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Effects Of Problem And Discovery-Based Instructional Strategies On Students' Academic Achievement In Chemistry

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***Abstract:** The study investigated the effects of problem-based and discovery-based instructional strategies on students' academic achievement in chemistry. 3 hypotheses were tested. The quasi-experimental design - non-equivalent control group pre-test posttest design. A sample of 316 Senior Secondary School two (SS II) chemistry students selected using stratified sampling technique from six secondary schools in Delta Central Senatorial District involved in the study. Chemistry Achievement Test (CAT) validated by one chemistry science educator, an expert in measurement and evaluation and an experienced chemistry teacher was used for data collection. The reliability of the instrument was established using Kudder-Richardson formula 21 which yielded coefficient of internal consistency of 0.83. The data obtained were analyzed Multivariate Analysis of Variance (MANOVA) and descriptive statistics. The results showed that there was a significant difference between the mean achievement scores of students in chemistry in the problem-based instructional strategy, discovery-based instructional strategy and lecture method with problem-based instructional strategy as the most effective. The results also showed that there was a significant interaction effect between teaching methods and genders on achievement scores in chemistry implying that the methods were gender sensitive. The study recommended that chemistry teachers should adopt problem-based and discovery-based instructional strategies in the teaching of chemistry concepts.*

***Keywords:** Problem-based instruction, discovery-based instruction, achievement, gender-sensitive, self-direct*

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I. INTRODUCTION

The performances of Nigerian students in chemistry at the secondary school level remain a dismal failure despite the increasing importance of chemistry (WAEC Chief Examiner report, 2017). Students' performance in chemistry has continued to decline irrespective of the efforts of government in provision of infrastructural facilities, instructional materials, conducive learning environment, in-service training to teachers and regular supervision of teachers. The desire to know the causes of poor performance in chemistry has been the focus of researchers for some time now. It has been observed that poor performances in the sciences in general and chemistry in particular are caused by poor quality of science teachers, overcrowded classrooms, lack of suitable and adequate science equipment, large class size, heterogeneous classroom in terms of ability level, ill equipped laboratories, overloaded chemistry syllabus and poor teaching methods (Kareem, 2003; Onwirhiren, 2005; Ahmed, 2008). These factors encourage chemistry teachers to resort to only lecture instructional strategies most of the time. It is a well-known fact that the quality of education depends on the teachers and so the method they adopt in teaching matters a lot.

A yardstick to determine the effectiveness of an instructional method is dependent on the extent to which the instructional method promotes the attainment of instructional objectives. The various methods of instruction are normally anchored on some theories of learning. Notable among these theories in recent times is the theory of constructivism. The constructivists hold the view that learning should primarily involve the learner and that it facilitates the learners' ability to conceptualize learning contents (Nwanze, 2016). The idea proceeds from the notion that knowledge is a human construct and is culturally and socially constructed. Thus, meaningful learning takes place when the learners are socially involved (Vygotsky, 1978). Teaching methods that enable students' subject matter conceptualization and student-student as well as teacher-student interactions could enhance achievement as students can learn from each other's concepts that they could not learn independently. Such learning approaches are better suited for teaching and learning science concepts including Chemistry. Problem-based and discovery-based instructional strategies are among these strategies.

Problem-based learning as a strategy for learning consists of carefully selected and designed problems that demand from the learner acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies and team participation skills (Maloney, 2004). It reduces teacher's centred instruction where learners are seen as active listeners and passively involved in classroom activities as in the case of lecture method. Problem- based learning is an example of constructivist learning strategy which poses significant contextualized real world situations and provides resources, guidance, and instruction to learning as they develop content knowledge and problem solving skills (Yager, 1991). Problem-based learning is closely related to discovery-based learning.

