INTERACTIVE INVENTION AND CROSSWORD PUZZLE-BASED INSTRUCTIONAL STRATEGIES, AND PRE-SERVICE TEACHERS LEARNING OUTCOMES IN CELL BIOLOGY IN SOUTHWESTERN NIGERIA

BY

Edidiong Emmanuel AKPAN

Matriculation Number: 201338

B. Sc. Ed [Biology Education] (Uyo); M. Ed [Science Education] (Ibadan)

A Thesis in the Department of Science and Technology Education,

Submitted to the Faculty of Education,

in Partial fulfilment of the requirements for the Degree of

DOCTOR OF PHILOSOPHY

of the

UNIVERSITY OF IBADAN

AUGUST 2023

CERTIFICATION

I certify that this work was carried out by Mr E. E. Akpan in the Department of Science and Technology Education, University of Ibadan.

Supervisor

Alice M. OLAGUNJU

B. Sc. (Ed) (Ife); M. Ed; PhD (Ibadan)

Professor of Science and Environmental Education,

Science and Technology Education Department,

University of Ibadan, Nigeria.

DEDICATION

I appreciate God almighty for His mercies, grace, strength and wisdom.

ACKNOWLEDGEMENTS

I reverence God Almighty for wisdom, grace, mercies and good health in my life. I therefore return all glory, thanks, praises and adoration to Him, for indeed He is a living God. I worship HIS name Jesus, Amen

I specially appreciate my supervisor, Professor (Mrs) Olagunju, A. M., who assumed the role of a mother and mentor to me and also for her patience in reading through this write up, further advice and for sacrificing her time and wealth of experience in guiding and encouraging me to make this work a reality. God Almighty will honour her (Amen).

I appreciate the current Acting Head of Department, Dr Edidiong E. Ukoh, who guided me, gave valuable contributions, mentored, suggested, prayed, and encouraged me throughout my programme, truly, you are a mother, and God bless her. I also appreciate the former Acting Head of Department, Dr A. Tella whose wealth of knowledge, and support has brought me this far, God bless him. I greatly appreciate Professor Temisan Ige for her motherly love, giving me prompt attention, invaluable corrections to my work and having keen interest in me. I thank her for everything, God bless her. I also appreciate my big brother, Dr N. A. Omilani who took interest in me, directed and showed me the way, contributed immensely to my success, mentored, prayed and guided me throughout my study, your kind is rare sir, I say God bless him.

I also appreciate Professor M. K. Akinsola for his suggestions and direction throughout my programme, God bless him. I also appreciate Professor Ayetola Aremu, and Dr Israel Olasunmkumi whose wealth of knowledge and push gave me the strength to complete this work I say God bless them abundantly and give them, their heart desires. Amen. I want to appreciate Drs Mabel Idika, Adetunmbi Akinyemi, Temitope Ojo and Miss Tomi Ogundipe who stood as my guide throughout my programme, encouraged and gave invaluable contributions. I want to appreciate Dr O. J. Olawuyi from the Department of Botany, for contributing tirelessly in both knowledge and in prayers to see that I succeed, those words of encouragements and constant push are highly appreciated, God bless him.

I thank my parents, Dr Emmanuel and Mrs Bassey Nse Akpan for their love and care. Both of you are my source of encouragement in the areas of prayers, financial support and words of encouragement. Jesus will keep, bless, and protect them to reap the good works (Amen). I also appreciate my siblings, Engr. Tony Akpan, Mrs

Uduak Ubong, Mrs Uyai Umoren, and Mr Ukemeobong Akpan for their support in all ways. I appreciate them for standing by me throughout my programme.

I specially want to thank my Ette Akamba, Professor Godwin A. Ikitde for the push, and words of encouragement and always-showing interest in my progress right from my undergraduate as my project supervisor, God bless, Sir. I want to appreciate Dr Abigail S. Essang, Professor Andrew Fadoju, Professor Charles Uwakwe, Drs M. Amosun, Eileen Akintemi, and I. Salami for always encouraging and praying for me, God bless them. I appreciate Pastor and Dr (Mrs) U. M. Uwemedimo, Mr Essien Umoren, Mr S. Udoh, Mrs Inemesit Sunday Udoh and Dr and Mrs Matthew Akpan for the push, prayers and encouragement throughout my academic pursuit, God bless them abundantly. I appreciate Dr Edet Okon and Mr Elisha Inyang (PhD in view) for their financial support, encouragement and prayers, God bless them.

