



## TWO MODES OF PROJECT-BASED TEACHING METHOD AS A FACTOR ON STUDENTS' ACHIEVEMENT IN BASIC SCIENCE: IMPLICATIONS FOR MATHEMATICS AND MEASUREMENT EXPERTS

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### Abstract

This study examined the efficacy of two modes of project-based teaching methods (grouped and individualized) on students' academic achievement in Basic Science. The study also examined the influence of gender and the interaction effect of teaching methods and gender on students' achievement. A quasi-experimental research design was adopted. The population of the study consisted of 2,279 Junior Secondary School II students, from which a sample size of 76 (34 males and 42 females) was drawn and assigned to experimental groups. Data were collected using a validated Basic Science Achievement Test (BSAT). The instrument yielded a reliability coefficient of 0.89 using KR-20 method. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings revealed that students taught using the group project-based teaching method achieved significantly higher mean scores than those taught using the individualized project-based teaching method. The results also showed that there was no significant difference in the mean achievement scores of male and female students in Basic Science. Furthermore, the interaction effect of teaching method and gender on students' achievement was not significant. Based on these findings, the study concluded that the group project-based teaching method is more effective in improving students' academic achievement in Basic Science and that the method is gender-inclusive. It was therefore recommended that Basic Science teachers should adopt structured group project-based instructional strategies to enhance students' learning outcomes.

**Keywords:** Project-based teaching method; Group project-based learning; Individualized project-based learning; Academic achievement; Basic Science; Gender.

### Introduction

Improving students' academic achievement continues to be a central concern of educational systems worldwide. In science education particularly, persistent reports of low achievement, shallow conceptual understanding, and weak problem-solving abilities have raised concerns among educators and policymakers. In Nigeria, evidence from internal and external examinations has revealed recurring challenges in students' performance in Basic Science, especially at the upper basic level (Federal Ministry of Education [FME], 2013; West African Examinations Council [WAEC], 2022). These concerns have intensified the search for innovative instructional strategies capable of enhancing students' engagement, understanding, and academic achievement.



For decades, instruction in many classrooms has been dominated by traditional teacher-centered methods characterized by lectures, note-taking, and memorization of facts. Although such approaches may facilitate coverage of syllabus content, they often fail to promote deep understanding, critical thinking, and long-term retention (Prince, 2004; Hmelo-Silver, 2004). Research in cognitive psychology suggests that meaningful learning occurs when learners actively construct knowledge rather than passively receive information (Bransford, Brown, & Cocking, 2000). Consequently, there has been increasing advocacy for learner-centered pedagogies that engage students in inquiry, collaboration, and authentic problem-solving tasks.

One instructional strategy that has gained prominence in this regard is Project-Based Teaching (PBT). Project-Based Teaching is an approach in which students gain knowledge and skills by working for an extended period to investigate and respond to complex questions, problems, or real-world challenges (Thomas, 2000; Krajcik & Blumenfeld, 2006). Unlike conventional methods, PBT emphasizes sustained inquiry, student autonomy, collaborative engagement, and the production of tangible artifacts. Through projects, learners connect theoretical knowledge with practical application, thereby enhancing both cognitive and affective learning outcomes (Bell, 2010).

The theoretical foundations of project-based teaching are deeply rooted in constructivist learning theory. Piaget (1970) posited that learners construct knowledge through active interaction with their environment, suggesting that learning is an active rather than passive process. Similarly, Vygotsky (1978) emphasized the importance of social interaction in cognitive development, introducing the concept of the Zone of Proximal Development (ZPD), within which learners achieve higher understanding through collaboration and scaffolding. Dewey (1938) also advocated experiential education, arguing that learning should be grounded in meaningful activities connected to real-life experiences. Project-based teaching reflects these theoretical assumptions by engaging learners in authentic tasks that require inquiry, reflection, and social interaction.

Basic Science occupies a critical position in the school curriculum because it provides foundational knowledge for advanced studies in biology, chemistry, physics, and technology-related disciplines. It also integrates essential skills such as observation, experimentation, measurement, and data analysis. These processes inherently require mathematical competence, particularly in areas such as quantification, estimation, graphical representation, and interpretation of results (National Research Council, 2012). However, when taught using teacher-centered approaches, students often struggle to relate scientific concepts to mathematical applications, leading to fragmented understanding (Krajcik & Blumenfeld, 2006).

