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RESEARCH ARTICLE

EFFECTIVE TEACHING-LEARNING STRATEGIES FOR SECONDARY LEVEL SCIENCE EDUCATION

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Abstract

Science Education at the secondary level holds paramount importance as it serves as the foundation for further scientific pursuits. The efficacy of secondary level science education significantly impacts a student's inclination towards higher studies and eventual contribution to scientific and technological advancements. In order to enhance the effectiveness of secondary level science education, it is imperative to explore innovative teaching-learning strategies that transcend traditional lecture-based methods. Research and surveys consistently advocate for activity-based learning approaches over conventional lecture methods, citing their ability to foster deeper understanding and retention among learners. Practical work emerges as a cornerstone of this approach, offering hands-on engagement and experiential learning opportunities. With the recent shift in the academic structure as per the National Education Policy of 2020 (N.E.P-2020), extending the secondary level from grades 9 to 12, there lies a crucial window for students to immerse themselves in scientific exploration and discovery.Subjects such as Physics, Chemistry, and Biology inherently lend themselves to practical applications, presenting ample opportunities for students to engage directly with scientific concepts. By integrating practical work into the curriculum, secondary level science education can cultivate critical thinking, problem-solving skills, and a deeper appreciation for the scientific method. This shift towards practical-based learning not only aligns with contemporary pedagogical trends but also serves as a catalyst for nurturing the next generation of innovators and scientists.

Introduction:-

Emergence of the Study:

As a science teacher, the investigator noticed that students often struggle to achieve the expected learning outcomes when chapters are taught in a traditional way. Many chapters in secondary-level science, like Acid, Base, and Salt in class 9 Chemistry, can be taught more effectively using activity-based strategies. When the investigator explained the concepts of acids, bases, and salts in a traditional manner, students had difficulty understanding and recalling the

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information. However, when practical experiments were conducted in front of them, their comprehension improved significantly.This experience highlighted the potential benefits of teaching science through experiments and hands-on activities. Applying this method to all chapters in Physics, Chemistry, and Biology could make these subjects easier for students to understand. It has become clear that finding an effective method for conceptualizing science at the secondary level is essential. In this study, the investigator aim to identify the best teaching and learning methods for science education at this level, focusing on how experimental and activity-based approaches can enhance student understanding and engagement.

Discussion about Secondary Level Science Education:
In the previous 10 + 2 education system, classes 9 and 10 were considered secondary level, while classes 11 and 12 were higher secondary level. However, after implementation of the National Education Policy (NEP) 2020, classes 9 to 12 are now classified as secondary level. In classes 9 and 10, all students are required to study science subjects, including Physics, Chemistry, Math, Biology, and Computer Science.In classes 11 and 12, students can choose their subjects and opt for different streams such as Science, Arts,commerce etc. Unfortunately, in classes 9 and 10, there are no scheduled laboratory classes for science subjects. Teachers can conduct scientific experiments during science classes, but this depends entirely on their initiative and is not mandatory. As a result, most schools do not teach science subjects through practical work.

This lack of hands-on experience in science education at the secondary level leads to students losing interest in the subject. Consequently, fewer students enroll in higher science education. Implementing practical experiments and activity-based learning could potentially revive interest in science among students and encourage more to pursue it at advanced levels.

Importance of Science Education at Secondary Stage:
Science education is crucial for a nation's development because progress relies on advancements in science and technology. At the secondary stage, students learn basic science, which forms the foundation for future studies. If students find science interesting and enjoyable at this level, they must be more interested in studying it in higher education. The National Education Policy (NEP) 2020 of India emphasizes the importance of science education and the growing demand for STEM (Science, Technology, Engineering, and Mathematics) fields. Here is a relevant quote from the N.E.P-2020: “Curriculum content will thus be reduced in each subject to its core essentials, and make space for critical thinking and more holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning.”Making science education at the secondary stage engaging and fun can lead to more students choosing to study science in the future. Therefore, it is essential for science teachers to be mindful of their teaching methods. They should strive to make science learning joyful, interesting, and activity-based. This approach can spark students' curiosity and interest in science.

