



## Effects of Concept-Mapping and Problem-Solving Strategies on Understanding of Nature of Science among Secondary School Biology Students, Zaria, Nigeria.

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### ABSTRACT

*This study investigated the Effects of Concept-Mapping and Problem-Solving Strategies on the Understanding of Nature of Science among Secondary School Biology Students, Zaria, Nigeria. A quasi-experimental with pretest and posttest control group design was employed. The population consisted of all co-educational Senior Secondary II Biology students for the 2016/2017 session in the Zaria education zone with a total of 1862 students. A total of 150 Senior Secondary two (SS2) Biology students took part in the study. This was made up of 84 male and 66 female students. The research instrument used was the Understanding of Nature of Science Questionnaire (UNSQ). One research question corresponding to one null hypothesis was formulated, tested and analysed using Analysis of Variance (ANOVA). The findings showed that students who taught respiratory concepts in organisms using problem-solving strategy performed better than those taught using concept-mapping strategy and lecture method and no significant difference in understanding of nature of science level of the students. Based on these findings, relevant recommendations were made. A major highlight of the recommendations is that In-service training for science teachers, seminars and workshops should be organized by the Ministry of Education for Biology teachers in secondary schools to employ problem-solving strategies in the classrooms to improve students' understanding of the nature of science.*

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### INTRODUCTION

Human survival depends on knowledge through the exploration of the environment. Science provides knowledge while technology provides ways of using this knowledge and our value concepts guide what we ought to do with both science and technology. Biology has contributed so much and continues to contribute to making life comfortable for people, whether in urban or rural areas, both developed and developing countries (Kumar, 2005). Despite the determination shown by many classroom teachers, administrators, curriculum developers, educators, biologists and policymakers, the performance of students has remained

persistently low as reported in various scientific tests. There are many reasons why students have difficulties in learning biological concepts (Zeidan, 2010). The nature of science itself and its teaching methods are among the reasons for the difficulties in learning science, the biological level of organization and the abstract level of the concepts make learning Biology difficult (Çimer, 2012). For the method used for teaching to be effective, teachers need to be conversant with numerous student-centred teaching strategies in which students are actively and creatively involved in the learning process. For this study, concept-mapping and problem-solving strategies were employed to examine the effects they would



have on the students' understanding of the nature of science.

Concept mapping is an instructional strategy that involves graphical or diagrammatical representation of concepts achieved by selecting and arranging concepts from lessons into a meaningful hierarchy, showing the relationship between levels and among concepts (Abayomi & Kehinde, 2012). Concept mapping has been found not only useful in promoting students' understanding of concepts, but also in facilitating students' ability to solve problems and to answer questions that require application and synthesis of concepts. It helps students to organize concepts into hierarchies. The concept-mapping teaching method is more effective in students' achievement than the traditional teaching method (Serap, Gamze, & Mustafa, 2010). According to Taie (2014), concept-mapping more effectively improved the students' learning achievement than the traditional teaching method because it is based on meaningful learning and learning occurs when the individual can organize and relate the concepts and new information with his/her cognitive mental structure. Cook, Schwartz, Bierema and Krajewski (2014) reported that concept-mapping is one tool that can be used in educational research to capture an understanding of the content and relationships to various contexts.

Problem-solving as a strategy of teaching may be used to accomplish the instructional roles of learning basic facts, concepts and procedures, as well as goals for problem-solving. Problem-solving can stimulate the interest and enthusiasm of the students (Ali, Amdad, Akhter & Khan, 2010). A problem is a situation where the path to the solution is not immediately known. Problem-solving means engaging in a task for which the solutions method is not known in advance. Problem-solving is using information and reasoning to overcome obstacles or barriers (Odundo & Gunga, 2013). Problem-solving is how to learn independently, it is the most convenient approach to achieve the aims of the teaching-learning process (Ali, Amdad, Akhter & Khan, 2010).

One of the important goals of teaching science is to have students understand science

and the nature of the environment (Nawaf, 2015). Individuals who understand the nature of science can recognize the functions of their subject matter and distinguish the differences among observations, inferences, scientific facts, laws and theories (Kiliç, Sungur, Çakiroğlu & Tekkaya, 2005; Nawaf, 2015). One goal of teaching the nature of science is to increase scientific literacy. Scientific literacy involves understanding not only scientific knowledge but also understanding of nature of science and the development of skills of scientific inquiry, problem-solving, critical thinking, adapting to change in the science and its applications, increasing the community's confidence in the value of knowledge and the importance of science, technology and their relationship to the mutual and overlapping with the community (Zeitone, 2013).

