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Comparative Effects of Problem-Based Learning and Programmed Instruction on Academic Achievement of Senior Secondary School Students in Biology

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ABSTRACT

This study investigated the comparative effects of Problem-Based Learning (PBL) and Programmed Instruction (PI) strategies on the academic achievement of senior secondary school students in Biology. A quasi-experimental pretest-posttest control group design was employed, involving 225 Senior Secondary ll students drawn from public schools in Lagos District II (Kosofe,lkorodu & Somolu), Lagos state, South-western Nigeria. The students were randomly assigned to one of three groups: PBL, PI, and a Control group taught with the conventional lecture method. The research instrument used for data collection was the Biology Achievement Test (BAT), developed by the researcher to assess students' understanding of key Biology concepts such as the respiratory system, tissues, and transport mechanisms in animals. Content and face validity of the BAT were ensured through expert review by specialists in science education and educational measurement. The reliability of the instrument was established using test retest, which yielded a coefficient of 0.879, indicating a high level of internal consistency. Data collected were analyzed using descriptive statistics and Analysis of Covariance (ANCOVA). The findings revealed that both PBL and PI significantly enhanced students' academic achievement in Biology when compared to the conventional lecture method. Among the three groups, students exposed to PBL achieved the highest mean gain in the post-test, indicating a stronger impact on conceptual understanding and knowledge retention. The study recommends the integration of PBL strategies into Biology instruction at the senior secondary level to promote meaningful learning and improve science achievement.

Keywords: Problem-Based Learning, Programmed Instruction, Biology Achievement, Instructional Strategies, and Secondary Education.

INTRODUCTION

Biology remains one of the most central and widely offered science subjects in Nigeria's senior secondary school curriculum due to its foundational role in preparing students for careers in fields such as medicine, nursing, agriculture, biotechnology, and environmental science. Its relevance to both individual growth and national development cannot be overemphasized. Despite the high enrollment in Biology at the secondary level, the persistent decline in students' academic performance in national examinations such as the West African Senior School Certificate Examination (WASSCE) remains a major concern. The West African Examinations Council (WAEC, 2023) reported that less than 45% of students achieved credit passes (A1–C6) in Biology in the 2022–2023 cycle, continuing a troubling trend over the last decade. Studies have repeatedly pointed to the dominance of teacher-centered methods—particularly the conventional lecture method—as one of the major contributor to students' underachievement in Biology (Yusuf, Ogunniyi, & Adeyemi, 2021; Eze & Ugwu, 2023). The conventional lecture method often prioritizes memorization of facts over deep conceptual understanding and application. It limits student engagement, suppresses curiosity, and provides few opportunities for collaborative learning or critical thinking. Consequently, many students develop negative attitudes toward Biology, find it abstract and difficult, and struggle to retain and apply biological concepts. In addition to ineffective pedagogy, several other factors contribute to poor performance. These include overcrowded classrooms, inadequate use of teaching aids, low motivation, test anxiety, and learners' poor foundational knowledge (Okoye & Adelakun, 2022). These challenges call for innovative and student-centered

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teaching strategies that can promote meaningful learning, active engagement, and improved academic achievement in Biology. However, in spite of the importance and popularity of the subject among Nigerian students, studies have shown that students lack interest, competence and the right attitude required to learn the subject effectively (Delphonso et., al. 2024). In Rwanda, Byusa et al. (2020) observed that teachers still rely heavily on didactic methods and teach science as a body of knowledge which the students often forget shortly afterwards.