I want to thank our wonderful Mrs Florence Adurota, Mr Felix Isola, Mr A. S. Oyetunji and Mr Akinwale for the push, advice and prayers during my study in the science and technology education department, I am happy our paths crossed, God bless them.

I specially appreciate the Heads of Departments in the Federal Colleges of Education who agreed that their departments be utilised. Thank you for the support throughout my stay. I want to appreciate most especially the Lecturers of the BIO 112 course tagged Cell Biology in the three federal colleges used for the study in persons of Mr B. Y. Lawal (FCE (special), Oyo), Mr Hamidu Muazu Musa (FCE, Osiele, Abeokuta) and Mr A. A. Muhammad (Adeyemi College of Education, Ondo). Thank you for the assistance in implementing the strategies. God Bless, Sirs. I equally want to appreciate the NCE I students that participated in the treatment groups drawn from the three colleges of education used for the study. Thank you for your participation. God bless them.

I also appreciate the following lecturers who assisted me during the cause of my study in the three federal colleges of education. In no particular order, they include Dr Olubukola Oke (FCE, Osiele), Dr D. O. Oyawole (FCE, SPED), Mr I. S. Oladipupo (FCE, SPED), Miss Agada Allwell (FCE, SPED), Mr S. O. Adeyeye (FCE, SPED), Dr G. A. Busari (FCE, Osiele) and Dr Olayemi Asaaju (ACE, Ondo). I thank them for the assistance rendered, God bless.

I thank Mr Nathaniel Bello for always being there for me and giving me listening ears, thank you for all you do Sir, and God bless. Special thanks to my friends

in the persons of Mr Success Akpojotor, Dr Uchenna Okeke, Mr Adeleke Adesina, Mr Oluwaseun Orefuwa, Mrs Faith Nworah, Mr Abimbola Babatunde, Mrs Joy Ginika Nsofor, Miss Miriam James, Engr. Daniel Goodspeed, Miss Aniema Eyoh, Mr Nnamso Inyang, Miss Rachael Peter, Miss Mfonobong Akpainyang, Mrs Gladys Kosoffa, and others so numerous to mention. Together, we have come thus far the sky is our springboard.

I thank you all and God bless you.

Edidiong Emmanuel AKPAN

ABSTRACT

Cell Biology, one of the courses offered at Colleges of Education (CoEs) in Nigeria, is basic for the understanding of all biological concepts. However, reports have shown that pre-service teachers' achievement and interest were poor and inconsistent. Previous studies largely evaluated the implementation and effectiveness of pre-service teachers' Biology curriculum with little attention paid to intervention using Interactive Invention Instructional Strategy (IIIS) and Crossword Puzzle-based Instructional Strategy (CPIS). Therefore, this study was designed to determine the effects of IIIS and CPIS on pre-service teachers' learning outcomes (achievement and interest) in Cell Biology in southwestern Nigeria. The study also examined the moderating effects of problem-solving ability and cognitive style.

Jerome Brunner's Constructivist Theory of Learning and Ashmore, Frazer and Casey's Problem-Solving Model were adopted as the framework, while the pretest-posttest control group quasi-experimental design with a 3×2×2 factorial matrix was adopted. Three Federal Colleges of Education were selected purposively out of the existing CoEs in southwestern Nigeria and an intact class of Nigeria Certificate in Education 1 Biology students were enlisted. The participating CoEs were randomly assigned to IIIS (146), CPIS (134) and control (124) groups. The instruments used were Pre-service Teachers Cell Biology Achievement Test (r = 0.79), Pre-service Teachers Cell Biology Interest Questionnaire (r = 0.82), Pre-service Teachers Cell Biology Problem-solving Ability Scale (r = 0.79), Pre-service Teachers Cell Biology Cognitive Style Test (r = 0.86) and instructional guides. The treatment lasted 14 weeks. Data were analysed using analysis of covariance and Bonferroni post-hoc test at 0.05 level of significance.