In discovery learning, students construct knowledge based on new information and data collected are used by them in an explorative learning environment (De-Jong & Van Joolingen, 1998). Bruner (1961) stated that learning happens by discovering, which prioritizes reflection, thinking, experimenting, and exploring. Discovery instructional approach to education is more closely aligned with constructivist concepts of exploration, discovery and invention (Bok, 2006). Discovery method according to Uwameiyi and Ogunbemeru (2005) is a method of teaching that has the advantages of allowing learners to use process skills to generate content information. Discovery learning can be guided or unguided. Guided discovery method activity engages learners in first hand real world learning. Uwameiyi and Ogunbemeru (2005) stated further that guided discovery method encourages learners to explore the content through the use of concrete experience. Fatokun and Yallams (2007) also describes discovery method as resource-based learning which is an innovation that reverses the usual role of the teacher from that in which he is the main authority and source of all knowledge to that in which he acts simply as a guide to the students to enable them to make use of other source of information. The teacher is no longer the focal point of the classroom, instead the instructor is now seen as a "facilitator, mentor, coach or consultant" (Honebein, 2006). Discovery-based instruction has been shown to bear beneficial boost on students' achievement (Balim, 2009). This unlike the lecture method of instruction commonly adopted by science teachers including chemistry teachers.

Over the years, the predominant method of instruction in schools has been the lecture method (Nwabufor, 2005). By this method, learners were encouraged to master course content through constant repetition of facts and drills (Anyafulude, 2014). The method guarantees the completion of the course outline on time, but incidentally encourages learners to memorize and regurgitate content of learning experiences instead of digesting and assimilating them (Ajaja, 2009). In Nigerian schools, most teachers use the lecture method, which unfortunately provides little or no room for active student participation in the lesson. Perhaps this may account for the poor achievement often recorded in public examinations. This is a pointer that something is wrong with the teaching and learning of the subject. It becomes pertinent that classroom practices should be improved using innovative teaching methods which will involve active participation of the students thereby stimulating learning. Thus, the researchers were incited to investigate whether recourse to problem-based and discovery-based instructional strategies could improve students' achievement in chemistry.

PURPOSE OF THE STUDY

The purpose of this study is to examine the effects of problem-based and discovery-based instructional strategies on secondary school students' academic achievement in chemistry. Specifically, the study sought to determine:

- ✓ If there is a difference in the mean achievement scores of students taught chemistry using problem-based, discovery-based and lecture methods with the intention of isolating which one among them will be most effective for teaching chemistry;
- ✓ If there is any difference in the mean achievement scores of male and female students.
- ✓ If there is any interaction effects of teaching methods and gender on achievement.

HYPOTHESES

- ✓ There is no significant difference in the mean achievement scores of students taught chemistry using problem-based, discovery-based and those taught using lecture method.
- ✓ There is no significant difference in the mean achievement of male and female students.
- ✓ There is no significant interaction of teaching methods and gender on students' achievement in chemistry.

II. METHOD

The study adopted a quasi-experimental design. Specifically, the non-equivalent control group, pretest, post-test design as shown below:

Group	Pre-test	Treatment	Post-test
E1	O_1	X_p	O_2
E2	O_1	X_d	O_2

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C O_1 X_c O_2

Figure 1: Diagrammatic representation of the design of the study

Where,

E1, 2 = Experimental groups 1 and 2 on problem-based and discovery-based instructions

C = Control group

O_1 = pretest

O_2 = post-test

X_p = treatment using problem solving instructional strategy

X_d = treatment using discovery instructional strategy

X_c = treatment of control group

The population of the study comprised 8, 945 (4668 females and 4277 males) at all senior secondary two (SS11) chemistry students in Delta Central Senatorial District of Delta State. The sample for the study was 316 SS2 chemistry students from six public schools obtained using stratified sampling. The instrument for data collection was Chemistry Achievement Test (CAT) drawn from the topic areas of : electronic structure and occurrence of nitrogen, laboratory and industrial preparation of nitrogen, physical and chemical properties of nitrogen and uses of nitrogen, Haber process of the preparation of ammonia, physical and chemical properties of ammonia and uses of ammonia. The content validity of the instrument was established using a table of specification. The face validity of the CAT was done by a panel of three experts made of one Science Educator in Chemistry in Delta State University Abraka, one experienced Chemistry teacher drawn from a school in Warri South Local Government Area of Delta State and an expert in Measurement and Evaluation from Delta State University Abraka. The reliability of the CAT was established using the Kuder-Richardson 21 formula method which yielded a reliability index of 0.83.