To improve learning outcomes, researchers and educators have advocated for the use of more interactive, student-centered instructional strategies such as Problem-Based Learning (PBL) and Programmed Instruction (PI) (Olorunfemi & Adeoye, 2022; Abubakar & Emeka, 2024). Both strategies represent a shift from passive knowledge transmission to active knowledge construction, offering the potential to enhance students' understanding of scientific concepts and improve their academic performance. PBL is a pedagogical approach that engages students in investigating and solving real-world problems in collaborative settings. It promotes inquiry, critical thinking, and self-directed learning while fostering deeper understanding and long-term retention of knowledge. In the context of science education, PBL has been shown to improve students' performance, attitude, and conceptual grasp of difficult topics (Ogunleye & Ogunbiyi, 2021). According to Putra and Dewi (2018), PBL enhances students' ability to analyze the material by challenging them to learn, work together in groups and find solutions to real problems curiosity and analytical skills.

Sari, Utomo, and Astna (2021) define problem-based learning as a learning approach based on authentic issues. Students gain knowledge through active participation in real-world problem-solving activities, thus developing their understanding. This teaching style requires students to actively engage in acquiring information and exploring potential answers, while the teacher acts as a facilitator. He asserted that problem-based learning offers students a genuine problem that frequently arises in their everyday lives.

A study by Nwankwo et., al. (2022) revealed that students taught using PBL in Biology significantly outperformed those taught with conventional methods, especially in complex topics like respiration, cell and transport.

Shamdas et.al (2023) study on PBL models showed that Biology learning by applying STEM - based PBL had a significant effect on communication skills of high school students in Indonesia compared to direct STEM based learning. A study by Orozco and Yangco (2016) also showed that PBL had higher posttest means score in the critical thinking skills test and creative thinking skills of Biology students in Philippines than those without PBL. Kusaga et al (2022) on their study observed that the use of PBL showed an increased in students achievement test compared to the traditional teaching method. Traditional teaching method they say have the ability to retain achievement at a low level of cognitive ability compared to PBL. The study recommends a continuous use of learner - centred approaches such as PBL in the teaching and learning of science subjects including biology in Tanzania.

Furthermore, PBL aligns with constructivist learning theory, which emphasizes that knowledge is best acquired when learners are actively involved in constructing meaning from experiences. This approach makes learning more relevant and applicable to real-life situations, helping students develop transferable problem-solving skills. As a result, PBL has been recommended for wide implementation in secondary school science education (Hub, 2023). Research indicates a positive correlation between problem-based learning and academic achievement in science education. Students engaged in PBL showed higher levels of understanding and retention of scientific concepts (Bara & Xhomara.2020). Programmed Instruction (PI) on the other hand is a self-paced, step-by-step instructional strategy that allows learners to progress through content in small, logically sequenced units. It often includes immediate feedback to reinforce learning and correct misconceptions. PI has been shown to enhance individualized learning, mastery of concepts, and retention, especially among learners with diverse academic abilities (Omolafe et al., 2023). Although PI is less common in Nigerian classrooms, its advantages in promoting autonomy, reducing cognitive overload, and supporting differentiated instruction have been widely documented. In an experimental study in Ado-Ekiti, Nigeria, PI was found to significantly improve science students' achievement and interest compared to conventional instruction (Adediran & Oladele, 2022). The structure and reinforcement built into PI are especially useful in large classes where individualized attention may be difficult to achieve. Its compatibility with digital and low-

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tech learning tools also makes it a potentially scalable solution in resource-limited settings. While both PBL and PI have independently demonstrated positive outcomes in science education, there is limited research directly comparing their relative effectiveness—particularly within the Nigerian secondary school context and specifically in Biology. Furthermore, most studies focus either on urban schools or on isolated instructional strategies, without evaluating their comparative benefits against the conventional method. This study, therefore, seeks to fill this gap by examining the comparative effects of PBL and PI on students' academic achievement in Biology, using a quasi-experimental design in selected secondary schools in Lagos State.

The purpose of this study

The purpose of this study is to investigate the comparative effects of Problem-Based Learning and Programmed Instruction on the academic achievement of senior secondary school students in Biology. Therefore, the **specific objectives** of this research are to:

(i) determine the difference in academic achievement between students taught using Problem-Based Learning and Programmed Instruction strategies and those taught using the conventional lecture method;

(ii) compare the effectiveness of Problem-Based Learning and Programmed Instruction on students' academic achievement in Biology;

Research Hypotheses

In the context of the above objectives the following research hypotheses will be tested:

(i) There is no significant difference in academic achievement between students taught using Problem-Based Learning and Programmed Instruction strategies and those taught using the conventional lecture method.