Here are a few studies that specifically highlight the importance of practical work in teaching science at the secondary level in West Bengal:

Bandyopadhyay, A. (2013). "Impact of Laboratory Method on Science Achievement of Secondary School Students in West Bengal." Bandyopadhyay's research focuses on the impact of laboratory-based learning on students' science achievement. The study concludes that practical work in laboratories significantly boosts students' conceptual understanding and retention of scientific knowledge.

Bhattacharya, K. (2015). "Role of Practical Work in Science Education: A Study on Secondary Schools in Kolkata, West Bengal." This study investigates the importance of practical work in science education within secondary schools in Kolkata. It highlights that students who participate in hands-on experiments and practical activities show greater enthusiasm and a deeper understanding of scientific principles.

Mukherjee, S. (2016). "Science Teaching in Secondary Schools of West Bengal: The Importance of Practical Work." Mukherjee's study examines the effectiveness of practical work in teaching science in secondary schools across West Bengal. The findings indicate that practical work is essential for developing students' critical thinking and analytical skills.

This study aims to identify the best teaching strategies for secondary-stage science education. The goal is to find effective ways to teach science that will make students enthusiastic about learning. By doing so, we can ensure that

more students will pursue science in higher education, ultimately contributing to the country's progress in science and technology.

Research Questions:
1. What is the impact of practical work on academic achievements of secondary students in science subjects ?
2. How do the availability and quality of laboratory facilities affect students' understanding of science concepts?

Objectives of the Study:-
1. To investigate the impact of practical work on students' academic achievements in science subjects.
2. To determine the influence of laboratory facility availability and quality on students' understanding of science.

Hypotheses of the Study:
HP-1: There is a significant relation between practical work and achievements of pupils.
HP-2: There are requirements of laboratory facilities to understand science education at secondary level.

Methodology of the Study:-

The methodology employed in this investigation is a descriptive survey research approach aims at evaluating the effectiveness of practical work versus traditional lecture-based methods in secondary-level science education. The study encompasses several steps to gather and analyze data effectively.

Population of the Study:
All Class -IX students of all Government sponsored Secondary Schools are the population.3306 schools in West Bengal as per UDISE+,2020-21;there are approx 3 lakh class-IX secondary students in 23 districts of West Bengal as per UDISE,2020-21 are the population of the investigation.The researcher has chosen schools under West Bengal Board of Secondary Education from South 24 PGS and North 24 PGS district in West Bengal.

Sample of the Study:
300 class-IX secondary students from five different schools of South 24 PGS and North 24 PGS districts of West Bengal are sample for this study.

Total 300 students are chosen randomly to conduct the research from the Government sponsored Secondary Schools of West Bengal.

Convenience sampling techniques will be used to select the schools and random sampling techniques will be used to select samples.

Tools of the Study:
Sample Selection:
300 students of class IX from five different secondary schools in South 24 PGS and North 24 PGS districts of West Bengal Board of Secondary Education.
School Types:
One boys' school, two co-educational schools, and two girls' schools.

Group Division:
In each school, 60 students were divided into two groups.
1) Control Group -30 students 2) Experimental Group -30 students.

Teaching Methodology:-
Control Group:
Students received traditional lecture-based teaching for 40 minutes.
Experimental Group:
Students engaged in practical work and experiments for 40 minutes under the guidance of a science teacher.
Achievement Test :
A 20-mark questionnaire was administered to both groups to assess their understanding and academic performance.

Data Collection:
Achievement Test Scores:
Scores from the 20-mark test were collected for both the control and experimental groups.

Z-Score Calculation:
Z-scores were calculated to analyze the differences in performance between the two groups.

Statistical Analysis:
Mean and Standard Deviation:
The mean and standard deviation of the test scores for both groups were calculated.

Z-Scores:
Z-scores were computed to determine the statistical significance of the difference in academic achievements between the control and experimental groups.

Graphical Representation:
Bar Graphs:
Mean scores for control and experimental groups were compared using bar graphs.
Z-Score Graphs:
Graphical representation is shown of Z-scores for all five schools to compare student achievements.