Project-based teaching has the potential to bridge this gap by integrating science concepts with mathematical reasoning. During project activities, students may measure variables, calculate averages, construct tables, and interpret graphs. Such integration aligns with interdisciplinary approaches advocated in contemporary education reforms (National Research Council, 2012). Moreover, research indicates that students engaged in project-based learning environments demonstrate improved conceptual understanding, increased motivation, and higher academic achievement compared to those taught through traditional methods (Bell, 2010; Hmelo-Silver, 2004).

Project-based teaching can be implemented in different modes, particularly individualized and group-based formats. Individualized project-based teaching involves students working independently on assigned projects. This mode promotes autonomy, self-regulation, and personal accountability (Zimmerman, 2002). Self-regulated learning theory posits that learners who set goals, monitor progress, and evaluate outcomes tend to achieve higher academic success (Zimmerman, 2002). Individual projects may therefore enhance deep cognitive engagement and mastery of subject matter.

On the other hand, group project-based teaching involves students working collaboratively in small teams to accomplish shared objectives. Cooperative learning theory emphasizes that structured group interaction fosters positive interdependence, peer support, and collective problem-solving (Johnson



& Johnson, 2009; Slavin, 2014). Empirical studies have shown that collaborative learning environments can significantly improve achievement outcomes by enabling students to exchange ideas, clarify misconceptions, and co-construct knowledge (Gillies, 2007; Slavin, 2014). Vygotsky's (1978) theory further supports this approach, as interaction among peers provides scaffolding opportunities that extend learners' cognitive capacities.

Despite strong theoretical support for both individualized and group project-based approaches, empirical findings regarding their relative effectiveness are not entirely consistent. Some researchers argue that collaborative approaches yield greater academic gains due to shared cognitive processing and social reinforcement (Johnson & Johnson, 2009). Others suggest that individualized learning environments may be more effective for promoting mastery and accountability, particularly for students with high intrinsic motivation (Zimmerman, 2002). These mixed findings highlight the need for comparative investigations examining the effects of the two modes on students' academic achievement in Basic Science.

Academic achievement is typically measured through tests, examinations, and performance-based assessments designed to evaluate students' mastery of instructional objectives. However, scholars have criticized traditional assessment practices for focusing primarily on lower-order cognitive skills such as recall and comprehension (Brookhart, 2010). Project-based environments require more authentic and performance-oriented assessment strategies, including rubrics, portfolios, and observational instruments. Messick (1995) emphasized that validity in educational measurement involves not only accurate score interpretation but also alignment between instruction, assessment, and intended learning outcomes. Therefore, changes in instructional approaches necessitate corresponding innovations in measurement practices.

The implications of comparing individualized and group project-based teaching extend to mathematics educators and measurement experts. Mathematics plays a crucial role in scientific inquiry through measurement, data handling, and quantitative reasoning. When instructional approaches enhance students' engagement with these processes, mathematics educators may need to adapt curricular materials to reinforce interdisciplinary integration. Furthermore, measurement experts must design reliable and valid instruments capable of capturing higher-order thinking, collaboration skills, and problem-solving competencies developed through project-based instruction (Brookhart, 2010; Messick, 1995).

Although project-based teaching has been widely researched, relatively few studies have explicitly compared individualized and group modes within the area of Basic Science education, particularly in Nsukka education zone. Moreover, limited attention has been given to the measurement implications of these instructional strategies. Addressing this gap is important for informing curriculum development, teacher training, and assessment design. Therefore, this study sought to investigate the effect of two modes of project-based teaching (individualized and group) on students' academic achievement in Basic Science, while examining the implications of the findings for mathematics educators and educational measurement experts. The study is expected to contribute empirical evidence that can guide instructional innovation and assessment reform in science and mathematics education.

### **Research Questions**

The study was guided by the following research questions;

1. What is the difference in the mean academic achievement scores of students taught Basic Science using individualized project-based teaching method and those taught using group project-based teaching method?
2. What are the mean achievement scores of male and female students' academic achievement in Basic Science?