The age of the pre-service teachers was 17.00±2.30 years, and 75.0% were female. There was a significant main effect of treatment on pre-service teachers' achievement ($F_{(2;403)}$ = 37.78, partial η^2 = 0.16). The participants in IIIS had the highest post-achievement mean score (17.75), as against those in CPIS (17.17) and the control (14.12) groups. There was a significant main effect of treatment on pre-service teachers' interest ($F_{(2;403)}$ = 55.00, partial η^2 = 0.22). The participants in IIIS had the highest post-interest mean score (82.25), as against those in CPIS (80.90) and the control (73.52) groups. The main effects of problem-solving ability and cognitive style were not significant. The two-way interaction effects were not significant. There was a significant interaction effect of treatment, problem-solving ability and cognitive style on pre-service teachers' achievement ($F_{(2;403)}$ = 40.00, partial η^2 = 0.02) in favour of high problem-solving ability from IIIS group with analytical cognitive style. The three-way interaction effect on pre-service teachers' interest was not significant.

Interactive invention and crossword puzzle-based instructional strategies enhanced pre-service teachers' Cell Biology learning outcomes in southwestern Nigeria, regardless of their problem-solving ability and cognitive style. These strategies should be adopted to teach pre-service Biology teachers in other to cater for their deficiency in Cell Biology.

Keywords: Interactive invention instructional strategy, Crossword puzzle-based instructional strategy, Learning outcomes in Cell Biology

Word count: 458

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

A	-	Analytical
ANCOVA	-	Analysis of Covariance
CIS	-	Conventional Instructional Strategy
CoEs	-	Colleges of Education
CPIS	-	Crossword Puzzle-based Instructional Strategy
DV	-	Dependent Variable
EMM	-	Estimated Marginal Means
FD	-	Field Dependent
FI	-	Field Independent
IIIS	-	Interactive Invention Instructional Strategy
IV	-	Independent Variable
MV	-	Moderator Variable
NA	-	Non-Analytical
NCCE	-	National Commission for Colleges of Education
NCE	-	Nigeria Certificate in Education
STEM	-	Science, Technology, Engineering and Mathematics

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Science is defined as a process that generates and applies scientific information in a bid to explain and predict the universe for the purpose of advancement of our scientific knowledge and understanding of the universe. Science education instils scientific attributes in students, for example reasoning, thinking critically, ability to solve problems, interest, and objectivity, culminating in the development of young scientists for future scientific pursuits. Scientific knowledge causes students' to perceive life challenges in a new light, which might be overwhelming to a non-scientist. A country's scientific advancement can be judged by the quality of its science education programs at elementary, lower basic, upper basic, secondary, and post-secondary levels (Ige and Oke, 2019). The science curriculum for Biology, Chemistry, Integrated Science, Mathematics and Physics at the Colleges of Education (CoE) level, on the other hand, has its goals to provide the citizens with highly motivated, expert, and efficient teachers who will assist students in internalising and understanding the principles and processes of science (Ugwe, 2014).

Biology Education, according to Okenyi (2015), is when educational ideas is used in the process of instruction during the biology lesson; It is the conveying of biological information to pupils through teaching and learning; and it is the process of conveying biological information, abilities, and attitudes to students of any level. It provides the learner with solid academic information, abilities, and numerous opportunities to put that knowledge into practice. It provides learners with the opportunity to attain high academic achievement as well as the ability to apply what they have learnt. The Colleges of Education Commission (NCCE) has stated the following goals and objectives for Biology Education (FRN, 2012): to see the earth through the mode of inquiry; organisms in the environment should be analysed

critically; should be able to display practical skills. Display required teaching skills when teaching biology; have appropriate science values and attitudes and spread the need to protection the environment and its enterprise. Replicate the biological knowledge gotten in totally new aspects and regular circumstances; be able to teach biology effectively and also further get the bachelor's degree in education after completing the certificate in education.

Biology pre-service teachers will receive a Nigeria Certificate in Education (NCE) in Biology as well as a second teaching subject, thus possible combinations include biology combined with agricultural science, mathematics, physics, geography, and chemistry, to name a few are allowed (FRN, 2012). In the colleges of education, the program spans three years (NCE I – NCE III). However, in the first semester of NCE 1, student teachers in education colleges offer five courses from the biology department. These include Bio 111 titled Basic Principles of Biology, Bio 112 titled Cell Biology, Bio 113 titled Viruses, Bacteria and Lower Plants, Bio 114 titled Biology Practical and Bio 115 titled Ecology.