Interviews:
Interviews were conducted with heads of institutions, science teachers, and students to gather qualitative data regarding laboratory facilities and perceptions of practical work.

These tools were employed to comprehensively evaluate the impact of practical work on student achievements in secondary-level science education and to test the study's hypotheses.

Data Analysis & Interpretation of Achievement Tests:
Table 1:-

Dum Dum Kishore Bharati High School,P.S-Dum Dum,North 24 PGS,West Bengal			
Control Group-30 Students (Traditional Teaching)		Experimental Group-30 Students (Practical Based Teaching)	
Mean	S.D	Mean	S.D
7.33333	2.70801	14.73333	2.89986
Z-Score:10.215			

Result Analysis:-
Table -1
The calculated Z-Score of 10.215 exceeds the critical values of 2.58 at the 1% significance level and 1.96 at the 5% significance level, indicating a significant difference between the two groups. The higher mean of the experimental group compared to the control group suggests that teaching through practical work is more effective than traditional methods in improving pupils' achievements.

Table 2:-

Protapnagar Giridhari High School (H.S),P.S-Sonarpur,Dist-South 24 PGS,West Bengal.			
Control Group-30 Students (Traditional Teaching)		Experimental Group-30 Students (Practical Based Teaching)	
Mean	S.D	Mean	S.D
7.06667	2.77841	13.6	2.7114
Z-Score: 9.219			

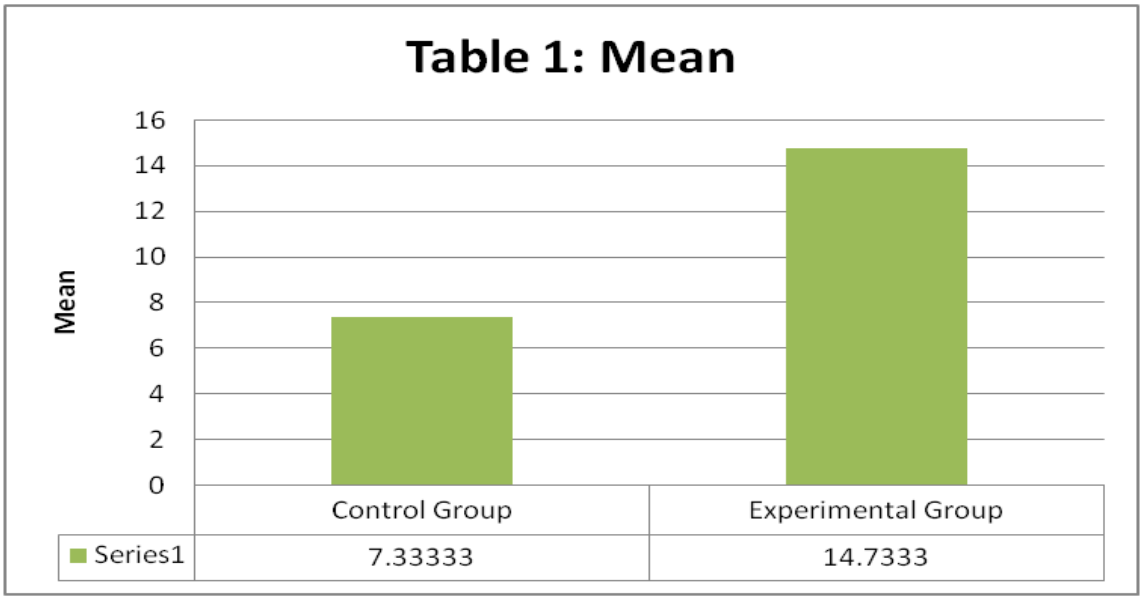


Figure 1:- Comparative study of mean scores for Control Group And Experimental Group by Bar Graph.

