# Effects of Problem-Solving and Concept Mapping Instructional Strategies on Ekiti State Secondary School Students' Performance in Biology

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***Abstract:***
*The study examined effects of problem-solving and concept mapping instructional strategies on Ekiti State Secondary School Students' performance in Biology. The study examined the difference in the performance of students' taught Biology using problem-solving instructional strategy, concept mapping instructional strategy and conventional strategy as well as influence of gender on students' performance using problem solving and concept mapping instructional strategies in teaching Biology. This study adopted a quasi-experimental pre-test and post-test control group design (two experimental groups and one control group). The treatments applied to the experimental groups were problem solving and concept mapping instructional strategies, while the control group was exposed to the conventional strategy. The population for this study consist of 19,603 Senior Secondary School Two (SSSII) Biology students in Ekiti State. The sample for the study was 240 SSSII Biology students in Ekiti State Public Secondary Schools. Multistage sampling technique was used to select the schools sample for the study. The instrument used for the study was Biology Performance Test (BPT). The face and content validity of the research instrument was confirmed through experts in Science Education Department while the reliability of instrument was established using test re-tests method. Reliability coefficient of 0.75 was obtained. The experimental procedures for this study were in three stages: pre-treatment stage (1 week), treatment stage (2 weeks) and the post treatment stage (1 week). Four weeks altogether were used for the whole study. Two research questions were raised and six hypotheses were formulated. The results of the data collected from both pre-test and post-test were collated and analysed using descriptive and inferential statistics. The questions raised were answered using mean scores and standard deviation while all the hypotheses generated for the study were tested at 0.05 level of significance using t-test, Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA). The findings show significant difference between the two experimental groups (those taught using concept mapping instructional strategy did significantly better than those taught using problem-solving instructional strategy); there is no difference in the performance means score of male and female students taught Biology using problem solving ,concept mapping, and conventional strategies. It was concluded that both strategies when adopted for the teaching of Biology are very rewarding for students' academic performance regardless of their genders. It was recommended that the use of problem solving and concept mapping should be adopted for the teaching of Biology as innovative tools to facilitate teaching on the teacher's part and learning on the learner's part.*

***Key words:*** *Problem-solving, Concept mapping, Instructional strategies, Performance.*

## 1. Introduction

Science educators over the years have been paying attention on how to improve science teaching in schools by going beyond the old methods of obtaining knowledge in science. This deliberate effort perhaps, spring from continual emphasis in science teaching and on students' active involvement in science. According to Feynman (2011) science has become such an indispensable tool that no nation, developed or developing, wishing to progress in socio-economic society will afford to relegate the learning of science in schools to the background. No wonder, Nwagbo in Usman (2000) explained science as an intellectual activity carried out by humans, designed to discover information about the natural world in which we live and to discover the ways in which this information can be organized to benefit human race. Therefore, when the students are involved in science,

science process skills such as careful observations, interpreting, predicting events, designing experiment, organizing information, reporting and generalization will be acquired.

Science comprises the basic disciplines such as biology, chemistry, physics and mathematics. The Federal Ministry of Education (FME, 2013) identified biology among the core-science subjects offered at the Senior School Certificate Examination (SSCE) level. Ramalingam,T.R (2003) defined Biology as one of the branches of science that involves the study of living things ranging from microscopic cellular molecules to the biosphere which encompasses the earth surface. According to Okenyi (2015) biology has been defined as a structured to equip the students with the knowledge of relevant concepts and scientific skills.

The importance of biology to the survival of human being and technological development cannot be underestimated in any society globally. According to Maduabum (2009), the importance of Biology are not limited to helping individuals to understand the parts of his/her body and their functions; enabling one to question superstition due to sustained interest arising from comprehension of the cause of events understanding and appreciating life; bringing into focus the need to maintain good health; promoting the individual for choice of careers; inculcating in the individual scientific skills and attitudes in his approach to personal and societal problem; but impart factual knowledge and stimulate scientific reflective thinking so as to produce a better informed individual.

It is interesting to further note that before, Biology has witnessed a high enrolment compared to any other science subject in the final year external examination (Sakiyo, 2014). Despite the high enrolment rate there has not been corresponding increase in students' academic performance and in spite of the efforts of both Federal and State Governments to encourage Biology Education, students' failure in Biology in Senior Secondary Certificate Examination (SSCE) is high. One of the major reasons for this poor performance could be due to ineffective methods of Biology instruction used by Nigerian secondary school teachers.

