IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 13, Issue 4 Ser. I (April. 2020), PP 38-49
www.iosrjournals.org

Effects of Using Synthesized Single Crystal Structure ofcoordination Polymers as a Teaching Resource on the Concepts of Coordination Chemistry in Colleges of Education

Stephen Adie Adalikwu (Ph.D.)[1]OrokEtim Effiom[2]James Umoru Igui[3]
Charles Egbonyi Igiri[4]
Chemistry Department,Cross River State College of Education, Akamkpa,Cross River State-Nigeria[1,2,3]
Educational Foundations & Administrations,Cross River State College of Education, Akamkpa,Cross River State-Nigeria[4]
Corresponding Author: Stephen Adie Adalikwu (Ph.D.)

Abstract
The research workinvestigated the effect of employing synthesized single crystal structure of coordination polymers as standard teaching materials as compared to improvised teaching materials and tradition methods in teaching coordination chemistry in Colleges of Education in South-South Geographical Zone of Nigeria. A quasi-experimental research design of the pretest-posttest non-randomized control group was adopted for the study. .A total of 153 Nigeria Certificate in Education (NCE) IIchemistry students were chosen for the researchemploying intact classes while stratified random sampling technique was used in selecting the four Colleges of Education. Three instruments were adopted for the research: Achievement Test in Chemistry (ATC) and Chemistry Retention Test (CRT)to evaluate thestudents' achievement, while Instructional Teachers' Guide (ITG) was used forteachers' instructions. Pearson Product Moment Correlation Coefficient Analysis and Crombach Alpha were used to get reliability co-efficient of 0.79 and 0.77 respectively. A research question and five hypotheses were constructed and examined at 0.05 significance level. Analysis of Covariance (ANCOVA) wasemployed for data analyses. Findings showed that there is a significant difference in the mean achievement scores/retention of students taught using standard teaching aids, thosetaught with improvised teaching aids and with traditional teaching method. There was no statistical significant relationship on the effect of gender on students' mean achievement scores in chemistry. As a recommendation; chemistry lecturers should be resourceful in exploring, selection, planning and utilization of teaching aids to enhance effective teaching and learning process.

Keywords: *Coordination chemistry, Improvised teaching materials, Standard teaching materials, Academic Achievement and coordination polymers.*

Date of Submission: 13-04-2020 Date of Acceptance: 28-04-2020

I. Introduction

Science has been observed to be the foundation of contemporaryscientific and technological revolution of every nation. Currently, nations all over the world, specifically the developing ones like Nigeria, are working hard to advancescientifically and technologically, since the world is becoming more sophisticated, animproved standard of living is hinge greatly on science and technology advancement. According to Ogunleye (2002), Science is a dynamic human activity interested in the comprehension of the workings of the universe. This understanding helps man to know more about his or her environment. The application of scientific procedures and knowledge helps us to develop fundamental information to predict and possibly clarify and comprehend phenomena in our environs and as a channel to accomplish a specific practical or suitable outcome. The prospect of every nation as well as Nigeria depends on the value of education given to herpeople. For every developing nation to attain a sustainable national development, a well-planned and implemented science and technology education remains the only essential tool for her national development (Chibabi*et at*, 2018). This is because individuals who acquire scientific technologies literacy think innovatively and rationally, thus enabling them to conduct themselves within the global acceptance standard. Science is therefore an initial part of every educational endeavor. This was the main idea why the Federal Republic of Nigeria in their National Policy on Education (FRN, 2004) emphasized the teaching and learning of science at all the levels of educational system across the country

Science comprises the basic disciplines such a Chemistry,Physics, Biologyand Mathematics. Several studies have revealed that secondary school students are displayingdeclining interest in Science (Esiobu, 2005)

and the resultant effectsare poor performanceamong students in secondary schools and low enrollments in tertiary institutions. Effective teaching/learning of any subject will not only awakens students'curiosity in the subject but also improve their achievement in the examination. To achieve effective teaching and learning process, there is the need for use of instructional materials also known as 'teaching aids' which constitute alternative means of communication that a teacher can employ to facilitate and convey more vividly instructional information to learners for the attainment of the specified objectives. They represent array of materials which can be employed to 'extend the range of vicarious experience' of learners in a teaching-learning circumstances(Amadioha, 2009). Availability of teaching/learning resources improves the effectiveness of schools as these are rudimentary things that can bring about good academic performance in the students. Maicibi (2003) opined that all institutions or organization are made up of human beings (human resources) and other non-human resources. He also declares that when the right quantity and quality of human resources is brought together, it can manipulate other resources towards realizing institutional goals and objectives. Consequently, every institution should strive to attract and retain the best of human resource.

The implication of these opinions is that well trained teachers in chemistry if well deployed to teaching and learning institutions will bring about experienced students who will perform academically well in chemistry. Most Nigerian teachers are trained and have clear goals to guide their teaching, but good teaching and learning materials seem not to be seen in most chemistry lessons. As a result, there has been a public outcry about poor performance in chemistry at both secondary schools and tertiary institutions levels. In Nigeria, Chemistry is a mandatory subject up to secondary school level and one of the subjects that one most to possess a credit to enable him/her gain admission to read any of the sciences and medical courses in tertiary institutions. In recent years, performance in Chemistry in National examination has dropped significantly and this has been a major worry for the society. By adopting and using appropriate teaching/learning resources in secondary schools and tertiary institutions, the concepts of coordination chemistry will be made simple and fascinating for students instead of viewing them as abstract/difficult concepts(Akani&Oketa, 2017).Chemistry is a branch of physical science, and it is the study of the composition, properties and behaviour of matter. Since it's a physical science, its teaching has to be physical and real (Baja, 1988). The teaching of chemistry is made interesting with the use of teaching aids which include flash cards, pointer, computers, improvised materials and overhead projectors among others. The knowledge of this subject is control to vocations in health services, pharmaceuticals, petroleum and petrochemical industries, food processing, teaching services and extractive industries, which is relevant for economic development. The teaching of this subject should aim at developing in the students those manipulative and experimental skills necessary to make them competent and confident in the investigations of the material resources around them.