One of these courses called cell biology covers the following topics: cell and its theories, flora and fauna cells structure; protoplasm together with its properties, Physical processes of the cell like osmosis, diffusion, plasmolysis, haemolysis, and so on; and the cell division, which involves mitosis, and meiosis, where it occurs and its significance to living things. This content has various benefits to the student's understanding of other courses, as it is the foundation of the biological sciences to solving various societal issues. This is why the concept of cell biology is taught at the NCE 1 first semester to help improve the understanding of the other concepts taught at NCE 1 up to NCE 111 levels, respectively (FRN, 2012).

Cell Biology deals with the study of cell structure and its functions; this encompasses the aspect of the cell which is the functional and basic unit of life (Idodo-Umeh, 2011). Cell biology (BIO 112) is a course taught with the following aims and objectives: give students' proper understanding of the cell and cell theory, brief history of cell, comparison between animal and plant cells using their constituents. It is important that learners are able to link the processes of the cell to the real world and understand the benefits and significance of mitosis and meiosis to all living things. One of the objectives includes going to new areas for future studies and these new areas include Forensic Science, Microbiology, Biochemistry, Biotechnology, Medicine, Pharmacy, Biomedical Engineering, Cytology, and so on. In the field of

Forensic Science, the knowledge of Cell Biology has been used in solving murder cases, rapes and kidnap by using samples such as blood, hair, fingerprints, and sperm and so on to carry out a genetic test. The knowledge of cell biology will enhance the understanding of its application in curtailing these crimes. Many crime cases have gone unsolved because Forensic Science courses have not been fully utilized in the country. This need must be intensified by teaching Cell Biology in a way that emphasizes the benefits and how it can help to curtail many societal issues.

Many courses and occupations in Biological, Medical, Pharmaceutical, Medical Laboratory Science, and other related fields are built on the foundation of Cell Biology. For instance, paternity fraud has been going on in Nigeria for decades now without sufficient answers. To find out a potential father of a child, a swab of the cheek cell is taken from the man to run the DNA test, the same will be done to the mother in case there is a dispute between two mothers. The approach taken to teach this concept of the cell should be that the students fully understand and can apply it to solve daily life issues. Students may develop an interest in studying genetics at the graduate and postgraduate degree levels respectively. Based on the benefits of cell biology stated earlier, the importance of cell biology cannot be overemphasised; as it is the foundation of understanding other concepts in the biological sciences and assisting people in solving real-life issues. Therefore, the performance in the cell biology course (BIO 112) as a compulsory course at the college of education is of immense interest (Akhtar *et al* 2011).

For many years, instructors of education, policymakers, and education stakeholders had been deeply concerned about students' academic performance in biology and cell biology. The course's curriculum material is meant to give biological content that will fulfil the demands of the learners and society as a whole (Arum, 2019). Research shows that students understanding of the diverse subject content has declined, particularly in the courses related to science at higher education institutions in Nigeria. Aina questioned how practically effective is the performance-based assessment in higher education (Aina, 2013). It was reported by Ali, Toriman and Gasim (2014) that there is a persistent decline of students' performance in biology and in extension cell biology in the past years. Another study by Owino, Osman and Yungungu (2014) reported some factors such as insufficient source of instruction resources in the form of models, charts and apparatus as difficulties that led to the poor achievement in biology/cell biology.

A further consideration of the student teachers performance in cell biology at the selected CoE revealed poor performances as indicated in table 1.1 below. Table 1.1 illustrates the achievement of the pre-service teachers in BIO 112 (Cell Biology) from two federal and two state CoE in Nigeria's' southwest for a period of five sessions. The table 1.1 depicts the achievement of pre-service teachers who offered BIO 112 – Cell Biology in four Nigerian colleges of education for five sessions (2014/2015 to 2018/2019). It further indicated the percentages passes of pre-service teachers' who offered cell biology even at an ordinary pass category varied and even fell below the national average. A review of their performance reveals that in nearly all of the colleges studied, some students scored E (40-44) and F (0-39), accounting for roughly 40% to 50% of total student performance. Students' dismal performance in the assessed Colleges of Education needs immediate intervention. The external moderator's evaluation noted that students' performance should be improved, as poor performance can be ascribed to large programs in addition to the lecturer's use of a traditional method of instructing cell biology.

In place of this, the moderator also proposed using activity-based techniques in delivering the course to increase performance, emphasizing that when lecturers use a teacher-centred approach, students will miss out on hands-on activities that would have reinforced the learnt concept. As a result, individuals would recall only a small portion of the information presented, which has implications for the concepts' interpretation and possibly comprehension (Danmole, 2012). A research by Olagunju and Babayemi (2014) asserted that when good strategies are lacking in the process of teaching difficult or abstract concepts, this has implications on the students' performance, as such, this will scare students away from studying biology and biology-related disciplines.

