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# Problem-Based Learning Strategy: Effect on Achievement of Genetics among Biology Students in Colleges of Education Oyo, Oyo State

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## ABSTRACT

This study examined the impact of Problem-Based Learning strategy (PBLS) on the academic achievement of biology students in genetics at Colleges of Education in Oyo State, Nigeria. The study was prompted by the challenges students encounter in understanding abstract genetic ideas when instructed through conventional method. A quasi-experimental design with pre-test, post-test, non-randomized control, and non-equivalent intact groups was employed. The sample comprised 193 individuals selected from two schools of 300-level biology students, with one group instructed via problem-based learning strategy (PBLS) and the other through conventional methods. Data were gathered utilizing a validated Genetics Achievement Test (GAT), and hypotheses were examined through Analysis of Covariance (ANCOVA) at a significance level of 0.05. The results demonstrated a substantial main effect of problem-based learning strategy (PBLS) on academic achievement ($F(1,95)=180.407$, $p<0.05$, $\eta^2=0.660$), signifying that 66.0% of the variance in achievement was due to the problem-based learning strategy (PBLS). Results indicated a significant main effect of gender on achievement ($F(1,64)=129.662$, $p<0.05$, $\eta^2=0.681$), with male and female students benefiting equally from the technique. The study determined that problem-based learning strategy (PBLS) surpasses conventional method in improving performance in genetics and advocated for its implementation by biology educators and incorporation into teacher training programs to promote parity and academic achievement among genders.

**Keyword**: Problem learning strategy, gender, genetics, achievement, Biology

## INTRODUCTION

The pursuit of effective pedagogical methods in biology education has consistently progressed, with problem-based learning emerging as a viable strategy to enhance student engagement and academic achievement. Problem-based learning emphasizes student-centered inquiry and real-world problem-solving, fostering interactive and dynamic learning environments that contrast with traditional lecture-based training. This pedagogical approach fosters the development of critical thinking, teamwork, and self-directed learning skills, which are especially vital in intricate disciplines like genetics. Due to the intricate nature of genetic concepts, students frequently find it challenging to comprehend fundamental principles and use them in practical situations. Genetics is a subject offered in biology and also in the minimum standard for colleges of education which covers the following aspects; variations, mitosis and meiosis, monohybrid crossings, sex-determination, co-dominance and mutation among others have been identified as one of the most difficult and abstract concept. Research indicates that the intricate nature of the course necessitates the implementation of successful tactics, distinct from conventional teaching methods, such as problem-based learning, to enhance teaching and learning, particularly in the realm of genetics.

The problem-based learning (PBL) technique enables pupils to engage with their surroundings while addressing ill-structured challenges. In Problem-Based Learning environments, knowledge develops through social bargaining. Moreover, situations without definitive solutions drive students to explore diverse perspectives and tactics, enabling them to apply their newly acquired information to different contexts. By tackling issues with no definitive solution, students acquire the ability to evaluate their existing knowledge, discern gaps in their

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understanding, obtain pertinent information, and collaborate in the assessment of hypotheses and concepts derived from the data acquired. As students endeavor to address the issue, the characteristics and definition of the problem may evolve. Educators function as facilitators, providing pupils with guidance for problem-solving. Students assume accountability for their learning (Gulsum & Semra, 2007). Numerous studies have contrasted students engaged in Problem-Based Learning (PBL) with those subjected to traditional instruction across various global contexts, revealing a significant advantage for PBL students over their traditionally taught counterparts (Bedemo, 2020; Eglitodo, 2019; Mahmood, 2017).

Additionally, a study conducted by Usman, Ali, and Ahmad in 2023 examined the effectiveness of STEM problem-based learning on the academic attainment in biology of secondary school students in Nigeria. The results indicate that STEM Problem-Based Learning (STEM-PBL) exerts a substantial and positive influence. A meta-analytical analysis conducted by Ufuk, (2023) The impact of Problem-Based Learning in Science Education on Academic Achievement indicates that the Problem-Based Learning approach significantly enhances academic performance compared to standard instructional methods.