(ii) There is no significant effect of Problem-Based Learning and Programmed Instruction on students' academic achievement in Biology

Scope of the study

This study examined the comparative effects of Problem-Based Learning and Programmed Instruction on the academic achievement of senior secondary school students in Biology. The geographical coverage of the study was restricted to Senior Secondary ll students drawn from public schools in Lagos District ll (Kosofe,lkorodu & Somolu), Lagos state, South-western Nigeria.

METHODOLOGY

This study adopted the non-equivalent pre-test, post-test control group design. There were three groups in the study, two experimental groups and one control group.

The design for the study can be represented as:

Experimental Group I O_1 X_1 O_2 O_3

Experimental Group II O_4 X_2 O_5 O_6

Control Group O_7 X_3 O_8 O_9

Population, Sample and Sampling Technique

The study population comprised Senior Secondary ll students drawn from public schools in Lagos District ll (Kosofe,lkorodu & Somolu), Lagos state, South-western Nigeria. A total of 225 male and female Biology students in their intact classes in three randomly selected secondary schools constituted the sample for the study. The schools were randomly assigned to experimental and the control groups.

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Instrument

The instrument used in this study is the Biology Achievement Test (BAT) which was used for pretest and post-test Biology Achievement Test (BAT) which comprises of 60 items of objectives questions. The face validity was undertaken by the researcher's colleagues in the department of test and measurement and two experienced Integrated Science lecturers in colleges of Education University respectively who are seasoned examiners of West Africa Examination Council (WAEC) and National Examinations Council (NECO) for comments on the validity and correctness of the questions and the options attached to them. Based on the comments of the assessors, some few questions were modified. The instruments were pilot-tested on a sample of 25 students selected from a SS II in Epe local government area of Lagos state using test-retest method. The scores on the administration of BAT (i.e. test re-test method) were subjected to correlation analysis using Pearson Product Moment Correlation Analysis (PPMCA). Subjects responded to each of the items in BAT. The responses were scored +2, +1, -1, -2 for positive items and -2, -1, +1, +2 for negative items , depending on the nature of each item. The Kuder-Richardson formula 21 method for determining the reliability of research instrument was utilized. The method is based on the consistency of an individual's performance from the item and the standard deviation of the test such that the estimate or the test reliability coefficient obtained denotes the internal consistency of the test. The internal consistency is the degree to which the items of the test measure a common attribute of the testee. The reliability coefficient (r) for the instrument was 0.84 (i.e.: r = 0.84) which is suitable and reliable for this study. Data collected were analysed using descriptive statistic and analysis of covariance.

Instructional Package

The instructional package consisted of topics that require identification of individual misconception and belief in Biology towards evolution. The content in this study was based on the evolution concepts viz ; concept of evolution, evidence of evolution, the geological timetable, trends and theories of evolution including pre-Darwinism and Neo Darwinism Theories, Darwinism Theories, Darwin's Theory of Natural Selection, Competition with particular emphasis on Competition for Food, Space and other resources among human population, Competition, Variation and Survival of the Fittest, Mutational Changes as causes of Evolution, Adaptive Radiation, Isolating Mechanisms, The Origin of life, Fossils and Human Evolution. The treatment package consisted of three (3) curriculum materials that contained the topics, and various pedagogical strategies that will facilitate meaningful learning. The schools used for the study officially endorsed the instructional package before administration the instrument.

The treatment curriculum packages included;

(a) Problem –Based Learning (PBL);

(b) Programme Instruction (PI) and

(c) Teacher Expository Method (TEM).