Scientific literacy can be acquired, not only through school learning but also through interaction with objects and people in one's immediate environment, engaging in scientific discussions and scientific activities. The foundation of scientific literacy is laid in schools, through the use of innovative teaching methods. Thus, science teachers need to understand the nature of science to improve the scientific literacy of their students (Kiliç, Sungur, Çakiroğlu & Tekkaya, 2005). It is on these bases that the researcher deemed it necessary to examine the effects of concept-mapping and problem-solving strategies on students' understanding of the nature of science.

The unsatisfactory performance of students in science as observed by Jibrin and Zayum (2012) and Çimer (2012) reflects how well they understand concepts, in addition, the method of instruction adopted by the teachers which are teacher-centred, abstract/difficult nature of some Biology concepts are identified as factors that cause low students' performance. Albert, Osman and Yungungu (2014) attached the problem to Biology teachers' irregularity in administration of practical, class discussion, the teacher not allowing students to ask questions, teachers not giving prompt feedback on assignments or exams, by not making the Biology subject interesting and teachers not conducting demonstration during practical.



On the other hand, Cheema and Mirza (2013) observed that concept-mapping is a more effective teaching-learning strategy than the traditional method in improving the academic achievement of students and their understanding of the nature of science, due to their active involvement in learning, discussion, sharing of concepts and removal of misconceptions. As students are not taught problem-solving they have a problem in learning because of the type of questions teachers ask which are normally recall and knowledge, as a result of being taught using lecture method and so as students acquire problem-solving skills through critical thinking which enhance academic achievement and understanding of nature of science, level of achievement and ability to apply their knowledge in the novel situation becomes more like that of expert problem solvers. This study, therefore, investigated the effects of instructional strategies (concept-mapping and problem-solving strategies) on students' understanding of the nature of science.

#### **Objective of the Study**

- i. Investigate the effect of concept-mapping and problem-solving strategies on students' understanding of the nature of science.

#### **Research Question**

- i. Using concept-mapping strategy, problem-solving strategy and lecture method what is the difference among the mean scores of students' understanding of the nature of science when exposed to respiratory concepts in organisms?

#### **Null Hypothesis**

**HO1:** The mean scores of students in understanding of nature of science taught respiratory concepts in organisms using concept-mapping, problem-solving strategies and lecture method did not differ significantly after instruction.

#### **METHODOLOGY**

The research design that was adopted for this study was a quasi-experimental control groups design, involving pre-test and post-test. The study involved control and two experimental groups consisting of both male and female subjects.

The population of the study was made up of all the co-educational public senior secondary two (SS2) Biology students for the 2016/2017 session in Zaria Education Zone. There are 13 co-educational senior secondary schools and 10 single-sex senior secondary schools in Zaria Education Zone. The total number of students in the co-educational senior secondary schools is one thousand eight hundred and sixty-two (1821) which is made up of 1127 males and 694 females in an average of 15 years of age.

A total of one hundred and fifty (150) Senior Secondary two (SS2) Biology students took part in the study. This was made up of eighty-four (84) males and sixty-six (66) female students. A random sampling technique involving the balloting method was used to select the three schools.

The instrument used for the study was the Understanding of Nature of Science Questionnaire (UNSQ) adapted from Liang, Chen, Chen, Kaya, Ebenezer, Adams and Macklin (2006). Consisting of 24 item statements which are made up of six sections with four items each about students' level of understanding of the nature of science. UNSQ was adapted because the essay part may be difficult for the participants to answer. The participants were accessed using Likert's five-point scale.

Mean and standard deviations of the data obtained from the three groups were used for answering the research questions while the hypothesis was tested using Analysis of Variance (ANOVA).

#### **RESULT**

**Research Question One:** What is the difference between the mean scores of students' understanding of the nature of science level taught respiratory concepts in organisms using concept-mapping strategy, problem-solving strategy and lecture method?



The data collected to answer research question one was analyzed using mean and

standard deviation and is shown in Table 1.

**Table 1:** Distribution of Means and Standard Deviations in Understanding of the Nature of Science of Students in the Experimental and Control Groups.

