachers implement practical approaches effectively and inclusively. Kambaila *et al.* (2019) in Zambia echoed these findings, reporting no significant gender differences in achievement following practical instruction. In Kenya, Osotsi *et al.* (2025) found that integrating Basic Science Process Skills into biology practical work significantly improved student achievement, further supporting the effectiveness of experiential learning across genders.

In contrast, the findings of the present study differ from those of Ihejiamazuzi *et al.* (2020) in Nigeria, who examined the impact of biology practical activities on achievement using a quasi-experimental design with 120 students. The results revealed significant improvement in achievement for students taught using practical activities, but gender had a significant influence on performance. The conclusion that gender affected achievement conflicts with the present study evidence that practical activity-based instruction benefits male and female students equally. Similarly, Okuakaji and Sukolatambaya (2020) found that male students outperformed females in biology when taught using experiential approaches.

The results of the present study also diverge from those of Almasri (2022) in Kuwait, who investigated gender differences in achievement across conventional, collaborative, and e-learning environments. The findings indicated that female students performed better in single-gender classrooms and collaborative sections, highlighting the influence of sociocultural factors. The study results contrast with the present study findings that practical activity-based instruction eliminates gender disparities, suggesting that contextual and cultural factors may moderate the relationship between instructional approaches and gender achievement.

The findings of the study reported by Bizimana *et al.* (2022) highlight that while concept mapping promotes gender equity, cooperative mastery learning may favor one gender over another. The evidence from this study reinforces the notion that instructional design plays a critical role in shaping gender outcomes in science education. In conclusion, the present study contributes to the growing body of literature indicating that practical activity-based instruction supports equitable academic achievement across genders. The current evidence underscores the importance of inclusive pedagogical strategies and aligns with the goals of Kenya's Competency-Based Curriculum (CBC) which advocates for learner-centered and gender-responsive teaching approaches.

Gender Comparison in Science Process Skills

The gender differences in science process skills were analyzed using the observation records available for the study. For the purpose of observations during laboratory sessions, the male and female students were grouped into 8 and 10 sub-groups respectively for convenience, giving an analysis total of 18 groups. Both male and female students were observed in groups and not individually.

Table 6: Mann-Whitney U Test of Pre-test Science Process Skills by Gender

Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	p-value
Male	8	10.13	81.00	35.000	90.000	0.472	0.637
Female	10	9.00	90.00				
Total	18						

The Mann-Whitney U test showed that male groups had a mean rank of 10.13, compared with 9.00 for female groups. The difference was not statistically significant, $U = 35.000$, $p = 0.637$. The reported standardized effect based on the Mann-Whitney Z value is $r \approx 0.11$, indicating a small effect. The observations represent groups rather than individual students.

Table 7: Mann-Whitney U Test of Post-test Science Process Skills by Gender

Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	p-value
Male	8	10.88	87.00	29.000	84.000	0.998	0.318
Female	10	8.40	84.00				
Total	18						

After the intervention, male groups had a mean rank of 10.88 and female groups had a mean rank of 8.40. The Mann–Whitney U test remained statistically non-significant, $U = 29.000$, $p = 0.318$. The corresponding effect size is approximately $r = 0.24$, a small effect. The result indicates no statistically significant gender difference in the group-level science skill acquisition.

The findings of the current study align with those of Achor and Shaibu (2013) in Nigeria, who reported that guided practical activities enhanced science process skills and motivation equally across genders. Similarly, Musyoka and Wambua (2021) in Kenya found no significant gender differences in motivation and process skill acquisition through inquiry-based learning. Kwarteng (2015) in Ghana also observed comparable gains among male and female students taught using practical activity-based approaches, reinforcing the inclusive nature of such approaches.

Gender Comparison in Motivation

Motivation levels of male and female students were compared before and after the intervention. While males showed higher motivation initially, post-test results revealed no significant gender differences, suggesting that the practical approach helped equalize motivation across genders. Information in Table 8 shows the pre-test motivational level analysis by gender across the sample using the Mann-Whitney U test.