PBL is a pedagogical approach that engages students in investigating and solving real-world problems in collaborative settings. It promotes inquiry, critical thinking, and self-directed learning while fostering deeper understanding and long-term retention of knowledge. In the context of science education, PBL has been shown to improve students' performance, attitude, and conceptual grasp of difficult topics (Ogunleye & Ogunbiyi).

PBL is an educational learning approach that involves learning through real-world problem. The purpose is to encourage students to tackle authentic issues and solve practical concerns. These issues provide opportunities for significant activities that involve students in solving challenges and engaging in higher-level thinking in real-life situations (Schmid, 2004; Bolaji, 2014). In problem-based learning, learners gradually assume greater responsibility for their learning and grow more self-reliant, reducing their dependence on the teacher. Students expressed the value of having their voice and autonomy after scenarios were implemented, as well as the value of learning from self-reflection (Carrió & Llerena, 2023).

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The second treatment, Programme Instruction (PI) was utilized as a package for experimental group B. The content materials were extracted from the Biology curriculum of West Africa Examination Council (WAEC). Programme Instruction (PI) has been shown to enhance individualized learning, mastery of concepts, and retention, especially among learners with diverse academic abilities (Omolafe et al., 2023). Although PI is less common in Nigerian classrooms, its advantages in promoting autonomy, reducing cognitive overload, and supporting differentiated instruction have been widely documented. In an experimental study in Ado-Ekiti, Nigeria, PI was found to significantly improve science students' achievement and interest compared to conventional instruction (Adediran & Oladele, 2022).

Teacher Expository Method (TEM) utilized a package for Control group C. The content materials were extracted from the Biology curriculum of West Africa Examination Council (WAEC). .

Teacher Expository Method (TEM) involves verbal presentation of ideas, concepts, generalizations of facts by the teacher where the pupils are either passive listener or slightly involved. Hence this lead to rote learning whereby pupils memorize what they have learnt and regurgitate the facts, this method is one of the methods of teaching Science because it is popularly used in our schools for its instructional advantages in terms of quick and easy coverage of the school syllabus and dissemination of scientific information or principles to a large class (Delphonso 2015).This method of science instruction often fails to address or to change misconceptions about physical phenomena that students bring with them to the classroom (Eaton et al., 1984;Jones,1988) This traditional teacher-centered learning approach often favours passive reception of knowledge, where the teachers acting as repertoire of knowledge and students the dormant recipients (Delphonso et al.,2023).

Data Collection

Permission from the principals and teachers of the selected schools for the study were sought. Teachers and students were subjected to training of the two strategies. In the process, the purpose of the study and the procedural steps involved in the study were discussed with them.

The procedure for collection of data was in three main phases and it lasted for eight weeks.

The phases were:

Pre- test for the first one week

Prior to the commencement of the treatment, all participants were administered a pre-test using the Biology Achievement Test (BAT) to determine their baseline knowledge in Biology.

Treatment for next six weeks

Thereafter, the students were assigned to three groups based on their intact classes: one group was taught using the Problem-Based Learning (PBL) strategy; the second group was exposed to Programmed Instruction (PI), while the third group received instruction through the conventional teaching method. Each instructional method was implemented in line with a standardized lesson plan tailored to the respective strategies. All groups were taught the same Biology topic (Evolution) during the period of study to ensure uniformity of content across the treatments. Trained Biology teachers served as instructors and were properly briefed on the instructional procedures to ensure fidelity in implementation.

Post-test for the last one week of the eight weeks.

The post-test, which was the same as the pre-test (BAT), was administered to all the participants. The scores from the pre- and post-tests were subsequently used to assess the academic achievement of the students under each instructional strategy.

Data Analysis

Data collected were analyzed using descriptive statistics and Analysis of Covariance (ANCOVA) and the

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Scheffe Post-hoc test was used to determine the direction of the significance and also to account for the possible difference among the groups, the pre-test. All hypotheses were tested at $P < 0.05$ level of significance**.**

RESULTS

Hypothesis One: There is no significant difference in academic achievement between students taught using Problem-Based Learning and Programmed Instruction strategies and those taught using the conventional lecture method.