Conversely, gender refers to both sexes and sexual categories, specifically men and women. Gender pertains to the cognitive processes, behaviors, and reasoning of men and women (Bello, 2018). Gender is a cultural construct that delineates the roles, behaviors, attributes, and emotional traits of females and males as shaped by society (Ojo, 2017). Gender does not imply male dominance over females or vice versa in academia; rather, it promotes the acknowledgment, development, and use of the abilities and inherent capacities of both genders (Odionye et al., 2024). Numerous studies on gender disparities in academic achievement within science education, particularly in Biology, have been conducted by various researchers. Oludipe (2012) determined that there is no statistically significant difference in the academic achievements of students based on gender. Ann, Emmanuel, and Josiah (2019) discovered that male students outperformed female students in science. Khwaileh and Zaga (2011) demonstrated that female students surpassed their male counterparts in performance. Consequently, academics possess varying perspectives on gender disparities in academic attainment within the field of genetics.

**Statement of the Problem**

The instruction of genetics, a complicated and fundamental subject in biology, presents considerable obstacles in higher education due to its abstract character and intricate mechanics. Conventional teaching techniques may inadequately interest students or foster a deep comprehension of genetic concepts, perhaps leading to subpar academic performance and retention rates. Problem-Based Learning (PBL), an educational approach that fosters active engagement by investigating and solving real-world issues, has been suggested as a potential means to improve student comprehension and performance in genetics. This study aims to examine the impact of Problem-Based Learning Strategy on the academic achievement in Genetics of Biology students in Colleges of Education in Oyo, Oyo State.

**Objective of the Study**

The main objective of this study is to investigate Problem-Based Learning Strategy: Effect on Achievement of Genetics among Biology Students in Colleges of Education Oyo, Oyo state. While the specific objective is to:

i. examine the main effect of problem-based learning strategy on academic achievement of Biology students in Colleges of Education Oyo, Oyo State and

ii. determine the main effect of gender on academic achievement of Biology students in Colleges of Education Oyo, Oyo State.

**Hypotheses**

**$H_0$1:** There will be no significant difference between the main effect of problem-based learning strategy on academic achievement of Biology students in Colleges of Education Oyo, Oyo State.

**$H_0$2:** There will be no significant difference between the main effect of gender on academic achievement of

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Biology students in Colleges of Education Oyo, Oyo State.

## METHODOLOGY

The study adopted a quasi-experimental design which involved pre-test, post-test, non-randomized control and non-equivalent intact groups. The population for the study consisted of all Biology students in Colleges of Education, Oyo State, Nigeria. A purposive sampling technique was employed to identify two Colleges of Education that met the criteria of having appropriate facilities and qualified Biology lecturers available to teach genetics. This study involved two intact classes of 300-level Biology students. The sample for the study was 193 students from two intact classes; one experimental and one control group. One school was designated as the control group, taught using conventional methods, while the other was the experimental group, exposed to the problem-based learning strategy (PBL). Three (3) instruments were utilized in this study: Genetics Achievement Test (GAT): This consisted of 40 multiple-choice items covering the core areas of the genetics curriculum as outlined by the National Commission for Colleges of Education (NCCE). These included variation, mitosis and meiosis, Mendelian inheritance (monohybrid and dihybrid crosses), sex determination, mutation, and co-dominance. The items were designed at varying cognitive levels, ranging from recall to application and analysis, in line with Bloom's taxonomy. A pilot test established the reliability of the instrument with a Kuder Richardson (KR-20) coefficient of 0.70. The instrument was also validated by three experts in science education and genetics. Lesson Plan for PBL: The PBL lesson plans were designed to actively engage students through real-world problem scenarios in genetics. For instance, one sample activity involved analyzing a family pedigree with a hereditary disease, where students were required to predict inheritance patterns using Punnett squares, discuss possible genetic outcomes, and propose solutions to reduce misconceptions about genetic disorders. Students worked collaboratively in groups, identified knowledge gaps, researched information, and presented their findings under the guidance of the instructor as facilitator. Lesson Plan for Traditional Method: The control group was taught using lecture-based methods, with emphasis on note-taking, teacher explanation, and limited student interaction. A pilot study was conducted to determine the reliability of the main research instrument which will be the problem-based learning strategy to a sample of the population who did not participate in the main study. Kuder Richardson (KR-20) formular was used to find the reliability value of the instruments of 0.70 while the hypothesis formulated for the study were tested using analysis of covariance (ANCOVA) at 0.05 level of significance

## RESULT

### Test for Hypothesis

**$H_0$1:** There will be no significant difference between the main effects of problem-based learning strategy on academic achievement of Biology students in Colleges of Education Oyo, Oyo State

Table 1: Analysis of Covariance of main effect of problem-based learning strategy on academic achievement of Biology students