Okendu (2012) asserted that regularinstructional supervision has a significant bearingon students' academic performance. He alsoaffirmed that adequate supply of instructionalresources have significant effect on students'academic performance. Onasanya&Omosewo(2011) confirmed that both standard andimprovised instructional materials have the samepositive effects on students' academicperformance.The study conducted by Adalikwu& Iorkpilgh (2013**)** revealed that students taught with instructional materials performed significantly better than those taught without instructional materials and also that the use ofinstructional materials generally improved students' understanding of concepts and led to highacademic achievements.Okori& Jerry (2017) opined that both human and materialresources are inevitable in enhancing the teaching and learning of science and mathematics generally and practically at secondary Education. The instructional materials lend credence and reality to abstract concepts taught at this level. Such instructional materials include charts, computers, and television, audio and visual materials. When these materials are not available or inadequate, the teacher is expected to improvise. Adequate and relevant materials give room for effective and efficient teaching and learning of science and mathematics. It is the lack of such a situation that has resulted into poor performance and low achievement in science and mathematics

Aneale (2005) opined that ICT-driven instructional aids media has enhanced teaching and learning through its dynamic, interactive, and engaging content; it has provided real opportunities for individualized instruction. Information and communication technology (ICT) driven instructional aids has the potential to accelerate, enrich, and deepen skills; motivate and engage students in learning; help to relate school experiences to work practices; help to create economic viability for tomorrow's workers; contribute to radical changes in school; strengthen teaching, and provide opportunities for connection between the school and the world.

Information communication technology (ICT) can make the school more efficient and productive, thereby engendering a variety of tools to enhance and facilitate teachers' professional activities. Nwagbo&Ugwuanyi(2015) asserted that the use of ICT-driven instructional aids concretize abstract and difficult topics in Teaching and Learning Process. It makes learning real, practical and more permanents to the learners. It makes conceptual abstraction more meaningful. He also affirmed that, instructional materials are valuable assets in learning situations because they make lesions practical and realistic. They are the pivots on which the wheels of the teaching-learning process rotate. Since itconcretizes issues, it then facilitates revision (recall)

activities and provider very unique opportunities for self and group evaluation for the teacher and the students alike. It captures the student intellect and eliminates boredom; make the work easier, neater, and boosting for clarity and more appeal. With the use of projected and electronic materials such as television, overhead transparencies and computer especially, instructions are packaged in a very broad manners and which take care of wide range of learner in a classroom with less stress and time. Many students will be able to learn faster as the package takes care of various learners' interest at the same time. Teacher can handle a very large class conveniently as the teacher is guiding and displaying the instructional materials on the wall with the use of projector. It helps in perception and retention of information or knowledge in learners.

Mboto, Ndem& Stephen(2011) defined improvisation as the sourcing, selection, deployment of relevant instructional elements of teaching/learning process in the absence or shortage of the accredited teaching/learning element for a meaningful realization of specified educational goals and objectives. In support, Asokhia (2009), sees improvisation as the use of what is available as a result of lack of what is actually needed. Samba & Eriba (2011) see improvisation as the act of using alternative materials and resources to facilitate instructions whenever there is lack or shortage of specific first hand. Teaching aids. The authors see improvisation as the choice of the best instructional material which enables the teacher to achieve some carefully specified educational objectives. It was on this ground that Kurumeh (2006) observed that the utilization of improvised instructional materials take adequate care of the three domains (Cognitive, affective and Psychomotor) thereby reducing the abstractness of the mathematics concepts.

Therefore, Ogbondah (2008) advocated for of teachers'resourcefulness and also encouraged them to search for necessary instructional materials through local means to supplement or replace the standard ones. Oso (2011) also agreed that the best way for teachers to make use of their manipulative skills is to improvise so as to achieve their lesson objectives at least to a reasonable extent.Jekayinfa (2012) also identified the importance of improvisation of instructional materials as making learning concrete and real, substitutes one thing for another, allows the students to participate in the production of materials, economical and more teacher-student resource oriented. Abdu-Raheem (2014) submitted that improvisation of locally made teaching aids could assist to improve quality of graduates turn out from schools and standard of education generally. Abdu-Raheem and Oluwagbohunmi (2015) also corroborated the idea that resourceful and skillful teachers should improvise necessary instructional materials to promote academic standard in Nigerian schools.Furthermore, Otor, Ogbeba&Ityo (2015) revealed that students that were taught using improvised instructional materials performed better in chemistry than those that were taught using conventional lecture method. This is due to the fact that they were in touch with the actual (physical) improvised instructional materials which help to facilitate the learning and understanding of the subject

Several investigations have been carryout on porous coordination polymers (PCPs) also called metal-organic frameworks (MOFs). They are complexes comprising metal ions or clusters linked to often rigid organic molecules to form one-, two-, or three-dimensional structures that may be porous. More formally porous coordination polymers are coordination networks with organic ligands containing potential voids(Adalikwu, Offiong & Ayi, 2017; Batten *et al*, 2013). They can exhibit very high surface areas, as well as adjustable pore size and functionality, and can act as hosts for different guest molecules(Chakraborty, Haldar & Maji, 2013**)** Since their uncovering, PCPs have enjoyed broadinvestigation, with applications in several areas such as gas storage/separation(Leng*et al*, 2014), magnetism (Adalikwu *et al*, 2016), luminescence(Ali *et al*, 2019), catalysis(Adalikwu *et al*, 2019), drug delivery(AL Haydar*et al*, 2017) and sensing(Reib, Moos&Hagen, 2008).A preliminary literature review indicates that a lot of research work has been done on the synthesis, characterization and applications of porous coordination polymers (PCPs)but none has been used as a resource in teaching/learning situation to improve students' academic performance in tertiary institutions.

In this research work, a coordination polymer was synthesized through solvent diffusion method and its structure characterized via single crystal X-ray diffraction. The single crystal structure was used as a standard instructional material toinvestigateits effect on the academic achievement of Colleges of Education Chemistry Students in South-South Geographical Zone, Nigeria.

Statement of the problem:

As a key subject in the curriculum, many students find chemistry concepts difficult to learn and understand. Chemical bonding is imperative to understanding the compositions of chemical compounds and related concepts, and research has revealed that students struggle with the concept of coordinate covalent bonding (Dhindsa & Treagust, 2014). Senior Secondary School Chemistry results over the years have been consistently below average (Ampiah, 2001; Adesemowo, 2005). These students carry the same poor performances to the tertiary institutions. Investigations have indicated that students' underperformance in chemistry at the undergraduate level is due to the poor background of chemistry from pre-university level, that the students find chemistry concepts very complicated and that the students did not want to put in effort themselves rather believed in spoon-feeding by their instructors (Mahajan & Singh,2005). Aremu & Sokan,

(2003) stressed that academic failure is not only frustrating to the students and the parents, its effects are equally grave on the society in terms of dearth of manpower in all spheres of the economy and politics. Tertiary institutions are finding it difficult to enroll sufficient numbers of candidates in chemistry departments because of dwindling numbers of students satisfying the entrance requirements (Takawira & Admire (2012). This can have adverse effects on the advancement of science and technology in the country.