To further support the status of cell biology as a difficult course for pre-service teachers, the researcher requested lecturer's views on the difficulty level of cell biology course in 1st semester for NCE 1 see figure 1.1.

Table 1.1 – Performance of Pre-service Teachers in BIO 112 (Cell Biology) from Two Federal and Two State Colleges of Education (College A to D) in the Southwest, Nigeria from 2014/2015 Session to 2018/2019 Session.

		Performance and Percentages of candidates' Scores						
College	**Session**	**70-100**	**60-69**	**50-59**	**45-49**	**40-44**	**0-39**	**Total**
College A	**2014/2015**	2 (1%)	32 (9%)	92 (25%)	44 (11%)	146 (38%)	60 (16%)	**376**
	2015/2016	7 (4%)	12 (10%)	36 (26%)	11 (9%)	59 (42%)	12 (9%)	**139**
	2016/2017	2 (1%)	28 (17%)	53 (32%)	18 (11%)	44 (26%)	23 (13%)	**168**
	2017/2018	3 (1%)	31 (10%)	77 (26%)	44 (15%)	85 (28%)	58 (20%)	**298**
	2018/2019	2 (1%	1 (1%)	10 (4%)	10 (4%)	25 (10%)	199 (80%)	**247**
College B	**2014/2015**	32 (9%)	44 (13%)	74 (22%)	60 (18%)	79 (23%)	50 (15%)	**339**
	2015/2016	25 (12%)	34 (16%)	54 (25%)	27 (12%)	38 (17%)	40 (18%)	**218**
	2016/2017	29 (14%)	35 (17%)	51 (26%)	20 (10%)	35 (17%)	33 (16%)	**203**
	2017/2018	21 (8%)	38 (13%)	48 (18%)	18 (7%)	74 (27%)	74 (27%)	**273**
	2018/2019	23 (9%)	38 (14%)	50 (19%)	30 (11%)	77 (29%)	49 (18%)	**267**
College C	**2014/2015**	6 (4%)	9 (6%)	51 (35%)	5 94%)	44 (31%)	29 (20%)	**144**
	2015/2016	3 (2%)	23 (13%)	47 (26%)	31 (17%)	58 (32%)	17 (10%)	**179**
	2016/2017	1 (1%)	13 (6%)	54 (24%)	61 (27%)	50 (22%)	47 (21%)	**225**
	2017/2018	10 (5%)	34 (16%)	69 (26%)	31 (15%)	47 (22%)	19 (9%)	**210**
	2018/2019	11 (5%)	22 (10%)	56 (26%)	52 (24%)	41 (19%)	36 (17%)	**218**
College D	**2014/2015**	1 (1%)	9 (9%)	43 (41%)	11 (11%)	26 (25%)	15 (14%)	**105**
	2015/2016	2 (2%)	8 (7%)	36 (30%)	24 (20%)	30 (25%)	21 (17%)	**121**
	2016/2017	4 (4%)	17 (19%)	39 (43%)	4 (4%)	21 (23%)	6 (7%)	**91**
	2017/2018	2 (1%)	18 (11%)	42 (26%)	53 (32%)	34 (21%)	15 (9%)	**164**
	2018/2019	0 (0%)	7 (5%)	36 (27%)	28 (21%)	46 (35%)	16 (12%)	**133**

Source: NCE 1 BIO 112 (cell biology) scores from four (4) CoE in Nigeria's South-western States. See Appendix I

Key: A = 70% and above, B = 60 – 69%, C = 50 – 59%, D = 45 – 49%, E = 40 – 44 %, and F = 0 – 39%.