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 911.142[a] | 2 | 455.571 | 90.364 | .000 | .660 |
| Intercept | 394.706 | 1 | 394.706 | 78.292 | .000 | .457 |
| Pre_Test | .046 | 1 | .046 | .009 | .924 | .000 |
| Group | 909.521 | 1 | 909.521 | 180.407* | .000 | .660 |
| Error | 468.858 | 93 | 5.041 | | | |
| Total | 35130.000 | 96 | | | | |

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| | | | | | | |
|---|---|---|---|---|---|---|
| Corrected Total | 1380.000 | 95 | | | | |
| a. R Squared = .660 (Adjusted R Squared = .653) | | | | | | |

Source: Fieldwork 2024

Table 1 revealed that there is a significant main effect of problem-based learning strategy on academic achievement of Biology students ($F_{(1,95)}$=180.407, $p$<0.05, $\eta^2$=0.660). The null hypothesis was therefore rejected. This implies that the treatment of problem-based learning strategy on academic achievement of Biology students. Also, the eta square value of 0.660 shows the contributing effect size of 66.0%.

**$H_0$2:** There will be no significant difference between the main effects of gender on academic achievement of Biology students in Colleges of Education Oyo, Oyo State.

Table 2: Analysis of Covariance of main effect of gender on academic achievement of Biology students

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 699.955[a] | 2 | 349.978 | 65.057 | .000 | .681 |
| Intercept | 336.593 | 1 | 336.593 | 62.569 | .000 | .506 |
| Pre_Test | .820 | 1 | .820 | .152 | .698 | .002 |
| Group | 697.529 | 1 | 697.529 | 129.662* | .000 | .680 |
| Error | 328.154 | 61 | 5.380 | | | |
| Total | 21015.000 | 64 | | | | |
| Corrected Total | 1028.109 | 63 | | | | |
| a. R Squared = .681 (Adjusted R Squared = .670) | | | | | | |

Source: Fieldwork 2024

Table 2 showed that there is a significant main effect of gender on academic achievement of Biology students (t($F_{(1,64)}$ =129.662, $p$<0.05, $\eta^2$=0.681). The null hypothesis was therefore rejected. This implies that the treatment of problem-based learning strategy on academic achievement of Biology students. Also, the eta square value of 0.681 shows the contributing effect size of 68.1%.

## DISCUSSION OF THE FINDINGS

The results from hypothesis one indicated that students taught through a problem-based learning strategy outperform their peers instructed via traditional methods in genetics. This suggests that these strategies positively influence students' academic performance. The finding aligns with Bedemo (2020), Eglitodo (2019), and Mahmood (2017), who state that pupils instructed using problem-based learning strategies exhibit greater gains compared to those subjected to standard teaching methods. Additionally, a study conducted by Usman, A. & Ahmad (2023) examined the effectiveness of STEM problem-based learning on the academic accomplishment in biology of secondary school students in Nigeria. The results indicated that STEM Problem-Based Learning (STEM-PBL) exerts a substantial and positive influence. Ufuk (2023) demonstrated that the Problem-based learning method employed in scientific education significantly enhances academic achievement relative to the standard teaching method.

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Hypothesis two indicated a substantial main effect of gender on the academic achievement of Biology students, suggesting that both male and female students derived comparable benefits from this technique. This finding coincides with other studies indicating that gender does not imply male dominance over females or vice versa in academia, but rather promotes the recognition, development, and usage of the skills and inherent capacities of both sexes (Odionye et al., 2024). In a prior study, Oludipe, (2012) discovered that there is no statistically significant difference in the academic achievements of pupils concerning gender. Furthermore, Ann, E. & Josiah (2019) indicated that male students outperformed female students in science. Khwaileh and Zaga (2011) demonstrated that female students surpassed their male counterparts in performance. Consequently, academics possess varying perspectives on gender disparities in academic attainment within the field of genetics.

The findings of this study are consistent with international evidence that problem-based learning improves student achievement in science education. For example, studies conducted in Ethiopia (Bedemo, 2020) and Turkey (Ufuk, 2023) reported that PBL significantly enhanced students' understanding of scientific concepts compared to traditional methods. Similarly, research in Jordan (Khwaileh & Zaza, 2011) found positive gender-related learning outcomes under active learning contexts. These parallels suggest that PBL is adaptable across diverse educational systems and cultural environments.