3. What is the interaction effect of two modes of project based teaching and gender on students' academic achievement in Basic Science?

### Hypotheses

The following null hypotheses tested at 0.05 level of significance further guided the study;

1. There is no significant difference in the mean academic achievement scores of students taught Basic Science using individualized project-based teaching method and those taught using group project-based teaching method.
2. There is no significant difference in the mean academic achievement scores of male and female students in Basic Science.
3. There is no significant interaction effect of two modes of project based teaching and gender on students' academic achievement in Basic Science.

### Methods and Procedures

This study adopted a quasi-experimental pretest–posttest non-equivalent group design. The design was considered appropriate because intact classes were used for the study. This design made it possible to compare students' academic achievement across instructional modes while controlling for initial differences using pretest scores. The study was conducted in Nsukka Local Government Area, Enugu State Nigeria. The area was selected due to observed low academic achievement of students in Basic Science and the need to explore innovative instructional strategies within the region. The study population consisted of 2,279 Junior Secondary School Two (JSS2) students who were offering Basic Science in Nsukka Local Government Area of Enugu State, including 1,092 males and 1,187 females. From this population, a sample of 76 JSS2 students, comprising 34 males and 42 females, was drawn for the study using a multistage sampling procedure. The instrument used for data collection was the Basic Science Achievement Test (BSAT). The items measured knowledge, comprehension, application, and basic analytical skills. The test items were developed using a table of specification to ensure adequate coverage of content areas and cognitive domains. The BSAT was subjected to both face and content validation. The face validity was ascertained by three experts in Science Education Department, two from Integrated Science unit and one from Measurement and Evaluation unit), Faculty of Education, University of Nigeria, Nsukka. Their corrections and suggestions regarding clarity, relevance, and alignment with instructional objectives were incorporated before final administration. The content validity was established with the use of table of specifications. The reliability of the BSAT was determined using Kuder-Richardson Formula 20 (KR-20) since the test items were dichotomously scored. A reliability coefficient of 0.89 was obtained, indicating that the instrument was reliable for the study.

### Experimental Procedure

The experimental procedure for this study was carried out in several stages to ensure proper implementation of the experiment. First, permission was obtained from the school authorities whose schools were used for the study before the commencement of the study. The sampled schools were informed about the purpose of the research. The students in their classes were then assigned to different groups: Group Project-Based Teaching Method (GPBTM) and Individualized Project-Based Teaching Method (IPBTM). Before the commencement of the treatment, a pre-test was administered to both groups using the Basic Science Achievement Test (BSAT) to determine their entry-level knowledge and ensure group equivalence. The pre-test scores also served as covariates during data analysis.

The treatment lasted for a period of six weeks, during which the experimental groups were taught the same Basic Science topics but using different instructional approaches. Students in the group project-based class were organized into small collaborative groups and engaged in structured project tasks that required cooperation, discussion, shared responsibilities, and collective problem-solving. On the



other hand, students in the individualized project-based class carried out similar project tasks independently, with minimal peer collaboration.

Throughout the treatment period, the researcher monitored the instructional process to ensure uniformity in content coverage, time allocation, and learning objectives across both groups. At the end of the treatment, the same instrument was administered as a post-test to assess students' achievement after exposure to the instructional methods.

Data collected were analyzed using mean and standard deviation to answer all the research questions, while Analysis of Covariance (ANCOVA) was used to test the formulated null hypotheses at 0.05 level of significance, using pretest scores as covariates.

### Control of Extraneous Variables

The following measures were taken to control extraneous variables:

- Use of intact classes to maintain normal school structure.
- Equal duration of instruction across all groups.
- Same content coverage for all groups.
- Training of teachers before the experiment.
- Use of pretest scores as covariate during data analysis.

### Result

#### Research Question One

What is the difference in the mean academic achievement scores of students taught Basic Science using individualized project-based teaching method and those taught using group project-based teaching method?