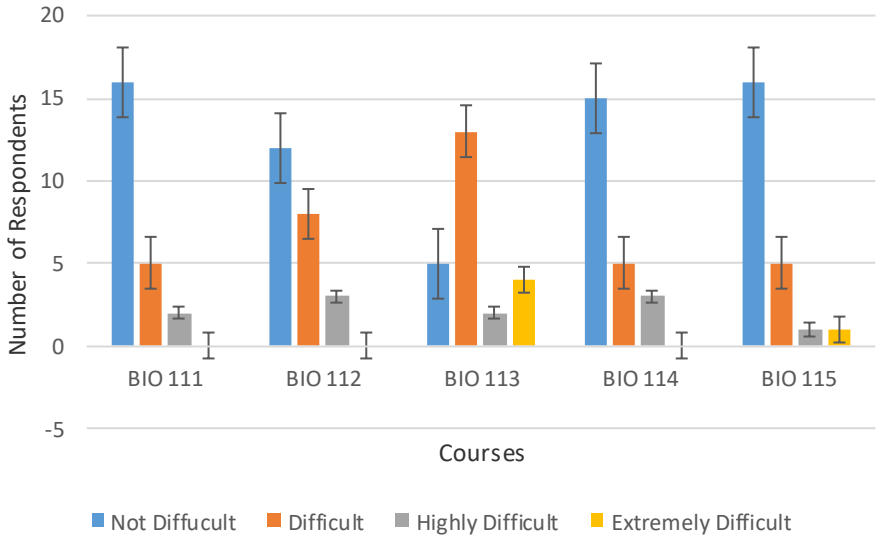


Figure 1.1 Lecturers' Perception of the Difficulty Level of the Biology Courses of Students in the First Semester of the NCE 1 at the College of Education.

Source: Researchers' Pilot Study, 2021

Figure 1.1 shows the lecturers' perception of the difficulty level of NCE 1 first semester courses, and the results reveal that 52.17% of the teachers regard BIO 112 as a course that is not difficult. On the other hand, 34.78% and 13.04% of lecturers considered the course as difficult and highly difficult respectively. Given the closeness of the perception of difficulty (52.17 not difficult; 47.83 difficult) and the poor achievement of the student teachers' indicated in table above calls for concern. Perhaps, lecturers who agreed to the difficulty did so based on students' performance, whilst those who considered the course not difficult did so based on the content's simplicity. The conflict that exists between the simplicity of content and student performance questions the teacher-centred strategy that is widely used for instructional delivery at this level (Muhammad and Sabiru, 2016). Even though they are not qualified to teach natural science at the senior secondary level after they graduate, pre-service biology teachers must cover the curriculum from BIO 112 in order to teach Integrated Science at the junior secondary level. The course is required for basic biology literacy for a graduate of NCE and it will provide a solid foundation should they want to study Biology in higher education. Studies such as Adekunle and Femi-Adeoye (2016) and Fakolade (2019) have shown a link between interest and achievement, therefore interest is the second dependent variable considered in this research.

When individuals learn, curiosity is a powerful motivator where if learners lack interest, they will be unable to study successfully because nothing will motivate them to do so (Jakel, 2014; Serafin, 2016). In a study by Nwafor and Oka (2018), they indicated that girls had an increased interest in biology and biology related concepts than boys. A study by Fakolade (2019), reported there existed a link between the mean interest rating and mean achievement scores in biology. A separate research by Adekunle and Femi-Adeoye (2016), reported a significant link between students' achievement and interest in biology. Knekta, Rowland, Corwin, and Eddy's (2020) study revealed that students' interest is low at the secondary school level but may tend to increase especially on human biology related courses maybe due to their personal health issues.

A study by Holsternmann, Grube, and Bogeholz (2009) on hands-on activities and its effect on students' interests, these activities have a variety of effects on students and are capable of influencing their interests in different ways. They argued that hands-on activities should be designed around activities that can influence interest.

Biology students' interest inventory in secondary schools revealed that when students were asked the extent to which they will choose a cell biology-related career as one of the items, it revealed that most students chose a very small interest in a cell biology-related career. As such if the trend goes on there will be fewer candidates and experts for courses or fields related to biology, and cell biology or cytology in the future (Nwafor and Oka, 2018).

Various influences were listed as the reason for the poor achievement and a lack of interest in cell biology. These include the use of a teacher-centred approach/strategy in the teaching of cell biology, fewer hands-on activities, the usage of insufficient instructional approaches in teaching challenging concepts, less student participation and so on as stated in the moderator's report from the colleges of education. Different scholars and researchers have attributed various factors to the lack of interest and poor achievements in Natural science and some associated sciences that cuts through diverse categories of schooling. There are several issues with biology textbooks, including an abundance of abstract biology material (Akingbemisilu, 2017), usage of insufficient instructional approaches for grasping challenging concepts (Okoye and Okechukwu, 2010), lack of appropriate teaching strategies to teach abstract concepts (Olagunju and Babayemi, 2014). Negative attitude to science (Adeoye, 2011; Tella, 2013), inadequate teaching material or resources, and practical workstations (Aremu and Sangodoyin, 2010; Omilani, Akinyele, Durowoju and Obideyi, 2018), poor success rate when lecture method is used (Ogundiwin and Ahmed, 2015) and insufficient practical skills (Danmole, 2012; Olagunju and Babayemi, 2015).