Groups	Levels	N	Mean	SD	MD
Concept-Mapping	High	47	2.94	0.34	
Problem-Solving	High	50	3.00	0.00	2.92
Lecture	High	46	2.86	0.50	

Table 1 shows that subjects taught using problem-solving strategy had the highest mean scores of 3.00 in the understanding of the nature of science level while subjects taught using lecture method had the least mean scores of 2.86 in the understanding of nature of science level. Those in the concept-mapping strategy had a mean score of 2.94. The mean scores, however, were very close.

**Hypothesis One:** The mean scores of students in Understanding of Nature of Science taught respiratory concepts in organisms using concept-mapping, problem-solving strategies and lecture methods did not differ significantly after instruction.

The hypothesis was analyzed using ANOVA at a  $p \leq 0.05$  level of significance. The result is presented in Table 2.

**Table 2:** Results on Understanding of the Nature of Science Level of Students in Experimental and Control Groups.

Source	Sum of Squares	df	Mean Square	F	p	Remark
Between Groups	0.493	2	0.247	2.049	0.133	Not Significant
Within Groups	17.700	147	0.120			
<b>Total</b>	<b>18.193</b>	<b>149</b>				

Table 2 indicates no significant difference between the mean scores of students' understanding of the nature of science taught respiratory concepts in organisms using concept mapping, problem-solving strategies and those taught with lecture method. This is because the p-value of 0.133 obtained is higher than the level of significance set at  $p \leq 0.05$ . Therefore, the null hypothesis which states that the mean scores of students in understanding the nature of science taught respiratory concepts in organisms using concept-mapping, problem-solving strategies and lecture method did not differ significantly after instruction is retained.

## DISCUSSION

This study investigated the effect of concept-mapping and problem-solving strategies on students' understanding of the nature of science. Table 1 shows that subjects in the

problem-solving group with a mean score of 3.00 had the highest level of understanding of the nature of science while the lecture method group with a mean score of 2.86 had the least the level of understanding of the nature of science. The result from the hypothesis testing in Table 2 revealed that no significant difference exists in the mean scores of students' understanding of the nature of science among subjects taught using concept-mapping and problem-solving strategies and lecture methods. This may be due to subjects actively engaged in meaningful learning in which they relate new concepts to their prior knowledge and use their new understanding to explain experiences they encounter. This is because student's Understanding of the Nature of Science led to meaningful learning taking place which in turn led to the student's improved performance in science. That is, subjects developed a deeper



understanding of science and scientific processes increasing their understanding of the nature of science.

The result from this finding is not in agreement with the findings of Ozdem, Cavas, Cavas, Cakiroglu and Ertepinar (2010) who indicated that there was a significant difference in the mean scores of students' understanding of the nature of science. The differences in the result of the findings may be due to varying methods used, as the researcher of this study utilized a closed-ended instrument to evaluate student's understanding of science and also the instrument used to assess student's understanding of the nature of science in both cases is not measuring the same components of the understanding of the nature of science. This study agrees with the study of Nawaf (2015), Alswelmyeen and Alolimmat (2013) who revealed that there was no significant difference in the understanding of the nature of science among science majors and non-majors using the survey method. The reason for the similarity in the result of the findings is that science major students participated in the study and the subjects used for this study were also science students.

## CONCLUSION

This study was carried out to determine the effect of concept-mapping, problem-solving strategies on an understanding of the nature of science among secondary school Biology students, Zaria, Nigeria. From the findings the following conclusions are drawn:

- i. The characteristics of problem-solving strategy are learner-centred and hence their teamwork, peer interactions, raised the students' understanding of the nature of science.
- ii. The methods of teaching teachers employed in the teaching and learning of Biology have an impact on students' understanding of the nature of science.

## RECOMMENDATIONS

Based on these findings, the following recommendations are hereby suggested:

- i. This study has shown that problem-solving is a more effective method of instruction for teaching and learning

Biology as compared to concept-mapping strategy and lecture method of teaching. Therefore, the teachers of Biology should be encouraged by the Ministry of Education, National Teachers Institute, National Commission for Colleges of Education among others to use problem-solving strategies to improve students' understanding of the nature of science.

- ii. In-service training for science teachers, seminars and workshops should be organized by the Ministry of Education for Biology teachers in secondary schools to employ problem-solving strategies in the classrooms to improve the students' understanding of the nature of science.

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