Among the reasons cited for poor performance in chemistry according to Uchegbu*et al.* (2016), Samba & Eriba (2012), Agwai, (2008) & Agogo (2003) are the abstract and difficult nature of chemistry concepts, non-functional laboratories and non-use of instructional elements. Nevertheless, researches have revealed that improvisation-sourcing, careful selection and utilization of relevant instructional materials of teaching/learning process in the absence or shortage of standard or accredited teaching/learning materials can always help in filling the gap especially when the materials are drawn from the learners' local environment (Onasanya, 2004 & Eshiet, 1996). The mission of this investigation is to find out what can be done to improve the students' retention and achievement in chemistry? Can students' retention and achievements also be effectively enabled in coordination chemistry through the use synthesized coordination polymers as a resource in teaching? This study seeks to employs standard and improvised teaching/learning aids in teaching the concepts of coordination chemistry in tertiary institutions as compared to traditional teaching method.

Purpose of the study

The main purpose of the study was to synthesized coordination polymer and characterize its single crystal structure in order to investigate the effects of standard and improvised instructional materials in Colleges of Education students' academic achievement in chemistry as compared with the traditional teaching method. Specifically, the researcher hopes to:

i. Find out the effects of standard and improvised instructional materials on Colleges of Education students' mean achievement scores in chemistry.
ii. Find out the effects of standard instructional materials and traditional teaching method on Colleges of Education students' mean achievement scores in chemistry
iii. Find out the effects of improvised instructional materials and traditional teaching method on Colleges of Education students' mean achievement scores in chemistry.
vi. Find out the effect of the use of standard and improvised materials on male and female students' mean achievement scores in chemistry.
v. Find out the effect of Chemistry students' mean retention scores when taught the concept of coordination with both standard and improvised teaching materials and without instructional materials.
vi. Find out the suitability of using the synthesized coordination polymers' single crystal structure in teaching coordination chemistry.

Research question one

To what extend does the synthesized coordination polymers' single crystal structure issuitable for teaching coordination chemistry?

Hypotheses

The following null hypotheses were formulated and tested at an alpha levelof 0.05.

H_{O1}: There is no statistically significant difference in the mean achievement scores between students taught the concept of coordination withstandard materials and those taught improvised material.

H_{O2}: There is no statistically significant difference in the mean achievement scores between students taught the concept of coordination chemistry with standardteaching materials and those taught with traditional teaching method.

H_{O3}: There is no statistically significant difference in the mean achievement scores between students taught the concept of coordination chemistry with improvised teaching materials and those taught with traditional teaching method.

H_{O4}: There is no significant interaction effect between gender and instructional approach on students' mean achievement scores in chemistry.

H_{O5}: There is no statistically significant difference in the mean retention scores between students taught the concept of coordinationchemistry with instructionalmaterials and those taught with traditional teaching method

II. Methodology

Design of the study

The research design used for this study is a quasi-experimental of the pretest-posttest non-randomizedcontrol group. A pretest posttest design is an experiment where measurements are taken both before and after treatment where you are able to see the effects of some type of treatment on the group (Dimitrov&Rumrill, 2003). The pre-test post-test belongs to a category of research design that is being utilized in finding out the stability of an instrument. The previous knowledge and level achievements of the students employed for this research were determined through the use of pre-test and post-test respectively. The respondents were grouped into two viz experimental and control group, and both groups participated in the pre-test prior to experimentation.A post-test was administered on the two groups to test their level of achievement after the treatment instructions for the experimental group. A correlation was carried out on the mean achievement scores obtained in the first and second tests that were administered to the respondents.

Area of the study

The research took place in South-South Geographical Zone of Nigeria, which consists of twelve (12) Governments owned Colleges of Education.

Population of the study

The population of this research was made up of all the chemistry students in the twelve (12) Government owned Colleges of Education locatedin the South-South Geographical Zone of Nigeria.

Sample and sampling techniques

The size of sample for this researchis one hundred and fifty three (153) NCE II chemistry students which formed intact class from the four (4) Government owned Colleges of Education selected through stratified random sampling technique was the method used to select four(4) Colleges of Education and one hundred and fifty three (153)NCE II chemistry students from six hundred and twenty one (621) population of the study.

Research instrument

The instrument employed for the research was aself-designed achievement test in chemistry (ATC), Chemistry Retention Test (CRT) and Instructional Teachers' Guide (ITG). The Achievement Test in Chemistry and Chemistry Retention Test were separated into two key parts; Part A and B. Part A try to gather information based on the personal data of the students. While part B contains twenty five (25) items with four (4) options multiple choice-objective test which was constructed by the researchers based on coordination chemistry employing the standard and improvised teaching materials.

Validation of the instrument

The constructed instrument was validated by Test and Measurement and Evaluation,and chemistry education experts.The face and construct validity of the designed instrument was certified by the experts through careful examining and structuring the questions before its deployment on the testees.

Reliability of the instrument

The reliability of the designed instrument was tested for through the use of test-retest and estimated internal consistency using thirty (30) NCE II chemistry students from a different Government owned Colleges of Education located in the South-South Geographical Zone of Nigeria., using Pearson Product Moment Correlation Coefficient Analysis and Crombach Alphato obtain reliability co-efficient of 0.79 and 0.77 respectively.

Experimental procedure/data collection

Instructional Teachers' Guide was used to train the research assistants on the use of projectors for one week in each College in order to teach the students the concept of coordination chemistry. The instructions were carried out in three phases: were briefing of the research assistants on the modes of operation the guide and how to use the projector for teaching the lesson; demonstration on how to use the projectors to teach by the research assistants and the teaching of the lesson to students that are not part of the research by the research assistants.The two groups (control and experimental) were given a pretest for a period of one hour and results used as covariates. Sequel to pretest administration, the research assistants with the aid of instructional teacher's guide, taught the concept of coordination chemistry to the students in the various colleges for duration of three (3) weeks for four periods per week.