The six instructors that were used for the study were trained on the skills of using problem-based and discovery-based method for teaching for four days lasting for two hours per day. A week before the commencement of treatment, all the six chemistry instructors that were used for the study was given extracts which contained the contents in the six weeks instructional unit. The extracts were taken from New School Chemistry for senior secondary Schools by Ababio (2009). Lesson notes written on each of the concepts in the 6 week instructional unit using the problem and discovery-based instructional strategies formats were given to the specific teachers assigned to use the various instructional strategies for teaching. This was done to ensure that all the instructional presentations followed the recommended format for the designated classes. The lesson notes specified both the teachers and students activities during instruction.

Two days before the commencement of instruction, both the experimental and control groups were pre-tested with the 50 items Chemistry Achievement Test (CAT). This was done to determine the equivalence of the groups before treatment and be sure that any noticed change later was due to the treatment. On treatment, for the control group, each and all the contents in the 6 week instructional unit were presented to the students using lecture method. The two teachers who taught the control groups equally presented the content materials to the students in their final forms. In the experimental classrooms where problem-based and discovery-based instructional strategies were applied.

In the problem-solving classroom, the teachers who taught there performed the following activities by applying the approaches recommended by Woods et al. (1975) strictly. Specifically, the problem solving process recommended by Woods et al. (1975) that was used by the trained instructor in the problem-based instructional strategy classroom are as follows:

- ✓ Identify and define the problem: Instructors ask questions to help students identify the problem under study by interpreting the information provided in the problem statement. This enabled the instructor to isolate what is known to the students from what is unknown to the students.
- ✓ Analyze the Problem: Teacher engage students in critical analysis of the problem to discover the root cause of the problem after identifying the problem. Teacher provides learning resources to students to discover the root cause of the problem.
- ✓ Generate Potential Solution: Teacher guide students to generate solutions as many as possible. In this stage, there are no wrong answers and judgments are not passed on another's suggestions. At the end of this stage, teacher provides each student enough time to clarify their suggestions for a common understanding for later selection.
- ✓ Select and Plan Solution: Teacher guide students to select the best solutions from the wide variety of possible solutions to solve the problem given the circumstances, resources and other considerations. Here the group is trying to figure out exactly what would work best given who they are, what they have to work with, and other considerations that will affect the solution.
- ✓ Implement the solution: Teacher guide students to execute the solution. Teacher encourages students to try different strategy if the plan didn't work immediately.
- ✓ Evaluate the solution: Teacher encourages students to reflect on the solution. Once a solution has been reached, students should ask themselves the following questions:

The teacher in the discovery-based instructional strategy group adopted the discovery-based instructional strategy as recommended by Justin (2014) are as follows:

- ✓ Define the Problem: Teacher help students define the problem by asking thought provoking questions. This enhances students in depth understanding of the problem to enable them state feasible hypothesis that guided their discovery of the solution to the problem.
- ✓ Guide students plan where and how to gather data and information: Teacher guide, ensure the availability of necessary materials that enabled students to gather and interpret data in his/her quest of solving the problem.
- ✓ Students' present findings through graphs, charts, models, writing etc. Teacher evaluates students' findings to ensure that they are in accordance with scientific ideas. The teachers pointed out the strengths and weaknesses of each student.

The students in the experimental and control groups were post tested two days to the end of the six weeks treatment. Data obtained from the study was analyzed using multivariate

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analysis of covariance and the hypotheses tested at 0.05 level of significance.