**Table 1:** Mean and standard deviation achievement scores of students taught Basic Science using group project and individualized project-based teaching methods

Methods	N	Pre-test		Post-test		Mean Gain	Mean Gain Diff
		Mean	SD	Mean	SD		
GPBTM	36	20.48	2.64	56.10	6.35	35.62	10.69
IPBTM	40	20.14	3.13	45.07	8.48	24.93	

Result in Table 1 presents the mean and standard deviation of students' achievement scores in Basic Science using Group Project-Based Teaching Method (GPBTM) and Individualized Project-Based Teaching Method (IPBTM). From the Table, students taught using GPBTM had a pretest mean score of 20.48 with a standard deviation of 2.64, while students taught using IPBTM had a pretest mean score of 20.14 with a standard deviation of 3.13. The closeness of the pretest mean scores indicates that both groups were academically comparable before the treatment. After the treatment, the posttest mean score of students taught using GPBTM increased to 56.10 with a standard deviation of 6.35, whereas those taught using IPBTM obtained a posttest mean score of 45.07 with a standard deviation of 8.48. The mean gain for the GPBTM group was 35.62, while the mean gain for the IPBTM group was 24.93. This shows that students taught using the group project-based teaching method had a higher improvement in achievement compared to those taught using the individualized project-based teaching method. The smaller posttest standard deviation (6.35) for the GPBTM group compared to 8.48 for the IPBTM group suggests that students in the group-based method performed more consistently than those in the individualized group.



### Research Question Two

What are the mean achievement scores of male and female students' academic achievement in Basic Science?

**Table 2:** Mean and standard deviation of male and female students' achievement in Basic Science

Gender	N	Pre-test		Post-test		Mean Gain	Mean Gain Diff
		Mean	SD	Mean	SD		
Male	34	21.35	3.07	58.54	5.53	37.19	
Female	42	20.49	3.45	56.26	6.32	35.77	1.42

The pre-test results show that male students had a mean achievement scores of 21.35 (SD = 3.07), while female students had a closely related mean achievement scores of 20.49 (SD = 3.45). This indicates that both groups were almost at the same level of achievement in Basic Science before the treatment, suggesting that the students had comparable entry knowledge regardless of gender. After the treatment, the post-test results reveal that male students recorded a mean achievement score of 58.54 (SD = 5.53), while female students had a mean achievement score of 56.26 (SD = 6.32). This shows that both male and female students improved substantially in their achievement after the intervention. In terms of learning gains, male students achieved a mean gain of 37.19, whereas female students recorded a mean gain of 35.77. The difference in mean gain between male and female students is 1.42, which is small. This suggests that the instructional strategy used was almost equally effective for both male and female students.

### Research Question Three

What is the interaction effect of two modes of project based teaching and gender on students' academic achievement in Basic Science?

**Table 3:** The mean and Standard Deviation (SD) interest scores of male and female students taught Basic Science using GPBTM and IPBT

Teaching Methods	Gender	N	Pre-test		Post-test	
			Mean	SD	Mean	SD
GPBTM	Male	16	20.50	3.66	57.60	3.25
	Female	20	20.45	2.52	55.82	7.61
IPBTM	Male	18	19.89	3.86	47.58	9.51
	Female	22	20.33	2.48	43.08	7.15

The result presented in Table 3 above shows the mean and standard deviation achievement scores of male and female students taught basic science using GPBTM and IPBTM. For GPBTM, the result shows that the male students had a mean achievement scores of 20.50, SD = 3.66 at pretest and a mean achievement scores of 57.60, SD = 3.25 at posttest. On the other hand, the female students had a mean achievement scores of 20.45, SD = 2.52 at pretest and a mean achievement scores of 55.82, SD = 7.61 at posttest. For the individualized project-based teaching method, male students had a mean achievement scores of 19.89, SD = 3.86 at pretest and a mean achievement scores of 47.58, SD = 9.51 at posttest. While their female counterparts had a mean achievement scores of 20.33, SD = 2.48 at pretest and a mean achievement scores of 43.08, SD = 7.15 at posttest. This shows that male



students demonstrated higher achievement when taught basic science with IPBTM than their female counterparts. Therefore, students taught with GPBTM outperformed those in IPBTM, with both male and female students in GPBTM having higher achievement scores than their counterparts in IPBTM.

### Hypothesis One

There is no significant difference in the mean academic achievement scores of students taught Basic Science using individualized project-based teaching method and those taught using group project-based teaching method.