The teacher has been found to be a very important factor in the implementation of any curriculum, because what the student knows or does not know depend mainly on the teacher. But, Nwagbor (2001) reported that majority of teachers still shy away from the more effective activity-oriented teaching methods like inquiry, problem solving, concept mapping and constructivist methods in preference to conventional method which is easy and mostly inadequate and inappropriate. Many of the methods of conveying knowledge have been shown to be relatively ineffective on the students' ability to master and retain concepts. The manner in which Biology subject is presented to students can negatively influence their performance, the presentation should be activity-based rather than teacher-centered based. The use of conventional method entails a one way flow of communication from the teacher to the students, the method is a teacher-centered approach where most of the talking is carried out by the teacher while the students remain as passive listeners taking down notes.

Most of the teaching carry out in our schools today is through the use of conventional strategy, which according to Okebukola (2005) is passive rather than active and do not foster critical and creative thinking. Many teachers prefer the use of conventional strategy as revealed by Nzewi (2009) because it does not require the use of instructional materials or resources, to this effect, the students are denied the opportunity of developing manipulative skills. However, Agboghoroma (2009) pointed out that despite the existence of learning theories most teachers still dispense information using conventional method. Therefore, Biology teacher should be equipped with the right teaching strategies for effective learning to take place.

Problem-solving competencies are the knowledge, skills and general disposition or attitudes which individuals need, to be able to identify and tackle observed or perceived problems in the environment with a view to finding solution to them. Problem solving can be well-defined as any kind action a person grosses to channel the cavity between the anticipated solution and the problem itself. Problem solving ability is the ability to bridge the gap between a problem and a solution by using information (knowledge) and reasoning (Akuma, 2008).

Problem solving is described as formulating new answers, going beyond the simple application of previously learned rules to create a solution. Problem solving is an investigative task whereby the solver explores the solution path to reach a goal from given information. Research results have shown that students learn meaningfully when they work in small groups as they have the opportunity to negotiate meaning and construct

conceptual understanding in community of learners (Agbi, 2006). This is in agreement with a Chinese proverb that says "What I hear, I forget, what I see, I remember, what I do, I understand". The students' ability to achieve within the classroom setting has been largely adduced to the quality of instruction, personality of the teacher and availability of instructional materials among others (Adeshina and Oyebamiji, 2011).

Concept mapping according to Kinchin, (2005) is a strategy that help learners organise their cognitive frameworks into more powerful integrated patterns. Concept maps are diagrams indicating inter-relationships among concepts as representation of meaning or Educational framework specific to a domain of knowledge (Novak, Mintzes and Wandersee, 2000). Okebukola (2005) believed that the maps can be applied to any subject matter or to any level within the subject. Biology being a somewhat difficulty aspect of science deserve a systematic way of teaching.

Concept mapping as a strategy in Education is parallel with the movement from teacher to learner-centred method which has the power to improve academic performance (Peterson and Snyder, 2008). Concept mapping has been widely recommended and used in a variety of ways. It has been used to help teachers and students build an organized knowledge based on a given discipline or on a given topic (Blackwell & Pepper, 2008). It has also, been used to facilitate middle level students' learning of Biology content (Adlaon, 2002; Dhaaka, 2012). Findings from these studies indicate that problem solving and concept mapping is an effective tools for aiding students' comprehension and retention of Biology concept.

Jegede cited in Nnamdi and Okechukwu (2006) showed that the use of teaching strategies like concept mapping and problem solving methods increases performance and reduces both male and female students' anxiety. Moreover, Orado (2009) recommended that, giving students more chance to get involved in the learning process through the use of concept mapping and problem solving skills makes them perform significantly better than their counterparts who have been exposed to the conventional method. It has also became clear that for students who have some concept mapping experience, there exists a correlation between their concept mapping ability and performance in Biology test.

It appears that gender issue in any science oriented subjects including Biology cannot be unconnected with conventional approach to classroom instruction. In biology class for instance, the researcher observed that female students' performed better than their male counterparts. Whereas, this gender differences can be eliminated when teachers used certain teaching strategies that can bring about gender equity in Science Education and Biology in particular.