III. RESULTS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10232.264[a]	6	1705.377	13.404	.000
Intercept	77078.368	1	77078.368	605.826	.000
Pretest	381.299	1	381.299	2.997	.084
Method	9080.411	2	4540.205	35.685	.000
Gender	1.243	1	1.243	.010	.921
Method * Gender	1130.827	2	565.414	4.444	.013
Error	39313.622	309	127.229		
Total	661850.000	316			
Corrected Total	49545.886	315			

a. R Squared = .207 (Adjusted R Squared = .191)

Table 1: 2 (gender) x 3(teaching methods) multivariate analysis of covariance for testing null hypotheses 1, 2 and 3

- ✓ There is no significant difference in the mean achievement scores of students taught chemistry using problem-based, discovery-based and those taught using lecture method.

Table 1 shows that there was a significant main effect of the treatments on students' achievement in chemistry F (6, 315) = 35.685, P < 0.05. Null hypothesis 1 was rejected. Thus, there is a significant difference in the mean achievement scores of students taught chemistry using problem-based, discovery-based and those taught using lecture method. To determine the order of significant difference, Scheffe Post-Hoc test was ran.

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Problem-Solving	Discovery Method	9.048*	1.559	.000	5.21	12.88
	Lecture Method	12.279*	1.567	.000	8.42	16.13
Discovery Method	Problem-Solving	-9.048*	1.559	.000	-12.88	-5.21
	Lecture Method	3.231	1.599	.132	-.70	7.16
Lecture Method	Problem-Solving	-12.279*	1.567	.000	-16.13	-8.42
	Discovery Method	-3.231	1.599	.132	-7.16	.70

Table 2: Scheffe's Post-Hoc test to compare the experimental and control groups

The scheffe's post-hoc analysis shows that there is a significant difference in the mean achievement scores of students taught chemistry using problem-based instructional strategy and those taught using discovery-based instructional strategy in favour of problem-based instructional strategy. There is also a significant difference in the mean achievement scores of students taught chemistry using problem-based instructional strategy and those taught using lecture method in favour of problem-based instructional strategy. There is also a significant difference in the mean achievement scores of students taught chemistry using discovery-based instructional strategy and those taught using lecture method in favour of discovery-based instructional strategy. Table 2 shows that out of the three methods, problem-based instructional strategy proved most effective.

- ✓ There is no significant difference in the mean achievement of male and female students.

From table 1, data on gender shows that at 0.05 level of significance, the value of F was .010 with a Pvalue of .921 which is greater than 0.05. Null hypotheses two was therefore not rejected. Thus, there was no significant difference in the mean achievement scores of male and female students.

- ✓ There is no significant interaction of teaching methods and gender on students' achievement in chemistry.

Also, from table 1, there was significant interaction of teaching methods and gender on students' achievement in chemistry, F (6, 315) = 4.444, P < 0.05. Null hypothesis three was rejected. Therefore, there is a significant interaction of teaching methods and gender on students' achievement in chemistry. This implies that the students' achievement scores relative to the teaching methods is influenced by gender as shown in figure 2.

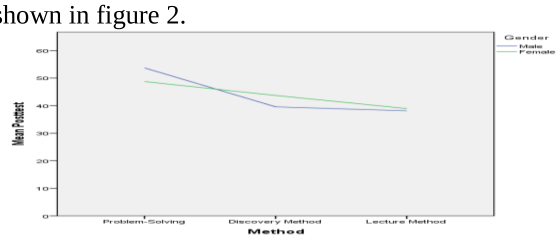

Figure 2: Plot of the interaction between gender and teaching methods on achievement

The plot of the interaction effect between gender and teaching method is significant and disordinal. This shows that the teaching method has different effects on different conditions, for example, the effect of the teaching method changed when gender is put into consideration as shown in table 3.