**Table 4:** Analysis of Covariance on the mean achievement scores of students taught Basic Science using GPBTM and those taught using IPBTM

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2271.023 <sup>a</sup>	4	567.756	14.509	.000	.420
Intercept	2206.417	1	2206.417	56.384	.000	.413
Pretest	.596	1	.596	.015	.902	.000
Methods	2091.757	1	2091.757	53.454	.000	.401
Gender	81.617	1	81.617	2.086	.153	.025
Method * Gender	365.919	1	365.919	9.351	.172	.105
Error	3130.553	73	39.132			
Total	67962.000	76				
Corrected Total	5401.576	75				

Result in Table 4 shows that teaching method is a significant factor on students' achievement in Basic Science; F-ratio is 53.454 with 1 degree of freedom and p-value of .000. Thus, the null hypothesis of no significant difference in the mean academic achievement scores of students taught Basic Science using individualized project-based teaching method and those taught using group project-based teaching method was rejected because the exact probability value of .000 is less than the level of significance set at .05. Therefore, the researchers conclude that there is a significant difference in the mean academic achievement scores of students taught Basic Science using individualized project-based teaching method and those taught using group project-based teaching method.

### Hypothesis Two

There is no significant difference in the mean academic achievement scores of male and female students in Basic Science.

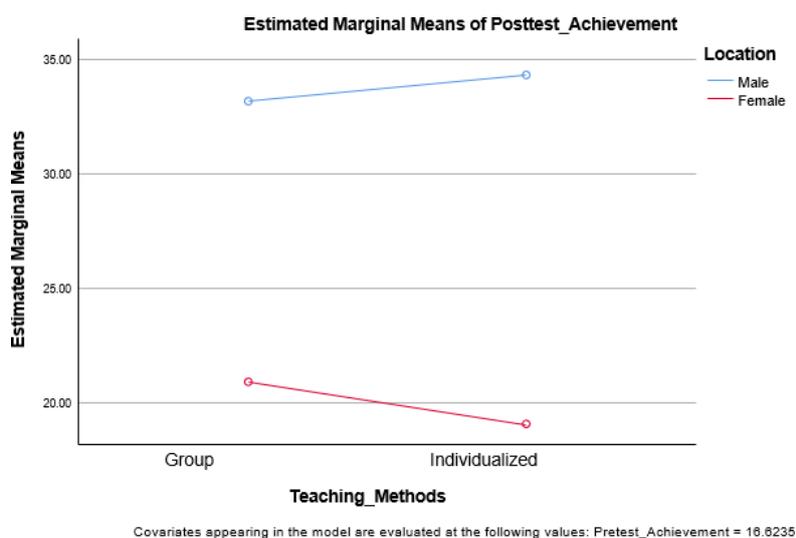
Result in Table 4 was also used to test hypothesis two. Result in Table 4 shows that the F-ratio is 2.086 with 1 degree of freedom and 0.153 significant level. Since the associated alpha level of 0.153 is greater than the p-value of .05 ( $P < 0.05$ ), the null hypothesis of no significant difference in the mean academic achievement scores of male and female students in Basic Science was accepted. Thus, the researchers conclude that there is no significant difference in the mean achievement scores of male and female students in Basic Science.



### Hypothesis Three

There is no significant interaction effect of two modes of project based teaching and gender on students' academic achievement in Basic Science.

The analysis in Table 4 was also used to test hypothesis three. The Table shows that the probability value of .172 associated with method and gender is greater than the 0.05 level of significance ( $F = 9.351, p = .172 > 0.05$ ). Thus, the null hypothesis of no significant interaction effect of two modes of project based teaching and gender on students' mean achievement scores in Basic Science was accepted. The researchers, therefore, conclude that the interaction effect of two modes of project based teaching and gender on students' mean achievement scores in Basic Science was not significant. The interaction effect was also interpreted using the profile plot as shown in Figure 1 below.



**Figure. 1:** Graph of the interaction effect of two modes of project based teaching and gender on students' mean achievement scores in Basic Science

The profile plot in Figure 1 shows that there is no interaction effect of two modes of project based teaching and gender on students' mean achievement score in Basic Science. This is indicated by the separate lines for the male and female students' achievement in Basic Science in the respective two modes.