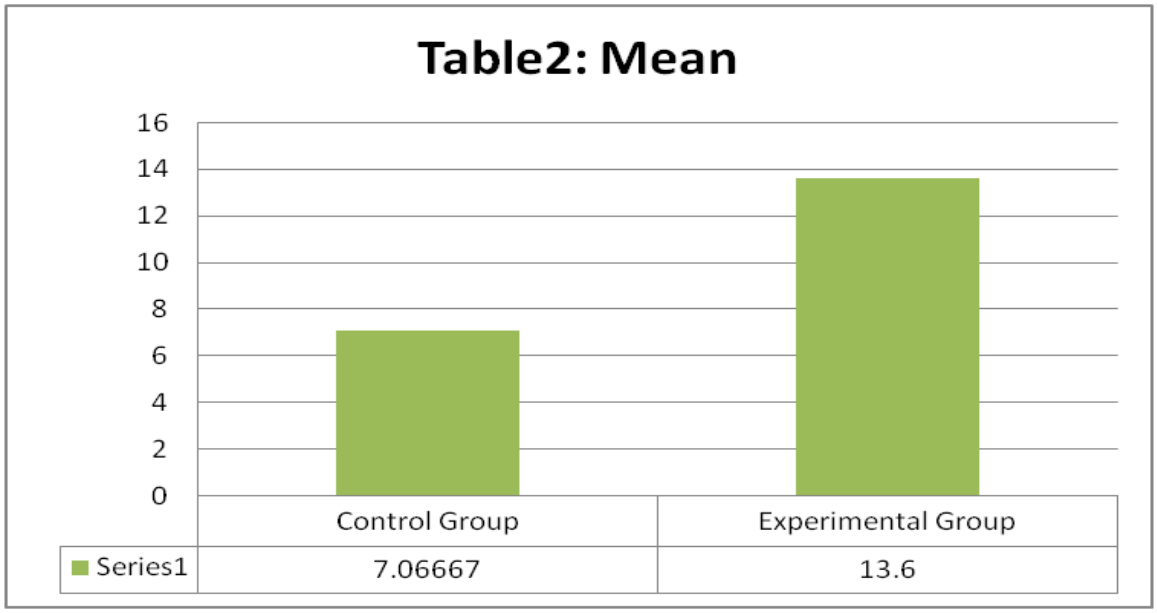


Figure 2:- Comparative study of mean scores for Control Group And Experimental Group by Bar graph.

Result Analysis:-

Table-2

The calculated Z-Score of 9.219 exceeds the critical values of 2.58 at the 1% significance level and 1.96 at the 5% significance level, indicating a significant difference between the two groups. The higher mean of the experimental group compared to the control group suggests that teaching through practical work is more effective than traditional methods in improving pupils' achievements.

Table 3:-

Gorkhara VidyaMandir High School(H.S),P.S-Sonarpur,Dist-South 24 PGS,West Bengal.			
Control Group-30 Students (Traditional Teaching)		Experimental Group-30 Students (Practical Based Teaching)	
Mean	S.D	Mean	S.D