Performance is defined as the observable or measurable behaviour of a person or an animal in a particular situation usually experimental situation. This means that performance measures the aspect of behaviour that can be observed at a specific period. To determine performance, a performance test is conducted. Performance test is the type of mental test in which the subject is asked to do something rather than to say something. Performance test is the type of test which throws light on the ability to deal with things rather than symbols. In relation to educational research, academic performance of a student can be regarded as the observable and measurable behaviour of a student in a particular situation. For example, the academic performance of a student in Biology includes observable and measurable behaviour of a student at any point in time during a course.

In Biology, students' academic performance consists of his scores at any particular time obtained from a teacher- made test. Therefore, we can equate academic performance with the observed behaviour or expectation of achieving a specific statement or statement of educational intention in a research. Academic performance of students consists of scores obtained from teacher-made test, first term examination, mid-semester test, and so on. However, there is an obvious tendency that practical scientific methods such as problem solving and concept mapping is muddled up with theory during teaching to the extent that the efforts distort theoretical understanding of biological concepts.

Biology teachers must consider separately the aims of each topic and use appropriate method of teaching it so that students can establish a self-sufficient rationale for each. It is this area of interaction between problem solving and concept mapping strategies that this study seeks to examine, to see how the two teaching strategies may help to ensure better understanding of Biology in senior secondary schools. The implication of this to Biology teaching is to help students to acquire cognitive understanding of biological knowledge and concepts

and also a mastery of the skills for their private studies in science. The study therefore seeks to examine the effects of problem solving and concept mapping strategies on performance in Biology among secondary schools' students in Ekiti State.

**2. Statement of the Problem**

The yearning for quality and effective instruction delivery has been a long standing objective of science educators. The emerging concern for the poor performance of students in Biology had led to the search for instructional strategies that promote effective teaching and learning of Biology. Based on the experience of the researcher as a class teacher for years, the researcher observed that the performance of students' in Biology is not encouraging and this could be due to the instructional method used by Biology teachers in our secondary schools in Ekiti State. The need to redress this alarming academic problem necessitated exploring the effects of problem solving and concept mapping teaching strategies on students' performance in Biology.

**3. Purpose of the Study**

- The study determined the effects of problem-solving and concept mapping instructional strategies on Ekiti State Secondary School Students' performance in Biology.
- It examined the effects of gender on students' performance in Biology using problem-solving and concept mapping instructional strategies.

**4. Research Questions**

The following questions were raised to guide the study:

i. What is the difference in the performance mean scores of students taught Biology with problem solving instructional strategy, concept mapping instructional strategy and conventional strategy?
ii. To what extent would gender influence the performance mean scores of students taught with problem solving instructional strategy, concept mapping instructional strategy and conventional strategy in the Biology Performance Test?

**5. Research Hypotheses**

1. There is no significant difference in the performance mean scores of the experimental and control groups.
2. There is no significant difference between the pre-test mean scores and post-test mean scores of the students in each experimental and control group.
3. There is no significant difference in the performance mean scores of students in problem solving and concept mapping instructional strategies.
4. There is no significant difference in the performance mean scores of the students exposed to concept-mapping strategy and conventional strategy.
5. There is no significant difference in the performance mean scores of the students exposed to problem-solving strategy and conventional strategy.
6. There is no significant difference between male and female students' performance in each experimental group and control group.

**6. Research Design**

The research design use for this study was quasi-experimental design, employing the pre-test, post-test control group design. The treatment (instructional strategy) operates at three levels namely: problem-solving, concept mapping and the control groups. Each of the groups was given pre-test while only the experimental group was given the treatment after which all groups was given post-test to ascertain the effects of the treatment given on the experimental group. The design was chosen because it will allow for separate determination of the main effects of treatments and pattern of interaction effects of gender on student performance. The pattern of the design is shown below.

$E_1$ = $O_1$ $X_1$ $O_2$

$E_2$ = $O_3$ $X_2$ $O_4$
C = $O_5$ C $O_6$

Where

| | |
|---|---|
| $E_1$ | Experimental Group 1 |
| $E_2$ | Experimental Group 2 |
| C | Conventional (Control Group) |
| $O_1$ $O_3$ $O_5$ | Pre-tests observation |
| $O_2$ $O_4$ $O_6$ | Post-tests observation |
| $X_1$ | Problem-Solving treatment ($X_1$ is to $E_1$) |
| $X_2$ | Concept Mapping treatment ($X_2$ is to $E_2$) |
| C | Control group |

**7. Population**

The population for this study was made up of 19,603 Senior Secondary School Two (SSSII) Biology students in 189 Public Secondary Schools in Ekiti State (Ekiti State Ministry of Education Science and Technology, 2018).