### Discussion

#### Effects of Grouped Project-based and Individualized Project-based teaching methods on Students' Achievement in Basic Science

The findings of the study revealed that students taught using the Group Project-Based Teaching Method (GPBTM) recorded significantly higher achievement scores than those taught using the Individualized Project-Based Teaching Method (IPBTM) in Basic Science. This suggests that collaborative learning environments enhance students' academic performance more effectively than individualized project approaches. One possible explanation for this result is that group project-based learning promotes peer interaction, knowledge sharing, and cooperative problem-solving. When students work in groups, they are exposed to diverse ideas, perspectives, and problem-solving strategies. This interaction enhances understanding, clarifies misconceptions, and deepens conceptual learning. In Basic Science, where many concepts require discussion and practical engagement, collaborative learning may foster better comprehension than working individually.

Another possible reason for the higher achievement of students in the group project-based method is increased motivation and engagement. Working in groups often fosters a sense of responsibility and belonging, which encourages students to participate actively in learning tasks. In contrast,



individualized project-based learning, while promoting independence and self-direction, may limit opportunities for collaborative reasoning and immediate peer feedback, which are critical for mastering complex scientific concepts. This finding is consistent with Social Constructivist theory as proposed by Lev Vygotsky, who emphasized that learning occurs through social interaction and collaboration. Vygotsky (1978) argued that cognitive development is enhanced through social engagement within the Zone of Proximal Development (ZPD), where learners achieve higher levels of understanding with the assistance of peers or more knowledgeable others. Group project-based teaching provides opportunities for scaffolding, shared reasoning, and co-construction of knowledge.

The result also aligns with the Social Learning Theory of Albert Bandura. Bandura (1977) posited that learning occurs through observation, imitation, and modeling. In a group project setting, students observe peers' approaches to solving scientific problems, adopt effective strategies, and receive feedback, which enhances motivation and self-efficacy. Such social reinforcement can significantly improve academic achievement. Furthermore, cooperative learning has been widely supported in empirical literature. Johnson and Johnson (2009) maintained that positive interdependence and individual accountability within group settings promote higher achievement compared to competitive or individualistic learning structures. Similarly, Slavin (2014) reported that structured cooperative learning strategies significantly improve students' academic outcomes across subject areas, including science.

### **Influence of Gender on Students' Achievement in Basic Science**

The finding of this study revealed that there was no significant difference in the mean achievement scores of male and female students in Basic Science. This implies that both male and female students performed comparably in the subject and benefited equally from the instructional strategy employed. The result suggests that gender did not significantly influence students' academic achievement in Basic Science within the context of this study. The finding also aligns with the principles of Social Constructivism as proposed by Lev Vygotsky, who emphasized that knowledge is constructed through social interaction and collaborative engagement (Vygotsky, 1978). In a classroom where interaction, dialogue, and participation are encouraged, learning becomes a shared process rather than a gender-dependent outcome. This may explain why both male and female students demonstrated comparable achievement levels.

This finding supports the view that intellectual ability and academic performance in science-related subjects are not inherently determined by gender. Contemporary educational research increasingly emphasizes that differences in achievement between male and female students are more often linked to environmental, instructional, and socio-cultural factors rather than biological differences. When both genders are exposed to similar learning opportunities, teaching methods, and classroom environments, their performance outcomes tend to be similar. The result is consistent with the Social Learning Theory of Albert Bandura, which posits that learning occurs through interaction with the environment, observation, and reinforcement (Bandura, 1977). According to this theory, both male and female students can achieve equally when they are provided with equal encouragement, modeling, and learning conditions. The absence of significant gender difference in this study suggests that the instructional approach created an inclusive learning environment that supported both groups effectively.

This finding is consistent with the findings of Oludipe (2012) who investigated gender differences in Nigerian junior secondary students' achievement in Basic Science and reported no significant difference between male and female students when exposed to cooperative learning strategies. Similarly, Afua Ntroaduro et al. (2024) found no statistically significant gender difference in academic performance among tertiary students in science-related courses when learning environments were equitable and supportive. International large-scale assessments also support this result. The Trends in International Mathematics and Science Study (TIMSS) reported that across many participating countries, there was no consistent statistically significant gender difference in



science achievement at the basic education level (Mullis et al., 2017). This suggests that gender alone is not a strong determinant of students' performance in science subjects.