Methods	Gender	Mean	Std. Error
Problem-Solving	Male	53.714[a]	1.612
	Female	48.617[a]	1.423
Discovery-based instruction	Male	39.678[a]	1.664
	Female	43.685[a]	1.494
Lecture Method	Male	38.186[a]	1.784
	Female	38.894[a]	1.444

a. Covariates appearing in the model are evaluated at the following values: Pretest = 20.35.

*Table 3: Method * Gender interactions on achievement in chemistry*

From table 3, it can be seen that male students had higher posttest mean than the females in problem-based learning group but in the discovery-based instruction group, female students had high posttest mean than the males. Thus, the instructional methods are gender sensitive.

IV. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

The first finding of this study revealed that there was a significant difference in the mean achievement scores among the experimental and control groups. The variations in

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achievement scores among the groups may be due to the variation in the teaching strategies adopted in each of the groups' and subjects' comprehension of the methods of instruction. These may again have translated into influencing subject's scores in the achievement test. The post hoc analysis which indicated that all the students taught with problem-based and discovery-based instructional strategies outscored those taught with lecture method suggests that the students in the experimental groups may have been more active in the learning process than those in the lecture group and thus have contributed to their higher achievement scores. This is hinged on the fact that you learn better by doing (Ajaja, 2013). The low achievement scores as found among the students taught with lecture method may not be unconnected with the transmission approach involved, where the teachers pass over their knowledge to their pupils. Bennett (2003) noted that the transmission view implies that pupil's role in the learning process is largely passive, and that a pupil's mind is what is some-times called a "tabula rasa".

The significant higher achievement of students taught with problem-based and discovery-based instructional strategies over those taught with lecture method as found in this study is consistent with the findings of earlier researchers on this same subject matter. For example, studies by Anyafulude (2014), Keislar (2008) and Mayer (2003) established the relative efficacy of problem-based and discovery-based instructional strategies in fostering students' achievement in chemistry relative to the lecture method. On the noticed significant higher achievement of students taught with problem-based instructional strategy over those taught with discovery-based instructional strategy, the limitations ascribed to discovery-based instructional strategy may be the possible explanation for the lower score. Anyafulude (2014) stated that while the discovery-based instructional strategy suggest that the learner is not provided with the target information or conceptual understanding and must find it independently or collectively in groups and only with the provided materials, the problem-based instructional strategy avails students of the opportunity to carefully select and design problems that demand from the learner acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies and team participation skills (Maloney, 2004). Problem-based strategy reduces teacher's instruction where learners are seen as active listeners and passively involved in classroom activities as in the case of conventional method.

More so, problem-based strategy as an example of constructivist learning strategy poses significant contextualized real world situation and provide resources, guidance and instruction to learning as they develop content knowledge and problem solving skills (Yager, 2001). These limitations may have frustrated the low achievers particularly and resulted in their lower achievement scores to produce the lower mean score for the discovery-based instructional strategy group.

The study also revealed a significant interaction effect between teaching methods and gender as measured by the mean achievement scores in chemistry achievement test. One possible explanation that could suffice is that the students' interest may have been aroused and sustained in a particular gender than the other through the discovery-based instructional strategy. Discovery-based instructional strategy influenced the mean achievement scores of female students than their male counterparts. This finding is in agreement with the finding of Dania (2014) who observed a significant interaction effect of treatment and gender on students' academic achievement in social studies. In the light of the findings of the study, it is recommended that:

- ✓ Chemistry teachers should adopt the use of problem-based and discovery-based instructional strategies in the teaching of chemistry at the secondary school level. These instructional strategies will ensure students active involvement, self-discovery of knowledge as well as interaction with the learning materials during the teaching-learning process.
- ✓ Special training on the effective implementation of problem-based and discovery-based instructional strategies should always be organized for teachers and students by the government, so as to help them become competent in the use of these teaching strategies in the teaching and learning process.

REFERENCES

[1] Ahmed, M. A. (2008). Influence of personality factors on biology lectures assessment of difficulty levels of genetics concepts in Nigerian Colleges of Education. Unpublished Ph.D Thesis, University of Ilorin.