**8. Sample and Sampling Techniques**

The sample for the study was 240 SSSII Biology students in Ekiti State Public Secondary Schools. Multistage sampling procedure was used to select the sample for the study. Stage one involved the selection of two Local Government Areas in each of the Senatorial District in Ekiti State through the use of simple random sampling technique. The second stage involved the selection of two schools, one experimental and one control group from each of the selected Local Government Areas using stratified sampling technique. This was followed by the use of intact classes in each of the schools selected.

**9. Research Instruments**

Four research instruments were used for this study; one response instrument which was Biology Performance Test (BPT). The BPT consists of two sections. Section A was seek to elicit information concerning the bio-data of the students. Section B consist of twenty multiple choice item questions with four options (A-D). Each correct questions carry two marks while wrong questions carry zero. The stimuli instruments are teaching guides prepared by the researcher for the teachers on problem solving, concept mapping and conventional teaching strategies. They were used by the teachers during the training period in the experimental and control groups. The stimulus instrument consist of the step–by–step procedure of teaching basic ecological concept, local biotic community, ecosystem and population study with the strategies according to the Biology syllabus for Senior Secondary Schools. They were:

i. Teacher's Instructional Guide on Problem – Solving Strategy (TIGPSS)
ii. Teacher's Instructional Guide on Concept – Mapping Strategy (TIGCMS)
iii. Teacher's Instructional Guide on Conventional Strategy (TIGCS)

Teacher's Instructional Guide on Problem – Solving Strategy and Concept Mapping Strategy is a student's centered approach while Teacher Instructional Guide on Conventional Strategy is a teacher centered approach.

**10. Experimental Procedure**

The experimental procedure was in three stages: The first stage was the pre-treatment stage where the researcher visit the schools to take permission from school authorities, after which the researcher orientate the research assistants who are the Biology teachers' that the researcher train on how to use the strategies for the administration of pre-test on the experimental and control groups. The second stage was treatment stage where the researcher and research assistants expose the respondents to problem solving and concept mapping teaching strategies in the class lessons for a period of four weeks while the control group was taught Biology using the conventional strategy in their normal class lessons for the same period. The third stage was the administration of the post-test for the students after the treatment to each group with the same time as observed during the pre-

test. The same Biology Performance Test questions used during the pre-test was rearranged to avoid practice effect and administered to the experimental and control groups.

## 11. Data Analysis

The data collected were analyzed using descriptive statistics and inferential statistics. The two research questions were analyzed using descriptive statistics of mean and standard deviation. Hypothesis 1 was tested with inferential statistics of Analysis of Covariance (ANCOVA); hypothesis 2 was tested with t-test while hypotheses 3-6 were tested using Analysis of Variance (ANOVA). All hypotheses were tested at 0.05 level of significance.

## 12. Results

This section contains the descriptive analysis of the data collected to answer the research questions as well as hypotheses testing.

**Question 1:** What is the difference in the post test mean scores of students taught Biology with problem solving instructional strategy, concept mapping instructional strategy and conventional strategy?

In order to answer the question, students' scores in Biology post-test was computed using mean and standard deviation. The result is presented below in Table 1 below.

**Table 1: Mean Scores and Standard Deviations (SD) of Students Performance in Biology**

| Group | N | Mean | S.D |
|---|---|---|---|
| Conventional Methods | 90 | 14.64 | 2.615 |
| Problem Solving | 89 | 17.98 | 3.115 |
| Concept Mapping | 59 | 26.02 | 2.270 |
| **Grand Mean** | **238** | **18.02** | **2.716** |

Table 1 shows that students in two experimental groups (concept mapping and problem solving) correspondingly had mean scores and standard deviations of 26.02±2.270 and 17.98±3.115 respectively. The mean score and standard deviation for the control group (conventional strategy) was found to be 14.64±2.615. The observation implied that the use of problem solving instructional strategy and concept mapping instructional strategy indicated a positive effect on students' performance in Biology.

**Question 2:** To what extent would gender influence the performance mean scores of students taught with problem solving instructional strategy, concept mapping instructional strategy and conventional strategy in the Biology Performance Test?