### **Interaction effect of two modes of project based methods and gender on students' Achievement in Basic Science**

The finding of this study revealed that the interaction effect of the two modes of project-based teaching methods and gender on students' achievement in Basic Science was not significant. This means that the effectiveness of the instructional methods (group project-based and individualized project-based approaches) did not depend on whether the students were male or female. In other words, both teaching methods had similar effects on male and female students' academic achievement. The absence of a significant interaction effect suggests that gender did not moderate the relationship between instructional method and achievement. This indicates that the project-based teaching strategies were equally beneficial to both male and female students. Regardless of the mode of project implementation, students' academic improvement was not influenced by their gender.

This finding aligns with the assumptions of Social Learning Theory as proposed by Bandura (1977), which emphasizes that learning outcomes are shaped by environmental conditions rather than inherent gender characteristics. When instructional strategies are designed to be inclusive and participatory, both male and female students are likely to benefit equally. The project-based methods used in this study may have provided equal opportunities for engagement, exploration, and problem-solving, thereby minimizing gender-related differences. The result is also consistent with Vygotsky's (1978) Social Constructivist theory, which posits that learning occurs through interaction with the social and learning environment. Since both male and female students were exposed to the same classroom environment and instructional support, their achievement levels were similarly influenced, leading to the non-significant interaction effect. Empirical studies have similarly reported non-significant interaction effects between instructional strategies and gender. For example, Oludipe (2012) found no significant interaction effect of treatment and gender on students' achievement in Basic Science when cooperative learning strategies were employed. Likewise, studies on project-based and inquiry-based learning approaches have shown that such instructional methods tend to benefit both genders equally when implemented effectively (Slavin, 2014).

### **Conclusion**

Based on the findings of this study, the study concludes that project-based teaching methods, particularly the group-based approach, are effective instructional strategies for improving students' achievement in Basic Science. This indicates that collaborative learning environments enhance understanding, engagement, and overall academic performance more effectively than individualized project approaches. The methods are also gender-inclusive and equitable, making them suitable for enhancing learning outcomes among secondary school students regardless of gender.

### **Recommendations**

Based on the findings and conclusions of this study, the following recommendations are made:

1. Basic Science teachers should adopt the group project-based teaching method more frequently in classroom instruction, as it has been found to significantly enhance students' academic achievement compared to the individualized project-based method.
2. Teachers should structure group activities carefully to ensure active participation, positive interdependence, and individual accountability among students. This will help maximize the benefits of collaborative learning.
3. Since the findings revealed no significant gender difference in achievement, teachers should continue to implement gender-inclusive instructional strategies that provide equal opportunities for participation, leadership, and contribution during project activities.



4. School administrators should organize workshops, seminars, and in-service training programs to equip teachers with the skills required to effectively implement project-based teaching methods in Basic Science and other science subjects.
5. Curriculum planners should integrate structured project-based learning activities into the Basic Science curriculum to promote active learning, critical thinking, and problem-solving skills among students.
6. Government and educational stakeholders should provide adequate instructional materials, laboratory equipment, and supportive learning environments necessary for the effective implementation of project-based teaching methods.

### Implications for Mathematics and Measurement Experts

The findings of this study have important implications for mathematics and measurement experts in education. The significant improvement in students' achievement under the group project-based teaching method highlights the need for assessment tools that accurately measure learning outcomes across different instructional strategies. Experts should develop reliable and valid achievement tests that capture both individual and collaborative learning gains, ensuring that instructional effects are properly evaluated.

Additionally, since gender did not significantly influence achievement and there was no significant interaction between teaching method and gender, measurement experts are reminded to design assessment instruments that are gender-inclusive and free from bias. They should also employ appropriate statistical methods, such as ANCOVA or factorial designs, to detect main and interaction effects in educational research. These practices will help ensure that evaluation and monitoring of teaching interventions are data-driven, equitable, and informative for improving learning outcomes in Basic Science and other STEM subjects.

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