The lecture method as a teaching method is criticized mostly because it is still used even in a period of technological advancement among educators. The method is still in use in colleges and universities as the means of instruction in these higher institutions (Kuar, 2011). According to Ogundiwin and Ahmed (2015), the traditional method used to teach science is extremely ineffective at all levels. Olatoye and Adekoya's (2010) research showed that when the lecture method is employed it is ineffective in the instruction of science. Hence, the need for a different approach to science teaching. Aloovi (2016) suggested the use of hands-on activities, as it was able to improve students' interest, which translates to an improvement in their achievement. Amongst these are student-centred strategies such as crossword puzzles, interactive

invention, think-pair-share, interactive lecture demonstrations, concept mapping and so on.

These instructional strategies allow students to construct their experiences by making them active partakers in the teaching procedure rather than inactive learners. Interactive invention and crossword puzzle-based instructional strategies are the two strategies chosen for this study. Interactive invention strategy provides the learners the chance to interrelate through the learning material repeatedly and a periodic review done to enable understanding of the cell biology concepts while the crossword puzzle enhances students' critical thinking skills when answering the puzzles and improve on their collaborative approach through brainstorming for the understanding of cell biology concepts respectively.

Ukoh (2012) stated that Interactive Invention Strategy (IIS) is utilized in the teaching of skills and concepts by to imparting both concepts and skills by linking teacher's explanation with pre-service teachers' practice, knowledge invention, periodic review and feedback to impart various ideas and abilities. Ukoh's research on NCE physics educators in CoE in southwest part of the country showed that the interactive invention strategy was found to be effective and proved to affect the performance of the NCE educators, compared to those in the conventional method. Ogunbowale (2014) investigated the impact of interactive invention and problem-based approaches on learners' performance in the field of biology and discovered that interactive invention strategy was able to improve learners' performance in natural science at the secondary school level with a better achievement mean when compared to those in the traditional approach to instruction.

Okurumeh's (2016) study on the effect of discussions and inventive methods on the retention of learners in chemistry revealed that learners who were taught using the invention approach outperformed those who were taught using both the discussion and traditional techniques in terms of student retention. Since the three studies carried out by Ukoh was in NCE physics educators in CoE, and Ogunbowale/Okurumeh studies were on secondary school students in biology and chemistry respectively, the researcher carried out the research on NCE biology educators at the CoE level.

The puzzle-based instructional strategy is a strategy conceived by John Spilsbury in the year 1760. An activity-based learning technique known as a puzzle-based instructional strategy allows students to interact with the learning materials, encourages student discussion, and allows for the exploration of concepts through

questions (Umoru, Adejoh, and Iji, 2016). The study by Franklin, Peat, and Lewis (2003) and Derer and Berkant (2019) on the use of puzzles and games with first-grade high school biology students revealed that they profited from playing games on cards and class puzzles, and the students acknowledged that it helped create an engaging, active learning environment.

The study by Olumide (2018), on the impact of using digital puzzle packages on learners' achievement, ability to solve problems, and attitudes in ecology and genetics revealed that these packages could improve learners' achievement, attitude, and problem solving in some biological concepts. Ogundiwin's (2013) research, using puzzles to teach biology to secondary students has improved their performance in some environmental biology themes. Ogundiwin and Oladipo's (2019) research showed that puzzle-based instructional strategy improved secondary school students' practices towards sustainable environmental development.

Stetzik, Deeter, Parker, and Yukech's (2015) research on the use of puzzle compared with lecture method to improve on students achievement in university students' physiology and anatomy practical showed that the learners achievement in a standardized test such as objective and essay increased by 2.1% for quiz and 0.4 % for test scores. Lastly, there is evidence when puzzle is used as a method of instruction in science education in universities in Korea showed it was able to improve the understanding of topics especially abstract topics and was able to develop in the students' abilities such as problem-solving (Anany and Mary 2002; Adesina, Adegoke, and Ogundiwin, 2015). The research studies reviewed on puzzle was examined at the secondary level but the current study intends to investigate the impact of puzzle-based teaching strategy at the higher institution, hence, the need for this study.