**Table 2: Performance Mean Scores of Male and Female Students in Biology**

| Group | Gender | N | Mean | S.D |
|---|---|---|---|---|
| Conventional Methods | Male | 40 | 14.40 | 2.649 |
| | Female | 50 | 14.84 | 2.598 |
| Problem Solving | Male | 31 | 18.81 | 3.637 |
| | Female | 58 | 17.53 | 2.729 |
| Concept Mapping | Male | 25 | 25.40 | 2.500 |
| | Female | 34 | 26.47 | 2.004 |

Table 2 shows that female students in conventional strategy and concept mapping groups had higher mean scores than their male counterparts. Similarly, the result shows that male students in problem solving group had higher mean score than their female counterparts. The observation implied that female students are likely to exell more in Biology with the use of conventional strategy and concept mapping instructional strategy as male students' excell more with the use of problem solving instructional strategy.

**Hypothesis 1:** There is no significant difference in the performance mean scores of students in the experimental and control groups.

In order to test the hypothesis, data obtained in the pre-test and post-test were analysed using Analysis of Covariance (ANCOVA) at 0.05 level of significance as shown in Table 3 below.

**Table 3: Analysis of Covariance (ANCOVA) of Differences in Experimental and Control Groups**

| Source | SS | df | MS | F | $p_{-value}$ | $Eta^2$ |
|---|---|---|---|---|---|---|
| Corrected Model | 4826.425[a] | 3 | 1608.808 | 232.302 | .000 | .749 |
| Intercept | 3082.748 | 1 | 3082.748 | 445.129 | .000 | .655 |
| Covariate (Pre-test) | 140.990 | 1 | 140.990 | 20.358 | .000 | .080 |
| Groups | 4791.081 | 2 | 2395.540 | 345.901 | .000 | .747 |
| Error | 1620.571 | 234 | 6.926 | | | |
| Total | 89763.000 | 238 | | | | |
| Corrected Total | 6446.996 | 237 | | | | |

$p<0.05$ (Significant)

Table 3 indicate that ($F_{3,\ 234}$ =345.901, $p<0.05$). The hypothesis is rejected. Therefore, there is significant difference in the performance mean scores of students in Biology in the experimental and control groups. The magnitude of the observed variance in students' performance in Biology due to the effectiveness of the treatment was about 74.7% ($Eta^2$=0. 747). However, in order to determine which of strategies has comparative effectiveness on the performance of students in Biology, Multiple Clarification Analysis (MCA) was carried out. The result is presented in Table 4.

**Table 4: Scheffe's Post Hoc Multiple Clarification Analysis of Post-Test Scores for Treatment Groups**

| (I) Groups | (J) Groups | Mean Difference (I-J) | $p_{-value}$ |
|---|---|---|---|
| Conventional | Problem Solving | -4.286* | .000 |
| | Concept Mapping | -12.030* | .000 |
| Problem Solving | Conventional | 4.286* | .000 |
| | Concept Mapping | -7.744* | .000 |
| Concept Mapping | Conventional | 12.030* | .000 |
| | Problem Solving | 7.744* | .000 |

$p<0.05$ (Significant)

Table 4 shows that students in the two experimental groups (problem solving and concept mapping) are significantly different from those in the control group and that their performance was better than those in the control group. The result indicated that there was a significant difference between the two experimental groups (those taught using concept mapping instructional strategy did significantly better than those taught using problem-solving instructional strategy)

**Hypothesis 2:** There is no significant difference between the pre-test mean scores and post-test mean scores of the students in each experimental and control group.

**Table 5: t-test Analysis of Differences Between the Pre-test Mean Scores and Post-test Mean Scores of the Students in Biology**

| | | N | Mean | SD | df | t | $p_{-value}$ |
|---|---|---|---|---|---|---|---|
| Conventional Method | Pre-test | 90 | 13.78 | 2.43 | *89* | 2.258 | *.026* |
| | Post-test | 90 | 14.64 | 2.62 | | | |
| Problem Solving | Pre-test | 89 | 10.42 | 3.16 | 88 | 21.335 | .001 |
| | Post-test | 89 | 17.98 | 3.12 | | | |
| Concept Mapping | Pre-test | 59 | 11.46 | 2.46 | 58 | 45.105 | .001 |
| | Post-test | 59 | 26.02 | 2.27 | | | |

$p<0.05$ (Significant)

Table 5 indicates that t(89) = 2.258, p=0.026 for conventional strategy, t(88) =21.335, p=0.001 for problem solving and t(58) = 45.105, p=0.001 at 0.05 level of significance. The null hypothesis is rejected. Therefore,

there is significance difference in the pre-test mean scores and post-test mean scores of the students in each experimental and control group. This implies that effective teaching contribute to students' knowledge of Biology irrespective of the method used.