Table 8: Mann-Whitney U Test of Pre-test Motivation by Gender

Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	p-value
Male	49	54.64	2677.50	850.500	1978.500	2.208	0.027
Female	47	42.10	1978.50				
Total	96						

The Mann–Whitney U test showed that male students had a higher mean rank (54.64) than female students (42.10), and the difference was statistically significant, $U = 850.500$, $p = 0.027$. The effect size calculated from the reported Z value is approximately $r = 0.23$, which is a small-to-moderate effect. This indicates a measurable baseline difference in motivation.

Table 9: Mann-Whitney U Test of Post-test Motivation by Gender

Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	p-value
Male	49	46.61	1864.50	875.500	2051.500	0.709	0.479
Female	47	42.74	2051.50				
Total	96						

In the post-test, males had a mean rank of 46.61 and females 42.74. The Mann–Whitney U test showed no statistically significant difference, $U = 875.500$, $p = 0.479$. The corresponding effect size is approximately $r = 0.08$, indicating a very small effect. Thus, the post-test data do not provide evidence of a meaningful gender difference in motivation at the reported level of analysis.

The results indicate that the statistically significant baseline difference in motivation was not present in the reported post-test comparison. The findings of the current study are consistent with those of Teplá and Distler (2025), who examined the long-term effects of inquiry-based science education in the Czech Republic. The study found that such approaches reduced academic pressure and gradually improved student motivation across genders.

However, not all empirical evidence corroborates with the present findings of the study. Enebechi and Ezenwafor (2026) reported gender differences, with female students performing better in practical-based learning and male students excelling in project-based learning. This partially conflicts with the present study finding, which indicated that practical activity-based instruction benefits all learners equally in process skill acquisition regardless of gender.

Similarly, Kinyua and Nyaga (2019) reported gender-based differences in physics practical skills among secondary school learners in Mbeere North Sub-County, Kenya, particularly in activities involving equipment manipulation. Such contrasts with the current study underscore the importance of contextual variables including instructional design, teacher dispositions and resource accessibility in mitigating gender influence within science education.

In conclusion, the results of the current study support the broader empirical evidence that practical activity-based instruction promotes gender-inclusive learning in biology. By eliminating prior disparities and fostering equal achievement, motivation and science skill acquisition, the approach aligns with the goals of Kenya's Competency-Based Curriculum (CBC), which emphasizes equity, engagement, and learner-centered pedagogy. The current study findings advocate for the widespread adoption of practical teaching approaches to ensure inclusive and effective science education for all students.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary of Findings

The study examined gender differences in academic achievement, science process skills, and motivation in biology under practical activity-based instruction. The reported post-test analyses showed no statistically significant gender difference in achievement or motivation. The Mann–Whitney U analyses of science process skills were also non-significant. The baseline analyses indicated significant gender differences in achievement and motivation, making adjustment for pre-test scores important in any stronger test of the instructional effect.

Conclusion

Based on the empirical evidence generated in this study, it is concluded that male and female secondary school students achieve broadly comparable outcomes in biology when instructed through a structured, practical activity-based approach. The non-significant gender variances observed across academic performance, conceptual mastery, and science process skill domains underscore the gender-neutral value of experiential learning models.

While conventional teacher-centered instructions frequently sustain baseline performance gaps due to passive engagement profiles, active learning environments effectively democratize science education. Consequently, the integration of hands-on, collaborative laboratory tasks serves as a leveling force in classroom contexts, ensuring that both male and female learners find equitable opportunities to develop scientific process skills, enhance conceptual retention, and sustain academic motivation within secondary school frameworks.

Recommendations

Based on the study findings, the following recommendations are made:

- i. Biology teachers should embrace the effective use of practical activity-based approaches in classroom settings to establish gender equity across conceptual mastery, skill domains, and learning motivation.
- ii. Curriculum design panels and institutional bodies should structure professional development training focusing on gender-responsive active pedagogy frameworks to help teachers manage practical sessions inclusively.
- iii. School administrators should provide standard, equally accessible materials for science laboratories so that active, continuous experimentation remains a foundational baseline for both boys and girls.

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