Table 1: Summary of Analysis of Covariance of SS II Students' Achievement, Scores by Strategies.

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig. of F
Main Effects	3,583.372	1	3,583.372	156.295	.000
Covariates (pre-test)	1,848.755	1	1,848.755	80.637	.000
Treatment (PBL, PI, CM)	8,121.535	2	4,060.767	177.118	.000*

*indicate significant F at 0.05 level

$R^2 = .727$ (adjusted $R^2 = .712$)

Table 1 revealed the result of the main effect of instructional strategy on the SS students' achievement in Biology. The result revealed significant outcome ($F_{(2, 212)} = 177.118$, $P < 0.05$), implying that the post-test mean achievement scores of the students after exposure to the different instructional strategies are significantly different. As a result, the null hypothesis 1 which states there is no significant main effect of instructional strategies on students' achievement in Biology is rejected.

Hypothesis 2: There is no significant effect of Problem-Based Learning and Programmed Instruction on students' academic achievement in Biology.

Table 2: Students' Pre- and Post-Test Achievement Scores by Instructional Strategy

Instructional Strategy	Test Type	N	Mean	SD	Minimum	Maximum
Experimental Group 1 (PBL)	Pre-test	75	22.88	5.55	10	34
	Post-test	75	39.81	6.58	28	52
Experimental Group 2 (PI)	Pre-test	78	25.32	4.26	12	33
	Post-test	78	39.38	6.04	25	51
Control Group (CM)	Pre-test	72	24.39	4.88	14	39
	Post-test	72	25.07	4.52	14	34
Total	Pre-test	225	24.21	5.11	10	39
	Post-test	225	34.95	8.91	14	52

Note: PBL = Problem-Based Learning; PI = Programmed Instruction; CM = Conventional Method.

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Table 2 revealed the students' mean achievement scores in Biology before and after exposure to the instructional strategies used in the study. The table showed that the 75 students exposed to problem-based learning strategy (PBL) recorded post-test achievement score of 39.81 (S.D. = 6.58); followed by the 78 students exposed to programmed instruction strategy (PI) whose post-test mean achievement score was 39.38 (S.D. = 6.04), while the 72 students exposed to conventional method recorded the least post-test mean achievement score of 25.07 (S.D. = 4.52). Table 2 further revealed that the highest post-test achievement score of 52 was scored by a student exposed to PBL strategy while a student exposed to CM recorded the least post-test achievement score of 14. Table 2 further revealed positive mean gains across the three groups when the pre-test and post-test scores are compared, with the PBL strategy recording the highest mean achievement gain of +16.93. This outcome thus revealed that there was significant effect of PBL and PI on student's academic achievement in Biology. The hypothesis is therefore rejected.

To explain which of the strategies recorded higher mean achievement scores than the other, the magnitudes of the post-test mean achievement scores of the students exposed to the strategies in the study was computed and presented in Table 3.

Table 3: Multiple Classification Analysis of Students' Achievement Scores by Instructional Strategies

Grand Mean = 34.340

Variable + Category Presentation Media	**N**	**Unadjusted Deviation**	**Eta**	**Adjusted for Independent + Covariates**	**Beta**
1. Exp. Grp. 1 (PBL)	75	6.33	.675	5.47	.456
2. Exp. Grp. 2 (PI)	78	3.05		5.04	
3. Control Group (CM)	72	-9.38		-9.27	

Table 3 revealed the magnitudes of the adjusted post-test mean achievement scores of the students exposed to the three strategies. The MCA in Table 3 revealed a grand mean of 34.340, but the students exposed to PBL strategy recorded the highest post-test mean achievement score of 39.81. Those exposed to PI strategy recorded the next higher post-test mean achievement score of 39.38 while the students exposed to conventional method recorded the least post-test mean achievement score of 25.07. This outcome thus revealed that the problem-based learning strategy with the highest post-test term achievement score could enhance students' achievement in Biology than programmed instruction strategy and conventional method.