However, some differences exist. While this study found no significant gender differences in achievement, other contexts have reported male or female advantages in science learning (Ann et al., 2019; Oludipe, 2012). These contrasting results highlight the role of contextual factors such as cultural attitudes toward gender, availability of learning resources, and teacher training in shaping PBL outcomes. Thus, while the present study supports the general effectiveness of PBL, further cross-cultural research is needed to understand how local educational conditions mediate its impact.

Although this study analyzed main effects of instructional method and gender, interaction effects were not explored. Future studies should test whether gender moderates the impact of PBL on learning outcomes, as differences in collaboration styles, engagement, or prior achievement levels may lead to varied benefits across genders.

## CONCLUSION

The study determined that the problem-based learning (PBL) technique is a successful pedagogical method for improving biology students' academic performance in genetics, a discipline frequently seen as abstract and difficult. Research findings revealed that students instructed through Project-Based Learning (PBL) considerably surpassed their peers educated via standard lecture methods, illustrating that active, inquiry-based, and student-centered approaches enhance comprehension and recall of genetic ideas. The study demonstrated that gender did not impede students' performance, as both male and female learners derived equivalent benefits from the PBL approach, highlighting the strategy's inclusion and adaptability across genders. The research confirms that implementing PBL in biology classes enhances critical thinking, teamwork, and self-directed learning, which are vital for equipping students for future academic and professional pursuits.

## RECOMMENDATIONS

Based on the findings the following recommendations were proposed

1. Biology lecturers in Colleges of Education ought to implement problem-based learning methodologies in genetics instruction, as the study shown a considerable enhancement in students' academic performance relative to traditional methods. This will improve students' comprehension of difficult and intricate concepts in genetics.

2. Curriculum planners and teacher trainers ought to incorporate problem-based learning into teacher education programs impartially, as the data indicated that both male and female students derived equivalent benefits. This will guarantee equal learning opportunities and promote collaborative, critical, and inquiry-based methodologies among prospective biology educators.

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# APPENDIX WITH A SAMPLE PBL LESSON PLAN

**Appendix A: Sample PBL Lesson Plan**

**Topic:** Inheritance of Traits (Mendelian Genetics)

**Level:** 300-level Biology Students (Colleges of Education)

**Duration:** 80 minutes

**Instructional Strategy:** Problem-Based Learning (PBL)

**Facilitator Role:** Guide, questioner, and resource provider

**Group Structure:** 4–6 students per group

**Learning Objectives:**

By the end of the lesson, students should be able to: 1. Explain Mendel's laws of inheritance (segregation and independent assortment). 2. Apply Punnett squares to predict monohybrid and dihybrid crosses. 3. Interpret real-world inheritance problems (e.g., genetic disorders). 4. Collaborate effectively in groups to solve biology-related problems.

**Materials Needed:**

- Whiteboard/flip chart
- Markers
- Handouts with problem scenario
- Textbooks/online resources

**Problem Scenario (Trigger):**

A couple visits a genetic counselor. The husband's family has a history of albinism, while the wife has no known genetic disorders in her family. They are concerned about the possibility of having a child with albinism. Students are asked to determine: - The probability that their child will have albinism if the husband is heterozygous (carrier) and the wife is homozygous dominant. - How the results would differ if both parents were carriers. - How this knowledge could be applied in family counseling and public health awareness.

**Lesson Procedure:**

1. **Engagement (10 minutes):**
   - Teacher presents the problem scenario to the class.
   - Students brainstorm initial thoughts about inheritance and albinism.
2. **Group Inquiry (25 minutes):**
   - Students work in groups to identify what they already know, what they need to learn, and possible approaches.
   - Groups research Mendelian laws, genotype combinations, and Punnett squares.
3. **Problem Solving (25 minutes):**

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- Each group constructs Punnett squares for both cases (heterozygous × homozygous dominant; heterozygous × heterozygous).
- Groups calculate probabilities and prepare explanations.

4. **Presentation & Discussion (15 minutes):**

- Groups present findings to the class.
- Teacher facilitates discussion, clarifies misconceptions, and links concepts to curriculum content.

5. **Reflection & Conclusion (5 minutes):**

- Students reflect on how PBL helped them understand genetic inheritance.
- Teacher summarizes key points.

**Assessment:**

- Group presentations graded on accuracy, clarity, and teamwork.
- Individual reflection notes on learning process.
- Short post-lesson quiz with 5 items on Mendelian inheritance.

**Expected Outcomes:**

- Improved understanding of inheritance patterns.
- Enhanced problem-solving and collaboration skills.
- Ability to apply genetics knowledge to real-life situations.