**Hypothesis 3:** There is no significant difference in the performance mean score of students in problem solving and concept mapping instructional strategies.

**Table 6: Analysis of Variance (ANOVA) of Difference in the Performance Mean Score of Students Using Problem Solving and Concept Mapping Instructional Strategies**

| Source | SS | df | MS | F | $p_{-value}$ | $Eta^2$ |
|---|---|---|---|---|---|---|
| Corrected Model | 2513.601 | 2 | 1256.801 | 195.433 | .000 | .729 |
| Intercept | 2887.134 | 1 | 2887.134 | 448.951 | .000 | .756 |
| Covariates (pre-test) | 220.465 | 1 | 220.465 | 34.282 | .000 | .191 |
| Group | 1985.959 | 1 | 1985.959 | 308.818 | .000 | .680 |
| Error | 932.473 | 145 | 6.431 | | | |
| Total | 69853.000 | 148 | | | | |
| Corrected Total | 3446.074 | 147 | | | | |

$p<0.05$ (Significant)

Table 6 shows that ($F_{2, 145} = 34.282$, $p<0.05$). The hypothesis is rejected. Thus, there exist significant difference in the performance mean score of students taught Biology using problem solving and concept mapping teaching strategies. About 68% was the magnitude of the observed variance in students' performance in Biology due to the effectiveness of the treatment. In order to determine which of the strategies has comparative effectiveness on the performance of students in Biology, Multiple Clarification Analysis (MCA) was carried out. The result is presented in Table 7.

**Table 7: Multiple Clarification Analysis of Students' Performance in Biology Using Problem Solving and Concept Mapping Instructional Strategies**

| (I) Group | (J) Group | Mean Difference (I-J) | **$p_{-value}$** |
|---|---|---|---|
| Problem solving | Concept mapping | -7.598* | .000 |
| Concept mapping | Problem solving | 7.598* | .000 |

$p<0.05$ (Significant)

Table 7 indicates that the mean score for problem solving was significantly different from concept mapping instructional strategy by 7.598, $p<0.05$, indicating that concept mapping instructional strategy had comparative effectiveness over problems solving.

**Hypothesis 4:** There is no significant difference in the performance mean scores of the students exposed to concept mapping strategy and conventional strategy.

**Table 8: Analysis of Variance (ANOVA) of Difference in the Performance Mean Score of Students Using Concept Mapping Instructional Strategy and Conventional Strategy**

| **Source** | **SS** | **Df** | **MS** | **F** | **$p_{-value}$** | **$Eta^2$** |
|---|---|---|---|---|---|---|
| Corrected Model | 4626.534 | 2 | 2313.267 | 379.387 | .000 | .839 |
| Intercept | 1824.021 | 1 | 1824.021 | 299.148 | .000 | .672 |
| Covariate (Pre-test) | 17.388 | 1 | 17.388 | 2.852 | .093 | .019 |
| Groups | 4001.722 | 1 | 4001.722 | 656.302 | .000 | .818 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Error | 890.217 | 146 | 6.097 | | | |
| Total | 60145.000 | 149 | | | | |
| Corrected Total | 5516.752 | 148 | | | | |

p<0.05 (Significant)

Table 8 shows that ($F_{2, 146}$ =656.302, p<0.05). The hypothesis is rejected. Thus, there exist significant difference in the performance mean score of students in Biology in concept mapping strategy and conventional strategy groups. About 81.8% magnitude of the observed variance in students' performance in Biology was due to the effectiveness of the treatment ($Eta^2$ = 0.818). In order to determine which of strategies has comparative effectiveness on the performance of students in Biology, Multiple Clarification Analysis (MCA) was carried out. The result is presented in Table 9.