7.3	2.57508	11.7333	2.18037
Z-Score: 7.196			

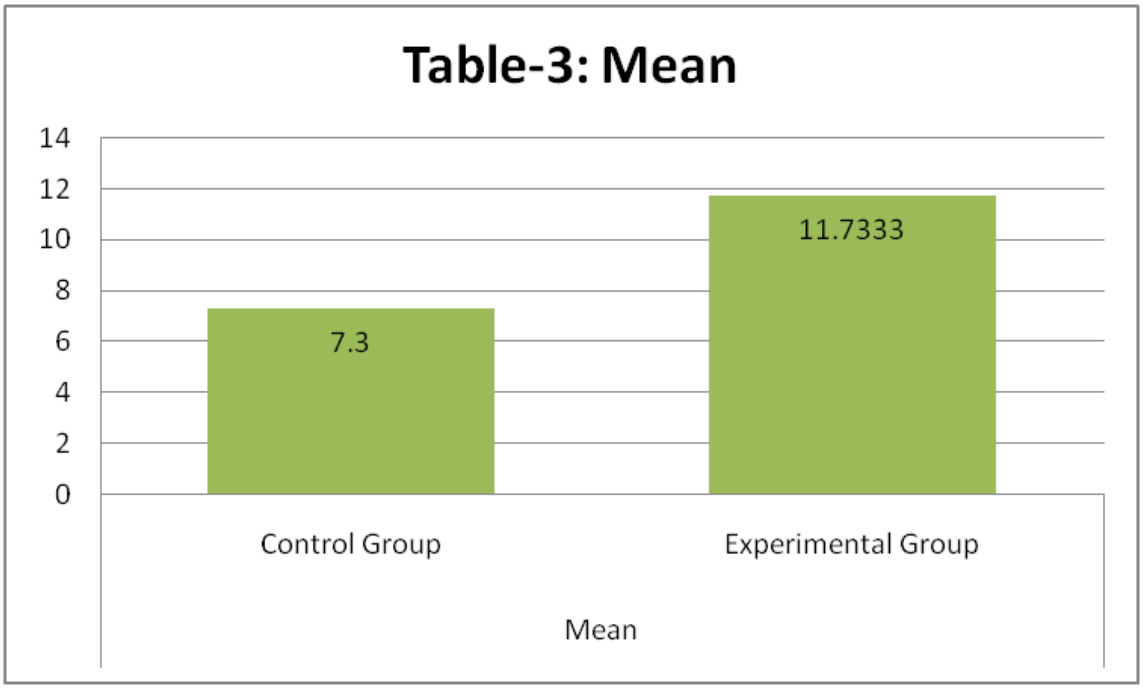


Figure 3:- Comparative study of mean scores for Control Group And Experimental Group of by Bar graph.

Result Analysis:

Table-3

The calculated Z-Score of 7.196 exceeds the critical values of 2.58 at the 1% significance level and 1.96 at the 5% significance level, indicating a significant difference between the two groups. The higher mean of the experimental group compared to the control group suggests that teaching through practical work is more effective than traditional methods in improving pupils' achievements.

Table 4:-

Laskarpur Rabindra Vidyapith For Girls(H.S),P.S-Sonarpur,Dist-South 24 PGS,West Bengal			
Control Group-30 Students (Traditional Teaching)		Experimental Group-30 Students (Practical Based Teaching)	
Mean	S.D	Mean	S.D
7.3	2.5209	13.0	2.7543
Z-Score: 8.36			

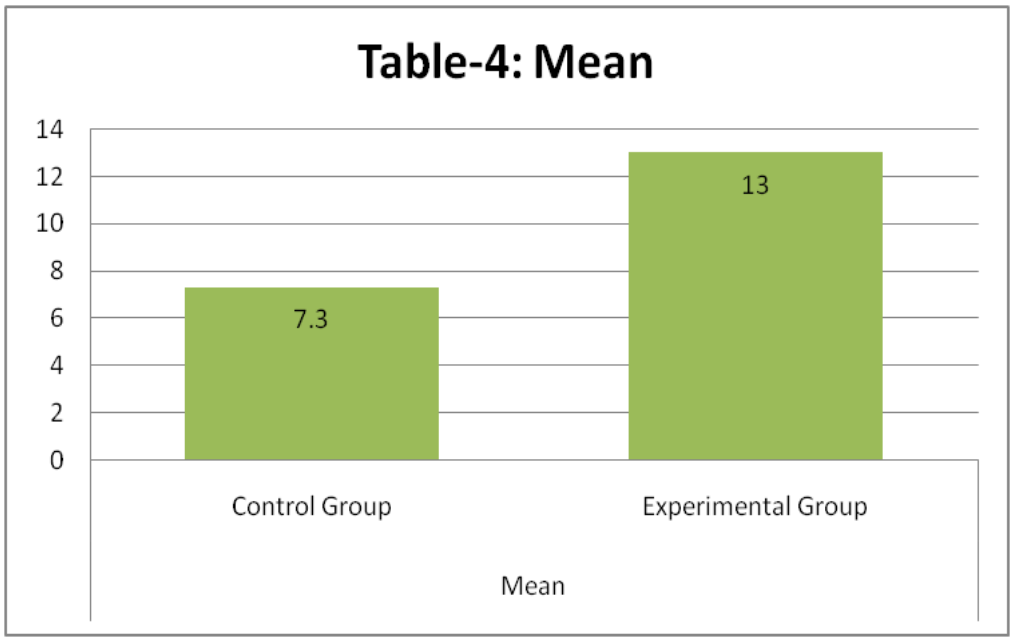


Figure 4:- Comparative study of mean scores for Control Group And Experimental Group of by Bar graph.