The concept was taught to the experimental group using synthesized single crystal structure as resource material with the aid of a projector, whereas the control group was taught with the improvised teaching

material/traditional method. The tests were administered, supervised, collected and collated by the Researchers and research Assistants as the students were allowed to work independently. A Chemistry Retention Test was given to the students two weeks after the posttest had been administered.Four marks were allotted to each rightly ticked answer.

Method of data collection

The achievement test in chemistry (ATC) constructed by the researchers was employed for data collection. One hundred and fifty three (153) NCE II chemistry students were used to form intact classes which the achievement test in chemistry were administered at. And the testees' answers were assembled from each College by the researchers with the support of the research Assistants.

Method of data analysis

The mean, standard deviation andAnalysis of Covariance (ANCOVA) statistical tools at an alpha level of 0.05 significance of the Achievement Test in Chemistry (ATC) were employed to analyze the collected data.

Results presentation and interpretation

The presentation of results is based on the formulated research question and hypotheses in a chronological order. One way Analysis of Covariance (ANCOVA) was employed as statistical tool for data analyses. All the hypotheses were tested at 0.05 alpha significance level.

Research question one

To what extend does the synthesized coordination polymers' single crystal structure is suitable for teaching coordination chemistry?

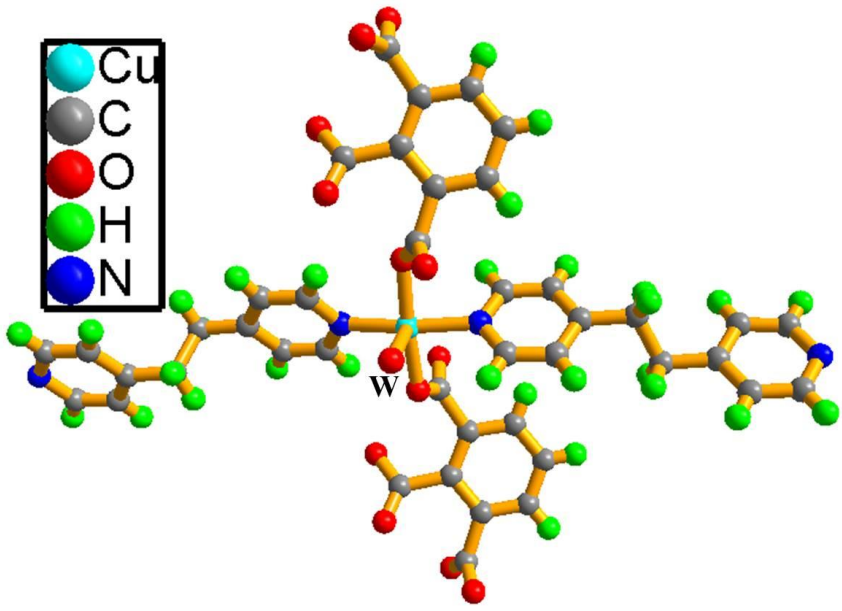

Figure 1: Single crystal structure of compound **1 (**W = water molecule**)**

H_{O1}: There is no statistically significant difference in the mean achievement scores between students taught the concept of coordination Chemistry with standard teaching materials and those taught improvised teaching materials.

ANCOVA was used to test the stated null hypothesis one (**H_{O1}**) as presented in **Table 1** below.

Table 1. ANCOVA for students' overall achievements mean scores taught coordination chemistry using standard and improvised teaching materials.

Variable: standard =2; Improvised = 3	$\bar{X}$	SD	N
2.00	57.85	4.53	72
3.00	54.62	10.1	81
Total	56.13	8.12	153

Source of variable	Type III sum of square	df	Mean square	F	Sign
Corrected Model	392.92	2	196.46	3.06	0.05
Intercept	7835.04	1	7835.04	122.05	0.00

Pretest	1.69	1	1.69	0.026	0,871
Method	311.37	1	311.37	4.85*	0.02
Error	9624.119	150	64.19		
Total	492185.00	153			
Corrected Total	10022,11	152			

*Significant at 0.05,df 2 & 150, F-Critical = 3.07

Table 1 revealed that the calculated F-value (4.85) is greater than the Critical F-value of 3.07 at 0.05 level of significant with degree of freedom 2 and 150 for the tailed test. It follows that the null hypothesis of there is no significant difference between the achievement mean scores of students taught coordination chemistry with standard teaching materials and those with improvised teaching materials is rejected and the alternate hypothesis retained. Therefore, it implies that there is statistical significant difference between the mean achievement scores of students taught chemistry using improvised teaching materials and those taught with standard teaching materials.

H_{O2}: There is no statistically significant difference in the mean achievement scores between students taught the concept of coordination Chemistry with standard teaching materials and those taught with traditional teaching method.

ANCOVA was used to test the stated null hypothesis two (**H_{O2}**) as presented in **Table 2** below

Table 2.ANCOVA for students' overall achievements scores taught Chemistry using standard and traditional teaching methods.

Variable: Traditional = 1, standard =2	**$\bar{X}$**	**SD**	**N**
1.00	50.96	4.50	84
2.00	50.85	3.28	69
Total	50.91	3.99	153

Source of variable	**Type III sum of square**	**df**	**Mean square**	**F**	**Sign**
Corrected Model	314.12	2	157.06	11.18	0.00
Intercept	2306.86	1	2306.86	164.32	0.00
Pretest	313.67	1	313.67	22.34	0,00
Method	104.67	1	104.67	7.45*	0.00
Error	2105.76	150	14.03		
Total	399048.00	153			
Corrected Total	2419.89	152			

*Significant at 0.05 Level of Significant: F-Critical (2 & 150) = 3.07

Analysis in **Table 2**indicated that computed F-value (7.45) is greater than the Critical value (3.07) at 0.05 level of significant with degree of freedom of 2 and 150. The interpretation is that the null hypothesis of no significant difference between mean achievement scores of students taught coordination chemistry using standard teaching method and those taught with traditional teaching method is rejected and alternate hypothesis upheld. It implies that there is significant difference between mean achievement scores of students taught coordination chemistry using standard teaching method and those taught with traditional teaching method.

H_{O3}: There is no statistically significant difference in the mean achievement scores between students taught the concept of coordination with improvised teaching materials and those taught with traditional teaching method.

ANCOVA was used to test the stated null hypothesis three (**H_{O3}**) as presented in **Table 3** below

Table 3. Summary dada of ANCOVA of students' achievements mean scores taught Chemistry using improvised teaching materials and those taught with traditional teaching methods.