**Table 9: Multiple Clarification Analysis of Students' Performance in Biology Using Concept Mapping Instructional Strategy and Conventional Strategy**

| (I) Groups | (J) Groups | Mean Difference (I-J) | $p_{-value}$ |
|---|---|---|---|
| Conventional | Concept mapping | -11.699* | .000 |
| Concept mapping | Conventional | 11.699* | .000 |

p<0.05 (Significant)

Table 9 indicates that the mean score for conventional instructional strategy was significantly different from concept mapping instructional strategy by 11.699 p<0.05, indicating that concept mapping instructional strategy had comparative effectiveness over conventional strategy of teaching Biology.

**Hypothesis 5:** There is no significant difference in the performance mean scores of the students exposed to problem-solving strategy and conventional strategy.

**Table 10: Analysis of Variance (ANOVA) of Difference in the Performance Mean Score of Students Using Problem-solving Strategy and Conventional Strategy**

| Source | SS | df | MS | F | $p_{-value}$ | $Eta^2$ |
|---|---|---|---|---|---|---|
| Corrected Model | 584.794[a] | 2 | 292.397 | 37.429 | .000 | .298 |
| Intercept | 1606.910 | 1 | 1606.910 | 205.697 | .000 | .539 |
| Covariate (pre-test) | 87.662 | 1 | 87.662 | 11.221 | .001 | .060 |
| Group | 572.892 | 1 | 572.892 | 73.335 | .000 | .294 |
| Error | 1374.915 | 176 | 7.812 | | | |
| Total | 49528.000 | 179 | | | | |
| Corrected Total | 1959.709 | 178 | | | | |

p<0.05 (Significant)

Table 10 shows that ($F_{2, 176}$ =73.335, p<0.05). The hypothesis is rejected. Therefore, there is significant difference in the performance mean score of students in Biology using problem-solving strategy and conventional strategy. The size of the effect due to the effectiveness of the treatment was about 29.4% ($Eta^2$ = 0.294). In order to determine which of the strategies has comparative effectiveness on the performance of students in Biology, Multiple Clarification Analysis (MCA) was carried out. The result is presented in Table 11.

**Table 11: Multiple Clarification Analysis of Students' Performance in Biology Using Problem Solving Strategy and Conventional Strategy**

| **(I) Group** | **(J) Group** | **Mean Difference (I-J)** | **$p_{-value}$** |
|---|---|---|---|
| Conventional | Problem-solving | -4.173* | .000 |
| problem-solving | conventional | 4.173* | .000 |

p<0.05 (Significant)

Table 11 indicate that the mean score for conventional instructional strategy was significantly different from problem-solving strategy by 4.173 $p<0.05$, indicating that problem-solving strategy had comparative effectiveness over conventional strategy of teaching Biology.

**Hypothesis 6:** There is no significant difference in the performance mean score of male and female students taught Biology using concept mapping, problem solving and conventional strategy.

**Table 12: Analysis of Variance (ANOVA) of Difference in Male and Female Students' Performance in each Experimental Group and Control Group.**

| Source | SS | df | MS | F | $p_{-value}$ | $Eta^2$ |
|---|---|---|---|---|---|---|
| Corrected Model | 35.378[a] | 2 | 17.689 | .648 | .524 | .005 |
| Intercept | 6075.649 | 1 | 6075.649 | 222.686 | .000 | .487 |
| Covariate (Pre-test) | 35.296 | 1 | 35.296 | 1.294 | .257 | .005 |
| Gender | .034 | 1 | .034 | .001 | .972 | .000 |
| Error | 6411.618 | 235 | 27.283 | | | |
| Total | 89763.000 | 238 | | | | |
| Corrected Total | 6446.996 | 237 | | | | |

$p>0.05$ (Not Significant)

Table 12 shows that ($F_{2, 235}=0.001$, $p>0.05$) at 0.05 level of significance. The null hypothesis is accepted. Thus, there is no difference in the performance mean score of male and female students taught Biology using problem solving, concept mapping and conventional strategies. This implies that gender has no influence on either of the instructional strategies to determine students' performance in Biology.

## 13. Discussion

Findings from the study shows that there is a significant difference in the performance mean scores of students taught Biology using problem solving, concept mapping and conventional instructional strategies. The result implies that the use of problem solving instructional strategy and concept mapping instructional strategy had positive effect on students' performance in Biology than conventional strategy. Independent interpretations from both descriptive and analysis of covariance (ANCOVA) clearly indicate that the strategy that performed better among the strategies considered in this study is concept mapping instructional strategy. The hierarchical order of performance and importance of the instructional strategies considered is thus: *concept mapping instructional strategy> problem solving instructional strategy > conventional teaching* strategy.