Result Analysis:Table-4

The calculated Z-Score of 8.36 exceeds the critical values of 2.58 at the 1% significance level and 1.96 at the 5% significance level, indicating a significant difference between the two groups. The higher mean of the experimental group compared to the control group suggests that teaching through practical work is more effective than traditional methods in improving pupils' achievements.

Table 5:-

Mallikpur Girls' High School (HS),P.S-Baruipur,Dist-South 24 PGS,West Bengal.			
Control Group-30 Students (Traditional Teaching)		Experimental Group-30 Students (Practical Based Teaching)	
Mean	S.D	Mean	S.D
7.1	2.5777	12.4666	2.4457
Z-Score: 8.273			

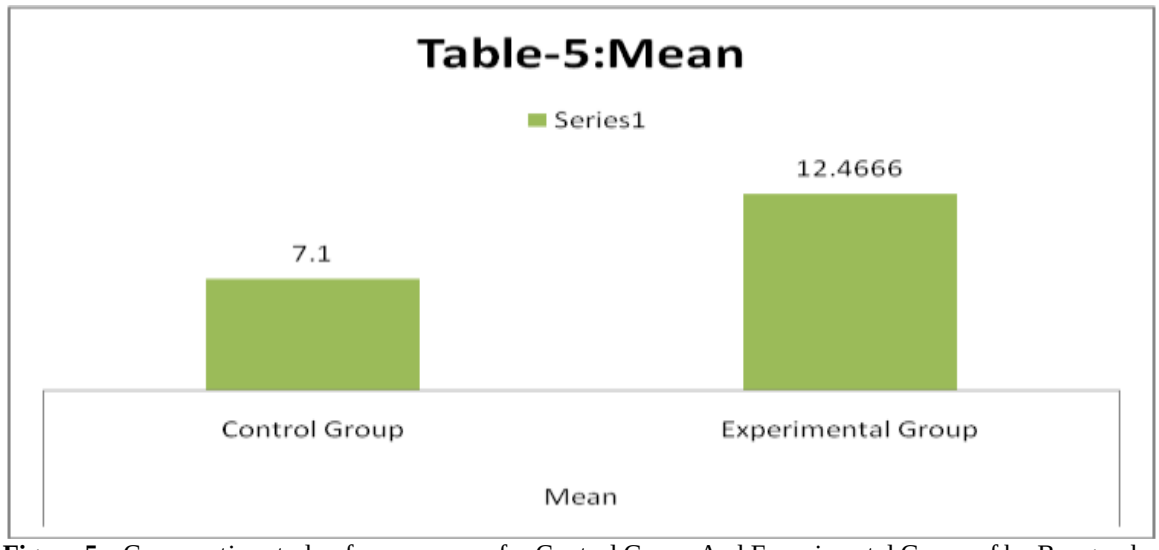
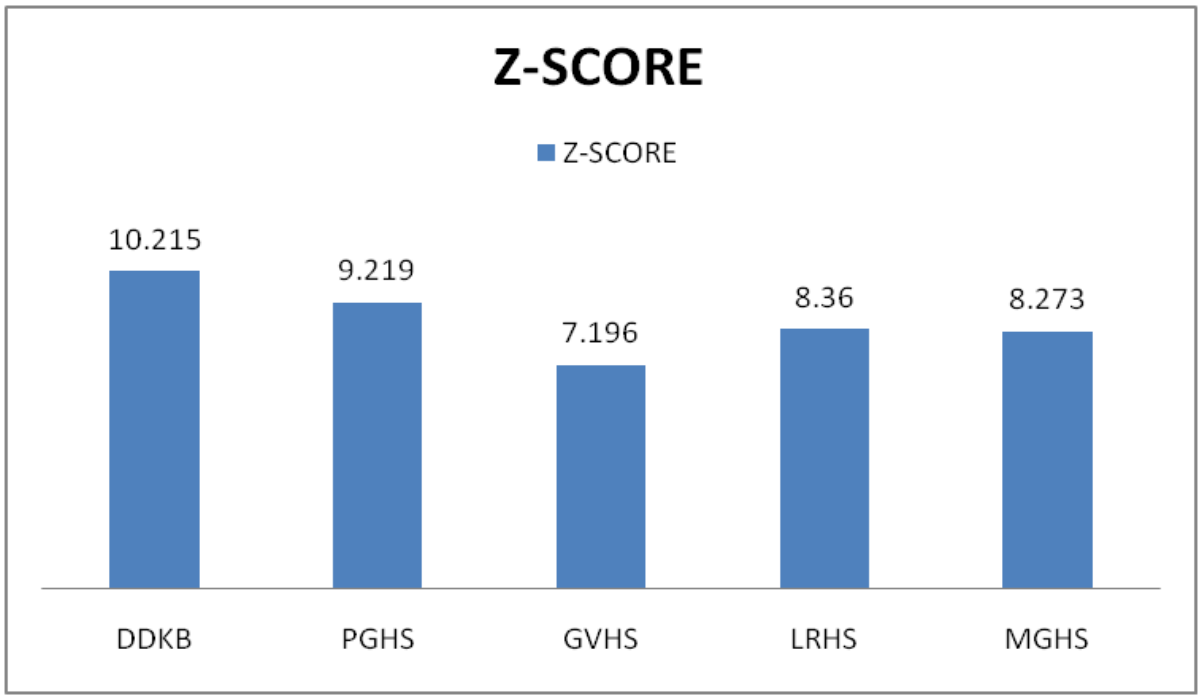