Traditional = 1, Improvised = 3	**$\bar{X}$**	**SD**	**N**
1.00	40,83	4.53	81
3.00	51.37	3.50	72
Total	45.79	6.62	153

Source	**Type III sum of square**	**df**	**Mean square**	**Sign**
Corrected Model	4541,02	2	159.31	0.00
Intercept	1392.93	1	79.74	0.00
Pretest	310.08	1	21.75	0,00
Method	2214.06	1	155.35*	0.00
Error	2137.69	150		
Total	327581.00	153		
Corrected Total	6678.71	152		

*Significant at 0.05 df (2 & 150), F-Critical = 3.07

Table 3 showed that computed F-ratio (155.35) is greater than F-critical (3.07) at 0.05 level of significant, the null hypothesis which state that there is no significant difference between the mean achievement

scores of students taught Chemistry using improvised teaching materials and those taught Chemistry with traditional teaching method is rejected implying that F-ratio is statistically significant.

H_{O4}: There is no significant interaction effect between gender and instructional approach on students' mean achievement scores in chemistry

The variables are gender which is a categorized variable, teaching methods and students' academic achievements and both are continuous variable. ANCOVA was used to test the stated null hypothesis four (**H_{O4}**) as presented in **Table 4** below.

Table 4. Summary dada of ANCOVA of significant effect of gender and teaching methods on students' achievements scores in Chemistry.

Traditional=1, Improvised = 2, standard =3		$\bar{X}$	SD	N
2.00	5.00	59.38	3.94	3
	6.00	60.00	4.16	31
	Total	58.45	4.06	44
3.00	5.00	57.13	9.13	36
	6.00	55.22	10.41	18
	Total	56.50	9.52	54
Total	5.00	56.04	5.68	81
	6.00	56.18	7.53	72
	Total	56.13	8.12	153

Source of variable	Type III sum of square	df	Mean square	F	Sign
Corrected Model	399.68	5	79.93	1.22	0.302
Intercept	7536.33	1	9536.33	115.13	0.00
Pretest	0.73	1	0.73	0.01	0,91
Method	290.71	1	290.71	4.44	0.03
Gender	3.79	2	1.89	0.029	0.92
Method x Gender	2.96	1	2.96	0.045*	0.83
Error	96224.32	147	65.45		
Total	492185.00	153			
Corrected Total	10022.11	152			

*P < 0.05: F-Critical (5 & 147) = 3.55

Since the calculated F-value (0.045) from the analysis of data presented in **Table 4** is less than the Critical F-value (3.55) at 0.05 Level of Significant with degree of freedom 5 and 147 for the two tailed tests, It follows that the null hypothesis of no significant interaction is not rejected but retained .Therefore, there no significant interaction effect of gender and the three teaching methods on chemistry students' academic achievements.

H_{O5}: There is no statistically significant difference in the mean retention scores between students taught the concept of coordination chemistry with instructional materials and those taught with traditional teaching method.

ANCOVA was used to test the stated null hypothesis two (**H_{O5}**) as presented in **Table 5** below

Table 5. Summary data of ANCOVA of significant difference by the mean of retention scores between the teaching methods on students' academic achievements in chemistry.

Improvised = 3, standard =2 , M=1, F=2		$\bar{X}$	SD	N
2.00	5.00	57.66	5.09	36
	6.00	57.94	4.04	36
	Total	57.83	4.53	72
3.00	5.00	54.75	10.61	45
	6.00	54.47	9.56	36
	Total	54.63	10.10	81
Total	5.00	56.04	8.68	81
	6.00	56.00	7.53	72
	Total	56.13	8.12	153

Source of variable	Type III sum of square	df	Mean square	F	Sign
Corrected Model	598.84	7	85.54	1.31	0.24
Intercept	8084.74	1	8084.74	124.40	0.00
Pretest	6.84	1	6.84	0.105	0,74
Method	427.84	2	213.92	3.29*	0.04
Gender	18.31	2	9.15	0.14	0.86
Method x Gender	69.93	2	34.96	0.53	0.58
Error	9423.27	145	64.98		
Total	492185.00	153			

Corrected Total	10022.11	152

*P > 0.05: F-Critical (7 & 145) = 2.07

Since the calculated F-value (3.29) from the analysis of data presented in **Table 5** is less than the Critical F-value (2.07) at 0.05 Level of Significant with degree of freedom 7 and 145 for the two tailed tests, It follows that the null hypothesis of no significant interaction is rejected andalternate is retained .Therefore, there significant difference in the mean of retention scores between the teaching methods on students' academic achievements in chemistry.

III. Discussion of Findings

To what extend does the synthesized coordination polymers' single crystal structure is suitable for teaching coordination chemistry?

Single crystal diffraction method was employed to test the research question. The crystal structure determination reveals that compound**1**is composed of five ligands or Lewis base and one central transition-metal ion or Lewis acid and the coordination number is five which is either a trigonalbipyramidal or square pyramidal complex**(Figure 1).**Ligands or Lewis bases are molecules or ions that are coordinated to the transition-metal ions or atoms to form complexes whereas coordination number is the number of ligands or Lewis bases that are bounded to the central transitional metal ions or atoms in complexes.

The research work was aimed at examining the effect of standard and improvised teaching aids in teaching coordination chemistry in Colleges of Education in South-South Geographical Zone of Nigeria. The findings of hypothesis one revealedthat there is statistical significant relationship between the mean achievement scores of students taught the concept of coordination with standard teaching aids andimprovised teaching aids. From **Table 1**, the findings indicates that the students taught with standard teaching aids with the standard deviation of 4.53 and mean score of 57.85 do better than those taught with improvised teaching aids standard deviation of 10.10and mean score of 54.62.

The findingsof this study is in agreement with Nguyen, Williams and Nguyen (2012) who listed LCD projector, Computer, Speakers and over-head Projector among the tools that support lectures in classroom. They emphasized some complex concepts that teacher may not be able to teach effectively but with the aid of computer and projectors such concepts could be effectively demonstrated to the students. However, the findings are contrary to Akani&Oketa(2017) who asserted that students taught chemistry by using improvised teaching aidsdid better than those taught withstandard teaching aids.But Onasanya&Omosewo (2011) opined that there is no significant difference in the academic achievement of students taught with standard teaching aids and those taught with improvised teaching aids. They stressed that the use of standard teaching aids have the same relevance in the teaching and learning process as improvised teaching aids.