Thus, both problem solving and concept mapping instructional strategies are much better in enhancing students' performance in Biology than the conventional teaching strategy. This may be due to the fact that all sense organs and other parts of the body of the students were involved in learning and they were left to discover the knowledge on their own when subjected to both concept mapping and problem solving instructional strategies. In agreement with this finding, Akeju, Rotimi and Kenni (2011) opined that the need to build teachers awareness of the new teaching strategies and tools that can be used in the classroom with initiatives in teaching-learning that integrates the inquiry based learning with Information Communication Technology is an effort to aid and effect student-centred learning. Hence, problem solving instructional strategy and concept mapping instructional strategy was designed to improve science teaching and learning through more innovative teaching strategies (Nwosu, Onyegegbu, Nwagbo, Nworgu, 2009; Jegede and Fatoke, 2014).

The findings also showed that there was significance difference in the pre-test mean scores and post-test mean scores of the students in each experimental and control group, indicating effective teaching contribute to students' knowledge of Biology irrespective of the method used. In support of this finding, Sakiyo (2014) concluded that teaching methods as pedagogical strategies are designed and adopted by the teacher to facilitate teaching on the teachers' part and learning on the learner.

The findings further confirmed significant difference in the performance mean score of students in Biology when taught with problem solving and concept mapping instructional strategies, indicating that concept mapping instructional strategy had comparative effectiveness over problems solving. This finding is not in support with Olajengbesi and Aluko (2008) who found students exposed to problem solving instructional strategy better than those exposed to concept mapping in Chemistry. Perhaps the adoption of concept mapping instructional strategy may be appropriate for the teaching and learning of Biology more than Chemistry.

It was also confirmed from the findings that there was significant difference in the performance mean score of students taught Biology using concept mapping strategy and conventional method groups, indicating that concept mapping instructional strategy had comparative effectiveness over conventional strategy of teaching Biology. This finding is in support with Ajaja (2013) who found students taught with concept mapping outscored those in lecture group both on immediate achievement and retention tests in Biology. The reason for this may be because concept mapping instructional strategy helps both the teacher and student to pay attention to the major concepts in any given topic in Biology as conventional strategy is found to be teacher-centred.

The findings also confirmed significant difference in the performance mean score of students in Biology using problem-solving strategy and conventional strategy, revealing that problem-solving strategy had comparative effectiveness over conventional strategy of teaching Biology. This finding is in support of Nbiti and Neji (2018) who found the use of problem-solving approach in teaching Physics and Chemistry served as synergy in enhancing Physics and Chemistry learning in school.

It was showed from the findings that there is no difference in the performance means score of male and female students taught Biology using concept mapping, problem solving and conventional strategy. This implies that gender has no influence on either of the instructional strategies to determine students' performance in Biology. The result is in line with Azman, Kamarudin, and Maaulot (2018) that gender is not associated with the scores of biology examinations among the students, though average score for male students was higher than the female students. However, the findings contract Amuda, Ali and Durkwa (2016) who found difference in participation and performance between male and female in several different subjects examined at the secondary school level. Thus, issues on gender influence on students' performance remain a controversial field of discourse that needed to be scrutinized for further investigation.

## 14. Conclusion

Based on the findings from this study, it could be concluded that the three groups (problem solving, concept mapping instructional strategies and conventional strategy) were homogeneous at the commencement of the experiment. The use of problem-solving and concept mapping teaching strategies enhance better academic performance of secondary school students in Biology than the conventional strategy. Students thought concept mapping teaching strategy performed better in Biology, followed by problem solving and lastly conventional strategy. It was also concluded that, both strategies when adopted for the teaching of Biology are very rewarding for students' academic performance regardless of their genders.

## 15. Recommendations

Based on the findings from the study, the following recommendations were made:

1. The use of problem solving and concept mapping should be adopted for the teaching of Biology as innovative tools to facilitate teaching on the teacher's part and learning on the learner's part.
2. Regular seminars and workshops should be organized for Biology teachers in other to broaden their knowledge on the use of problem solving and concept mapping instructional strategies in Biology classroom and laboratory.

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