Figure 5:- Comparative study of mean scores for Control Group And Experimental Group of by Bar graph.

Result Analysis:
Table-5
The calculated Z-Score of 8.273 exceeds the critical values of 2.58 at the 1% significance level and 1.96 at the 5% significance level, indicating a significant difference between the two groups. The higher mean of the experimental group compared to the control group suggests that teaching through practical work is more effective than traditional methods in improving pupils' achievements.

Table 6:- Comparison of Z-Scores of Differents Schools.

Name of Schools	Z-Score
1.Dum Dum Kishore Bharati High School(DDKB)	10.215
2.Protapnagar Giridhari High School(PGHS)	9.219
3.Gorkhara VidyaMandir High School(GVHS)	7.196
4.Laskarpur Rabindra Vidyapith For Girls(LRHS)	8.36
5.Mollikpur Girls High School(MGHS)	8.273



Graphical Representation of Z-Scores for Five Schools for comparing achievement of pupils.

Result Analysis of Table-6:
The presence and quality of laboratory facilities played a crucial role in the effectiveness of practical-based teaching. Schools with better-equipped labs, like Dum Dum Kishore Bharati High School, showed higher Z-scores, indicating more significant differences in student achievement.

Interviews:

Besides the above Achievement Tests among Students, Interviews were conducted with Head of the Institutions, Science Teachers and Students related to infrastructures and perceptions to gather additional insights for the study.

Interview Questions for Heads of Institutions:
1.How would you describe the current state of your laboratory facilities?
2.What are the key features of your science laboratories?
3.How frequently are the laboratory facilities maintained or upgraded?
4.What is the process for reporting and addressing maintenance issues in the lab?

5.How is the funding for laboratory facilities allocated and managed?
6.Are there any financial challenges affecting the quality of lab facilities?
7.What kind of support and training do you provide to science teachers regarding the use of laboratory facilities?
8.Are there any professional development opportunities focused on enhancing practical work in the lab?
9.Are there any plans for future improvements or expansions of the laboratory facilities?
10.How do you prioritize and plan for upgrades or new equipment in the lab?