[2] Ajaja, O. P. (2009). Teaching methods across disciplines. Ibadan: Bomn Prints.

[3] Ajaja, O. P. (2013). Which way do we go in the teaching of biology? Concept mapping, cooperative learning or learning cycle? International Journal of Science and Technology Education Research, 4(2), 18-29.

[4] Anyafulude, J. (2014). Effect of problem-based learning strategy on students' achievement in senior secondary schools chemistry in Enugu State. IOSR Journal of Research and Method in Education (IOSR-JRME), 4(3), 27-31.

[5] Balim, A. G. (2009). The effects of discovery learning on students' success and inquiry learning skills. Egitim Arastirmalari-Eurasian Journal of Educational Research, 35, 1-20.

[6] Bennett, J. (2003). Teaching and learning science. London: Continum

[7] Bok, D. (2006). Our underachieving colleges: A candid look at how much students learn and why they should be learning more. Princeton NJ: Princeton University Press.

[8] Bruner, J. S. (1961). Some elements of discovery. In L. S. Shulman & E. R. Keislar (Eds.), Learning by discovering: A critical appraisal (pp.104-111). Chicago: Rand McNally.

[9] De Jong, T., & Van Joolingen, W. R. (1998). Discovering learning with computer simulations of conceptual domains. Review of Educational Research, 68, 179-201.

[10] Fatokun, J. O., & Yallams, S. M. (2007). Effect of guided discovery approach on students' achievement in radio and television fault diagnosis and repair skills at the technical college Level. In B. G Nworgu (Ed), Optimization of

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ISSN: 2394-4404

service delivery in education sector: Issues and strategies (84- 89).

[11] Honebein, P. (2006). Seven goals for the design of constructivist learning environment. New York: Macmillan.

[12] Justin, D. (2014). Principles of teaching: Different methods and approaches. Switlu: Lynda.com premium video.

[13] Kareem, L. O. (2003). Effects of audio-graphic self-instructional packages on senior secondary school students' performance in biology in Ilorin, Nigeria. Unpublished PhD Thesis, University of Ilorin.

[14] Keislar, E. R. (2008). Learning by discovery: A critical appraisal. Chicago: Rand McNally.

[15] Maloney, D. P. (2004). Research on problem solving in physics. In D. L. Gabel (Ed.) Handbook of research in science teaching and learning (Pp. 327-354). New York: Macmillan Journal of Science Teachers' Association of Nigeria 32(1) 59-64.

[16] Mayer, R. E. (2003). Learning and instruction. Pearson Education, Inc: Upper Saddle River, p.287-88.

[17] Nwabufor, J. N. (2005). Curriculum implementation and instructional plan. Owerri: UP Thrust Publishers.

[18] Nwanze, A. C. (2016). Effect of multimedia synchronized instructional strategy on students' achievement and retention in secondary school in Onitsha Education Zone. Unpublished M.Ed Dissertation Submitted to the Department of Science Education, Nnamdi Azikiwe University, Awka.

[19] Onwirhiren, E. M. (2005). The effects of class size and gender on academic performance in chemistry at post-secondary levels. Nigeria Journal of Professional Teachers, 1(1), 146-150.

[20] Uwameiye, R., & Ogunbameru, M. T. (2005). A comparative analysis of two methods of teaching financial accounting at senior secondary school. Unpublished Manuscript Submitted to the Department of Vocational and Technical Education, University of Benin, Benin City.

[21] Vygotsky, L. (1978). Interaction between learning and development. Readings on the Development of Children, 23(3), 34-41.

[22] West African Examination Council (2005). WAEC Chief Examiner's report on students' performance in chemistry. Yaba, Lagos: WAEC reports.

[23] Woods, D. R., Wright, J. D., Hoffman, T. W., Swartman, R. K., & Doig, I. D. (1975). Problem solving skills. Engineering Education, 1(1), 238.

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