The findings of hypothesis two discovered that there is statistically significant difference between the mean achievement scores of students taught the concept of coordination with standard teaching materials and traditional teaching method. From **Table 2**, the findings indicates that the students taught with standard teaching aids with the standard deviation of 3.28and mean score of 50.96 do better than those taught with traditional teaching method with standard deviation of 4.50and mean score of 50.85. The finding are in line with Okori& Jerry (2017) who argued that standard teaching and learning aids lend credence and veracity to abstract concepts taught in sciences and chemistry. And that the teacher is required to improvise when they are inadequate or unavailable. They stressed that effective and efficient learning and teaching of chemistry as a science subject is enhanced by the availability of relevant instructional aids. Whereas poor academic achievement in chemistry is as a result of absence of these teaching aids. This also agrees with the opinion ofOlayinka (2016) found that gender effect of standard teaching aids was not statistically significant in his research work. The research established that students who were taught with standard teaching aids did better than those taught with conventional teaching method.Mboto,Udo, & Stephen(2011) also posited that standard teaching aidscomplement, elucidate, encourage, stress instruction and facilitate teaching and learning in the process of transferringskills, knowledge, attitude and ideas.Furthermore, Manjale& Abel (2017)who reported that hate widespread poor academic achievement and negative attitude of secondary school students towards chemistry has been mostlycredited to instructiondifficulties like the inadequate provision standardized teaching aids.

The findings of hypothesis three revealed that there is statistical significant change between the mean achievement scores of students taught the concept of coordination with improvised teaching materials and traditional teaching method. From **Table 3**, the findings indicates that the students taught with improvised teaching aids with the standard deviation of 3.50and mean score of 51.37do better than those taught with traditional teaching methodwith standard deviation of 4.53and mean score of 40.83. The findings of the study support the research ofKay (2008) who said that improvised teaching aids provide a cognitive link between

abstraction and reality and arouse the students' desire to learn. It supports teaching and learning process by making comprehension and recalling of abstract concepts easy. Also, it aids in creating attention which includes greater attainment and, as well as goals that might have been unreachable to many students. In line with the findings of this study,Oladejo(2011) opined that improvised teaching aids inspirecreativeness, taking learning home wards and often better appropriate for the climatic situations of the local environment which advance and booststudents'academic achievement. This finding validates the earlier finding ofOtor, Ogbeba, &Ityo (2015) who disclosed that students taught with improvised teaching aids outperformed their colleagues taught usingconventional teaching method.

The findings of hypothesis fourestablished that there is no statistical significant interaction between the mean retention scores of male and female students taught the concept of coordination chemistry using improvised teaching aids and those taught with traditional teaching method since the calculated F-value (0.53) from the analysis of data presented in **Table 4** is less than the Critical F-value (4.08) at 0.05 level of significant with degree of freedom 7 and 145 for the two tailed tests. This is in accordance with the findings ofIsola, 2010),Wambugu&Changeiywo (2008),Akani&Oketa(2017), Chibabi(2018) and Onwiodiuokit&Akinbobola (2005) disclosed no statistical significant change in the academic achievement between female and male students after treatment. They detected that both female and male students could do well in their studies when exposed to similar learning environments.The finding contradicts the view of Iwuji(2012) who stated that boysachieve more than girls in learning process.He argued that right from childhood, boyscustomarilyobtain more preparation and support towards academic achievement than girls. However, Oladejo (2011) in his research findings said that females did outperform the male students.

The findings of hypothesis five revealed that there is statistical significant interaction in the mean retention scores of students taught the concept of coordination chemistry using instructional materials and those taught with traditional teaching method**(Table 5).** This is in agreement with the findings ofEze (2017) who in his study on data analyzed on the effectiveness of instructional teaching aids on students' retention in Cross River State indicated that there is a change in mean retention scores. He stated that students exposed to instructional teaching aids achieved higher mean retention scores than those taught without instructional teaching aids. This might be ascribed to the method of instruction which is reasonably not similar to the teaching method of storytelling to students that is uninteresting. He emphasized that when image is used with text resources, it increases the quantity of content recollected over a period of time as it increase semantic recall of what is taught. Chibabi, (2018) and Ugbe& Adalikwu (2016) also posited that there is a statistical significant interaction in the mean retention scores of female and male students taught Biology using laboratory teaching method.Moreso, the findings of Bichi(2002) is in line with this study which established statistical significant change in the mean retention scores of students taught Biology using instructional teaching aids and those taught with conventional teaching methods. He recounted that teaching with instructional materials improves and facilitate retention of students.The result of the findings of this research work is in also in line with the findings of Ariyo (2011) that got a result in which those taught with instructional teaching aids performed better than those taught without teaching aids in the retention test.

IV. Conclusion

From analyses of the results of the research work, it is established that instructional materials whether standard or improvised teaching aids enhance and facilitate teaching and learning processes which in turn lead to improve academic achievement and retention of students. And if appropriate, relevant and adequate standard and improvised teaching resources in the teaching and learning of science and chemistry are deployed by lecturers/teachers who are curriculum implementers, then teaching and learning processes will be facilitated and enhanced. However, standard teaching materials are more effective in teaching some difficult topics than improvised materials.

V. Recommendations

The following recommendations were made as a result of the findings from the research work:

1. Chemistry lecturers should be resourceful in exploring, selection, planning and utilization of appropriate teaching and learning aids for teaching specific topics in their subject areas in order to enhance and facilitate effective teaching and learning process and in turn improve academic achievements and retention of chemistry students.
2. Government should provide standard teaching materials for secondary schools/higher institutions and train Teachers/Lecturers on how to use them or improvise when they are unavailable.
3. States and Local Government authorities should create resources centers for Teachers, where teachers will assemble for investigation, discussion, conferences and study workshops as advocated by Nigerian National Policy on Education (NPE), (FRN, 2004).

4. Students should be motivated with the assistance of their Lecturers/Teachers to construct locally made teaching and learning aids which should be employed in the teaching of Chemistry

Acknowledgements

We are grateful to Cross River State College of Education, Akamkpa for given us the opportunity to carry out this research work and Tertiary Education Trust Fund (TETFUND) for funding this research.