Interview Questions for Science Teachers:
1.How often do you use the laboratory facilities for practical work in your classes?
2.What types of experiments or practical activities do you typically conduct?
3.Are the available laboratory equipments and materials sufficient for conducting practical work effectively?
4.What challenges do you face in terms of equipment availability and functionality?
5.How do you ensure the safety of students during laboratory sessions?
6.Are there any specific protocols or guidelines that you follow in the lab?
7.How do you perceive the impact of practical work on students' understanding of scientific concepts?
8.Can you share any examples where practical work significantly enhanced student learning?
9.What kind of support do you receive from the institution regarding laboratory work?
10.Do you collaborate with other teachers or departments to optimize the use of laboratory facilities?

Interview Questions for Students:
1.How often do you participate in laboratory sessions as part of your science classes?
2.Can you describe a recent experiment or practical activity you conducted in the lab?
3.How does practical work in the laboratory help you understand scientific concepts better?
4.Do you find laboratory sessions engaging and interesting? Why or why not?
5.Are the laboratory equipment and materials adequate for the experiments you conduct?
6.Have you ever faced any issues with the availability or functionality of lab equipment?
7.How safe do you feel while working in the laboratory?
8.Are there any improvements you would suggest to enhance safety and comfort in the lab?
9.What do you think about the overall quality of the laboratory facilities at your institution?
10.How do you believe the laboratory experience could be improved to benefit your learning?

Based on the feedback from Head of Institutions, science teachers and students aim to gather comprehensive insights into the state of laboratory infrastructures and their impact on science education from various perspectives.

Findings of the Study:

Significance of Practical Work:
Across all five schools studied, the Z-scores indicated that the experimental groups, which engaged in practical work, performed significantly better than the control groups, which were taught using traditional lecture methods.

Specifically, the Z-scores for the experimental groups were as follows: Dum Dum Kishore Bharati High School (10.215), Protapnagar Giridhari High School (9.219), Gorkhara VidyaMandir High School (7.196), Laskarpur Rabindra Vidyapith For Girls (8.36), and Mallikpur Girls' High School (8.273). All these values exceed the critical value of 2.58 at a 1% significance level, underscoring the effectiveness of practical work over traditional methods.

Laboratory Facilities:
The presence and quality of laboratory facilities played a crucial role in the effectiveness of practical-based teaching. Schools with better-equipped labs, like Dum Dum Kishore Bharati High School, showed higher Z-scores, indicating more significant differences in student achievement.

In contrast, schools with less comprehensive laboratory facilities, such as those in village areas or without attached higher secondary sections, demonstrated lower but still significant Z-scores, suggesting that while practical work is beneficial, adequate lab resources enhance its effectiveness.

Engagement and Interest:
Practical work was found to significantly enhance students' understanding and retention of scientific concepts. This hands-on approach not only improved academic performance but also increased student interest and engagement in science subjects.

Consistency Across Different School Types:
The study included a diverse range of schools (boys, girls, and co-educational). Regardless of the type, practical work consistently resulted in better student performance, suggesting that this teaching method is universally beneficial.

Alignment with Educational Policy:
The findings support the National Education Policy 2020's emphasis on activity-based and experiential learning. Integrating practical work into the secondary science curriculum aligns with contemporary pedagogical trends and national educational objectives.

Conclusion:-

1. The study confirms the hypotheses that practical work significantly enhances student achievement in secondary-level science education.
2. Practical work not only improves academic outcomes but also fosters a deeper understanding and appreciation of scientific concepts, encouraging more students to pursue science in higher education.
3. Adequate laboratory facilities are essential to maximize the benefits of practical-based teaching.
4. Therefore, implementing practical work as a standard teaching strategy in secondary science education is recommended for better student outcomes and increased interest in science disciplines.

Recommendations:-

Investment in Laboratory Infrastructure:
Schools should invest in well-equipped laboratories to facilitate practical-based teaching methods. This investment is crucial for enhancing the effectiveness of science education.

Teacher Training:
Continuous professional development for science teachers should include training on conducting effective practical experiments and integrating them into the curriculum.

Curriculum Development:
Education authorities should revise the secondary science curriculum to include mandatory practical work for all science subjects, ensuring that students gain hands-on experience in addition to theoretical knowledge.

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