Table 3 further revealed that while instructional strategy alone contributed 67.5% of the variance in the students' achievement scores, the independent and moderator variables jointly accounted for 72.7% of the variance in the learners' achievement in Biology.

Table 4: Scheffe Pair-wise Comparisons of Achievement Scores on Instructional Strategies

Mean	**Instructional Strategies**	**PBL**	**PI**	**CM**
39.81	Problem-Based Learning (PBL)		*	*
39.38	Programme instruction (PI)	*		*
25.07	Conventional Method (CM)	*	*	

*denotes pairs of groups that are significantly different at $P < 0.05$.

Table 4 revealed that the obtained significant difference in instructional strategies used was as a result of the significant difference in the post-test mean achievement scores of students exposed to the pairs of PBL and PI

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strategies, PBL strategy and conventional method, as well as PI strategy and conventional method. That is, the obtained difference in the post-test mean achievement scores of the students exposed to pairs of strategies mentioned are statistically significant at the 0.05 level of significance.

DISCUSSION

Academic Achievement between students taught using PBL and PI and those taught using the CLM.

There were positive mean gains across the three groups when the pre-test score and post-test scores were compared. The Problem-Based Learning (PBL) recorded the highest mean achievement gain. The outcome thus revealed that when students are exposed to Problem-Based Learning (PBL) strategy, they record higher achievement gains in Biology than Programmed Instruction (PI) or conventional method. These findings provide support to earlier findings which indicated positive effects of metacognitive instructional strategies over conventional method, had positive effect on students' cognitive achievement and also promote students' scientific creativity (Bara & Xhomara.2020).This findings corroborate Nwankwo et al. (2022) whose study revealed that students taught using PBL in Biology significantly outperformed those taught with conventional methods, especially in complex topics like respiration and cell transport. This study is in agreement with Delphonso et., al. (2024) which opined that role of active learning strategies in the teaching and learning of basic science assisted the students to perform better than their counterparts in Lecture method. This implies that student learn by doing things themselves and through interaction with one another.

Effect of Problem-Based Learning and Programmed Instruction on students' Academic Achievement in Biology.

The focus of this analysis was to seek evidence for significant difference in the cognitive achievement of students in Biology after being exposed to instructional strategies of Problem-Based Learning (PBL) and Programmed Instruction (PI). The results provide evidence which indicate levels of differences through series of mean and standard deviation as recorded in Table 2. This Table reveals that instructional strategies of Problem-Based Learning (PBL) and Programmed Instruction (PI) were found to be effective in enhancing outcomes. There was a general increase in post-test scores over pre-test scores for learning outcomes in the two experimental groups. These findings also support the assertion that both strategies improves students performance and conceptual grasp of difficult topics and investigative nature of science as earlier indicated by Ogunleye & Ogunbiyi(2021). Olorufemi &Adeoye 2022;Emeka &Abubaka 2024 supported that indeed both strategies is a shift from passive knowledge transmission to active knowledge construction. Lisette Wijnia et tal (2024) meta-analysis study, it revealed nuanced insights- A small to moderate, positive, effect of problem-based (PBL), project-based (PjBL), and case-based learning (CBL).on students' motivation (compared to teacher-centered learning). This effect is more pronounced for students' competence beliefs, perceptions of value, and attitudes toward school subjects, such as science. Concerning students' reasons for studying, it was also discovered that a trivial, positive effect. The latter effect conflicts with the popular belief that methods such as PBL can increase students' intrinsic motivation for studying

The strategies aligned with the theory of constructivist which emphasise active involvement of students in the construction of their learning. PBL fosters collaboration, critical thinking, and application of prior knowledge and PI improves self-paced mastery but less effective than PBL in engagement.