References

[1]. Abdu-Raheem, B. O. (2014). Improvisation of instructional materials for teaching and learning in secondary schools as predictor of high academic standard. *Nigerian Journal of Social Studies, 17*(1), 131-143.
[2]. Abdu-Raheem, B. O. andOluwagbohunmi, M.F. (2015). Pre-service teachers' problems of improvisation of instructional materials in social studies in Ekiti State University. *Journal of Education and Practice, 6*(3), 160-16.
[3]. Adalikwu, S. A, Chakraborty, A,Hazra, A, Ghosh, D, Pati, SK andMaji, T. K. (2016). 2D coordination polymer composed of 1D $\{Ni^{II}(\mu\text{-}O)(\mu\text{-}H_2O)Ni^{II}\}n$ ferromagnetic chains: Modulation of magnetic properties based on dehydration and rehydration *Polyhedron,115*, 276-281.
[4]. Adalikwu, S. A, Offiong, O. E. andAyi, A. A. (2017). Solvent-mediated synthesis of M(II)-coordination polymer Part 1: crystal Structure of poly[(1,2-di(4-pyridyl)ethylene-k^2N,N')-bis(1,4-benzenediacetato k^4O,O',O'',O'')zinc(II)], $C_{22}H_{18}ZnN_2O_4$, *Molbank.* M952
[5]. Adalikwu, S. A. and Iorkpiligh, I T. (2013). The influence of instructional materials on academic performance in senior secondary students' chemistry in Cross River State .*Global Journal of Education Research*, *12*,39-45.
[6]. Adalikwu, S. A., Mothika, V. S., Hazra, A. and Maji, T. K. (2019). Polar functional groups anchored to a 2D MOF template for the stabilization of Pd(0) nps for the catalytic C-C coupling reaction. *Dalton Transactions*, Advance Article https://doi.org/10.1039/C8DT04766A.
[7]. Agogo P.O. (2003). A practical guide to the teaching of difficult in Nigerian secondary school. Knowledge Review. A Multi-disciplinary Journal. *6*(3), 32-34.
[8]. Agwai, V. (2008). Strategies for improving students interest in learning scientific concepts. Journal of Res. Educ. 2:225-230.
[9]. Akani, O. and Oketa, I. O. (2017).Effect of improvised and standard instructional materials on students' academic achievement in chemistry in secondary schools. *International Research Journal of Natural and Applied Sciences***,** *4*(6), 58-72.
[10]. Akani,O. and Oketa, I. O.(2017. Effect of improvised and standard instructional materials on students' academic achievement in chemistry in secondary schools. *International Research Journal of Natural and Applied Sciences (IRJNAS),4*(6), 58-72.
[11]. AL Haydar, M., Abid, H. R., Sunderland, B. and Wang, S. (2017). Metal organic frameworks as a drug delivery system for flurbiprofen. *Drug Design, Development and Therapy*. *11*, 2685–2695.
[12]. Ali, M. A., Ren, J., Liu, X., Hua, Y., Yue, Y. andJianrong, Q. (2019). Discovery of superbroad mid-infrared luminescent metal-organic framework glass. ChemRxiv. Preprint.**https://doi.org/10.26434/chemrxiv.7635746.v1**
[13]. Amadioha, S.W. (2009). The Importance of Instructional Materials in Our Schools: an Overview *New Era Research Journal of Human, Educational and Sustainable Development, .2*(3 & 4), 61-63.
[14]. Ampiah, J. G. (2001). Students' perception of topics in senior secondary school chemistry syllabus. *Journal of EducationalDevelopment, 1*(1), 85-93.
[15]. Aneale, E. (2005). Electrical/electronic skills needed by technical colleges' students for self-employment. *Journal of Vocational and Adult Education,4*(1), 27- 35.
[16]. Aremu, O. A. and Sokan, B. O. (2003). A multi-causal evaluation of academic performance of Nigerian learners: issues and implications for national development. Department of Guidance and Counseling, University of Ibadan, Ibadan.
[17]. Asokhia, M.O. (2017). Improvisation/Teaching Aids: Aid to Effective Teaching of English Language. *Journal International Journal of Educational Sciences, 1*(2), 79-85.
[18]. Baja, S. T. (1988). Senior Secondary Chemistry. Lagos: Longman.
[19]. Batten, S. R., Champness, N. R., Chen, X.-M., Garcia-Martinez, J., Kitagawa, S., Ahlstrom, L., O'Keeffe, M., Suh, M. P. and Reedijk, J. (2013). Terminology of metal-organic frameworks and coordination polymers (IUPAC Recommendations 2013). *Pure Appl. Chem., 85* (8), 1715-1724.
[20]. Chakraborty, A., Haldar, R. andMaji, T. K. (2013). Bifunctional Co(II)-Ag(I) and Ni(II)-Ag(I) frameworks: Modulation of magnetic property and CO_2 uptake based on organic pillars. *Cryst. Growth Des. 13*, 4968-4976.
[21]. Chibabi, A. A., Umoru, S. E., Onah, D. O. and Itodo, E. E. (2018).Effect of laboratory method on students' achievement and retention in senior secondary schools biology in Kogi East Senatorial Zone. *IOSR Journal of Research & Method in Education,8*(6), 31-39.
[22]. Dhindsa, H. S. andTreagust, D. F. (2014). Perspective pedagogy for teaching chemical bonding for smart and sustainable learning.*Journal of Chemistry Education Research and Practice.5*, 1-20.
[23]. Eriba, J. O and Regina, M. O.(2011). Laboratory and the Art of improvisation .His Masters Media publisher, Makurdi. Education Resource Centre-Use of improvisation and Learning Resources in Schools.
[24]. Eshiet, I. T. (1996). Improvisation in science teaching. Philosophy and Practice. Abak, Belpot.
[25]. Eze, P. I. (2017). Effectiveness of improvisation of instructional materials on students' academic achievement and retention in Christian religious studies (Crs). *International Academic Journal of Innovative Research. 4*(1), 51-57.
[26]. Federal Republic of Nigeria (2014). National Policy on Education. Abuja: FME.
[27]. Federal Republic of Nigeria (FRN), (2004). *National Policy on Education*. *Lagos: NERDC press.*
[28]. Isola, O.M. (2010). Effects of Standardized and Improvised Instructional Materials Students' Academic Achievements in Secondary School Physics. M. Ed Thesis, University of Ibadan, Ibadan.
[29]. Jekayinfa, A.A. (2012). *Fundamentals of instructional methods*. Ilorin, Kwara State, Olives Production Ltd.
[30]. Kurumeh, M. S. (2006). Effect of ethnomathematics approach on students' achievement in geometry and menstruation. *Journal of .mathematical Association of Nigeria*. *31*(1), 35-44.
[31]. Leng, F., Wang, W., Zhao, X. J., Hu, X. L., and Li, Y. F. (2014*).* Adsorption interaction between a metal-organic framework of chromium-benzenedicarboxylates and uranine in aqueous solution. *Colloids and Surfaces A: Physicochem. Eng. Aspects,441*,164-169.
[32]. Mahajan, D. S. and Singh, G. S. (2005). University Students performance in organic chemistry at undergraduate level: Perception of instructors from universities in the SADC region. *Chemistry*, 1(1), 1-20.