CONCLUSION

The study investigated the comparative effects of Problem-Based Learning and Programmed Instruction on the academic achievement of senior secondary school students in Biology and two hypotheses were generated and tested.

H_{01} states that there was no significant difference in academic achievement between students taught using Problem-Based Learning and Programmed Instruction strategies and those taught using the conventional lecture method. The outcome thus revealed that when students are exposed to Problem-Based Learning (PBL)

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strategy, they record higher achievement gains in Biology than Programmed Instruction (PI) or conventional method. The hypothesis was rejected.

H_{02} state that there was no significant effect of Problem-Based Learning and Programmed Instruction on students' academic achievement in Biology. The results provide evidence which indicate levels of differences through series of mean and standard deviation that revealed that instructional strategies of Problem-Based Learning (PBL) and Programmed Instruction (PI) were found to be effective in enhancing outcomes. There was a general increase in post-test scores over pre-test scores for learning outcomes in the two experimental groups. Therefore, the hypothesis was rejected. The Scheffe post-hoc test was then carried out on the group means for the significant comparison of the mean values of the three groups. The Scheffe analysis showed that there was a significant difference among the three groups.

In view of the above results, it implied that students that were exposed to Problem-Based Learning (PBL) strategy, recorded higher achievement gains in Biology than Programmed Instruction (PI) or conventional method. Indicating that this strategy is the best suitable and it enhances a shift from passive knowledge transmission to active knowledge construction of the students. The present research developed initiative from Science Education literature that highlighted the need for instructional strategies that could reduce students' dependence on teachers with the aim of contributing towards meeting this need. Far more than the conventional method, instructional strategies that were employed in this study emphasized the participation and active intellectual involvement of students. Finding from this study suggest the effectiveness of the learner-centred instructional strategies of Problem-Based Learning (PBL) and Programmed Instruction (PI) in promoting conceptual understanding in Biology. This study has highlighted the potential value of teaching cognitive strategies in addition to presenting instructional content. These metacognitive strategies are alternative to conventional method which is in vogue in our secondary schools.

Furthermore, these strategies could serve as effective tools that will assist learners to process information in a meaningful way and become independent learners. This, no doubt, will engender learning outcomes in science. PBL, PI and other innovative strategies are most effective for improving academic achievement in Biology

RECOMMENDATIONS

1. Teachers are encouraged to utilize PBL, PI in the teaching and learning of Biology for better comprehension. Biology is a subject that study life, students should not be discouraged with the teachers normal method.

2. Teachers should be trained on the use of different methods that allows active participation or involvement in the teaching and learning process.

3. Curriculum developers should integrate PBL, PI and other metacognitive strategies into the curriculum and enforce the use.

4. Policy makers should fund the development and implementation of innovative strategies in schools.

5. Government should sponsor Biology teachers to conferences, workshops, and seminars to enable them update their knowledge on new methods of teaching Biology.

Suggestion for further studies

This study documents the effectiveness of using Problem-Based Learning (PBL) and Programmed Instruction (PI) for presenting Biology to students in the experimental groups. There is a need, however, to use these strategies on a larger sample in other educational settings with different student's cultural and educational backgrounds. The result of the findings also suggests that cognitive strategies could assist learners in expressing ideas and communicating experiences in science lessons. This will assist the learners after formal schooling system. Further research is therefore, needed to better understand the process of making learners achieve metacognitive sophistication in other subject areas. This will make one determine effectiveness of learning cognitive strategies in these areas in order to ascertain generalisation of the findings.

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In Science Education, a very important area of concern is provision of appropriate instructional strategies that can enhance learner's performance. Since this study suggests that metacognitive instructional strategies of Problem-Based Learning (PBL) and Programmed Instruction (PI) are viable alternatives to conventional method, there is need to look at its effectiveness in our teacher education programme. This is because no education can rise above the quality of its teachers .A possible replication of this study can be undertaken with attention on the effect of other variables like socio-economic background of learners and geographical location of schools.

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