[33]. Maicibi, N.A. (2003). *Human Resource Management Success*. Kampala.Net Media Publication. Ltd. Uganda
[34]. Manjale, N. B. and Abel, C. (2017). Significance and adequacy of instructional media as perceived by primary school pupils and teachers in Kinondoni District, Tanzania.*International Journal of Educational Policy Research and Review,4*(6), 151-157.
[35]. Mboto, F. A., Ndem N. U and Stephen, U. (2011). Effects of improvised materials on students' achievement and retention of the concept of radioactivity.*An International Multi-Disciplinary Journal, Ethiopia*, *5*(1),342-353.
[36]. Nguyen, N, Williams, J and Nguyen, T. (2012). The use of ICT in teaching tertiary physics: Technology and pedagogy. *Asia-Pacific Forum on Science Learning and Teaching*, *13*(2), 6-11.
[37]. Nwagbo, C. R and Ugwuanyi, C.S. (2015). Assessment of Science Teachers Pedagogical Beliefs and information and communication Technology (ICT) classroom practices in secondary schools in Enugu State of Nigeria. *Journal of the Science Teachers Association of Nigeria (JSTAN)*, *50*(1), 24-33.
[38]. Ogbondah, L. (2008). An appraisal of instructional materials used to educate migrant fishermen's children in Rivers State, Nigeria. *International Journal of Scientific Research in Education, 1*(1), 13-25.
[39]. Okendu, J. N. (2012).The Influence of instructional process and supervision on academic performance of secondary school students of River State, *Nigeria. Journal of Academic Research International*,*2*(3), 36-40.
[40]. Okori, O. A and Jerry, O. (2017). Improvisation and utilization of resources in the teaching and learning of science and mathematics in secondary schools in Cross River State. *Global Journal of Educational Research, 16*, 21-28.
[41]. Okori, O. A. and Jerry, O. (2017. Improvisation and utilization of resource in the teaching and learning of science and mathematics in secondary schools in Cross River State. *Global Journal of Educational Research*,*16*, 21-28)
[42]. Oladejo, M. A., Olosunde, G. R., Ojebisi, A. O. and Isola, O. M. (2011). Instructional materials and students' academic achievement in physics: Some Policy Implications. *European Journal of Humanities and Social Sciences*,*2*(1), 112-24.
[43]. Oladejo, M.A, Olosunde,G.R, Ojebisi,A.O andIsola,O.M. (2011). Instructional materials and students' academic achievement in physics: some policy implications. European Journal of Humanities and Social Sciences, *2*(1), ISSN 2220-9425
[44]. Olayinka, A-R. B. (2016). Effects of instructional materials on secondary schools students' academic achievement in Social studies in Ekiti State, Nigeria. World Journal of Education, *6*(1), 32-39.
[45]. Onasanya, S.A., andOmosewo, E. O. (2011). Effect of improvised and standard instructional materials on secondary school students' academic performance in Physics in Ilorin, Nigeria. *Singapore Journal of Scientific Research, 1*(1), 68. 76.http://dx.doi.org/10.3923/sjsres.2019.68.76
[46]. Onasanya, S. A., M. V. Adegbija, C. O. Olumorin and F. O., Daramola, 2008.Education reforms and assessment of teachers' competence in instructional media technology use in junior secondary schools in Kwara State. In: Education reforms in Nigeria-past, present and future. Lawal, A.R. (Eds).Stirlings-Horden Publishers Ltd., Lagos, pp: 259-272.
[47]. Oso, L. (2011). Need for improvisation in classroom teaching. The Punch, June 20.
[48]. Otor, E. E. Ogbeba, J., and Ityo, C. N.(2015). Influence of improvised teaching instructional materials on chemistry students' performance in senior secondary schools in Vandeikya Local Government Area of Benue State, Nigeria.*International Research inEducation*, *3*(1), 111-18.
[49]. Otor, E.E.,Ogbeba, J. and Ityo, C. N. (2015). Influence of improvised teaching instructional materials on chemistry students' in senior secondary schools in Vandeikya Local Government Area of Benue State, Nigeria. *International Research in Education, 3*(1), 111-118.
[50]. Reib, S., Hagen, G. & Moos, R. (2008). Zeolite-based impedimetric gas sensor device in low-cost technology for hydrocarbon gas detection. Sensors 8, 7904-7916.
[51]. Samba, R. M. O. andEriba, J. O. (2012). Background information on teaching difficult science concepts. In Samba R.M.O. and Eriba J.O. (Eds). Innovative Approaches in teaching difficult science concepts (pp.1-5) Makurdi, Nigeria: Destiny Ventures.
[52]. Takawira C. K. and Admire M. (2012). Student Performance in A-level Chemistry Examinations in Makoni District, Zimbabwe. *Eurasian Journal Physics & Chemistry Education*,*4*(1), 2-29.
[53]. Uchegbu, R. I., Oguoma, C. C., Elenwoke1, U. E. andOgbuagu. O. E. (2016).Perception of difficult topics in chemistry curriculum by senior secondary school (II) students in Imo State.*AASCIT Journal of Education.2*(3), 18-23.
[54]. Uzuegbu, C.P., Mbadiwe, H. C. andAnulobi, J. C. (2013). Availability and utilization of instructional materials in teaching and learning of library education in tertiary institutions in Abia State. Wudpecker Journal of Educational Research, *2*(8), 111-120. Retrieved on October 3, 2019 from http://wudpeckerresearchjournals.org/WJER/pdf

Stephen Adie Adalikwu (Ph.D.),*et al.* "Effects of Using Synthesized Single Crystal Structure ofcoordination Polymers as a Teaching Resource onthe Concepts of Coordination Chemistry in Colleges of Education." *IOSR Journal of Applied Chemistry (IOSR-JAC)*, 13(4), (2020): pp 38-49.