To understand the nature of the concept of Cell Biology pre-service teachers needs the knowledge to solve problems in combination with the approaches materials such as worksheets and a puzzle, will need see the students teachers solve problems anchored the need for problem-solving ability as a moderator variable. Based on the nature of concept of cell biology having pictorial representation of concepts and the nature of the cognitive style that involves the analyses of pictures in relation to the concept of cell biology. Cell Biology content has various diagrammatic representation of concepts for easy explanation and understanding justified the use of both variables as moderating variables (Ogundiwin, 2013; Olumide, 2018). This called for the use of problem-solving ability and cognitive style as a moderating variable.

Temel (2014) describes problem-solving as a process in which a person overcomes obstacles in order to achieve a goal. He posited an issue is said to be a problem as far as the person involved does not have an idea of the way forward, and problem-solving is utilized when an individual does not have any atom of idea on what to do. His study on pre-service teachers' perception of problem-solving showed that students had a medium level of problem-solving as well as problem-based learning and traditional method having a different effect on the ability to solve problems base on their perception. The findings of Karademir (2019) on problem-solving skills showed that it was above the middle value. Based on these studies, shows that problem-solving ability in secondary schools is on the median level. Therefore, it is necessary to determine the present state of learners' abilities to solve problems in higher education.

Aydin's (2015) report stated that cognitive style was a concept first formed by Allport in 1937. Understanding cognition's definition is a prerequisite for comprehending cognitive style. Awareness, perception, reasoning, and judgement are all parts of the cognitive process. He reported that a person has a particular style of arranging and retrieving information. He stated that cognitive styles refer to how an individual is able to respond to diverse situations, it has to do with a person's way that categorises their problem-solving, reasoning, recollecting, and perception styles. In literature, there exists a range of dimensions of the cognitive style adopted by different researchers. Some scholars such as Hong, Hwang, Tam, Lai, and Liu (2012, Aydin (2015), Idika (2017), Altinta and Gorgen (2018), Hussin, Razali, and Agussalim (2021) all used the Field Dependent (FD) and field Independent (FI) categorisation for cognitive style.

Different scholars described field-independent level as individuals that can differentiate the different aspects of a picture or photo surrounding in a whole picture (that is, the field) without stress and seldom concentrate on unimportant details. On the other hand, FD individuals are said to be persons who pay more attention to important and unimportant details. However, in this study, the analytical and non-analytical cognitive style categorisations propounded by Kegan, Moss, and Sigel in 1963 was adopted for this study. Ogundiwin (2013) described analytical style learners as those who can distinguish objects or photos based on their shared attributes and superordinate features but are weak on the relational link while non-analytical style learners distinguish objects or photos based on relational links but weak on shared attributes and superordinate features.

Results from Aydin's (2015) research on the cognitive style of student teachers in science compared with structures in technology, implied that first-level learners that are FD cognitive style could associate more with concepts when aligned to their counterparts on the cognitive style level based on field-independent. Idika (2017) reported on the cognitive style influence on chemistry learners' achievement showed learners' in the FI had a better performance mean score in chemistry when compared with those in the FD cognitive style levels. Hong, Hwang, Tam, Lai, and Liu (2012) research on cognitive style showed that cognitive style relying on field independence predicted jigsaw scores based on puzzle successfully. In Altintas and Gorgen (2018) research showed that intending teachers generally possess a field-dependent cognitive style. It further indicated no difference significantly between intending educators' academic success and cognitive style scores. These results by the researchers shows inconsistencies which then calls for this study to fill this gap.

An examination of the evaluated studies and performance in BIO 112 - cell biology reveals an inconsistent trend and poor performance, as well as the impact of interest on achievement. To address this, the study examined the impact of two activity-based approach and NCE student teachers' learning outcomes in cell biology concepts, with the moderating effect of problem-solving ability and cognitive style.

1.2 Statement of the Problem

Issues regarding negative interest in biology was established in literature as the reason why students' performance in biology-related concepts like cell biology has continued to wane. Several deficiencies on issues regarding the NCE student teachers performance and interest was documented in literature. It shows that pre-service teachers' fluctuating and low level of performance in Biology is a result of some many variables, which include lack of adequate use of the appropriate instructional strategies, less hand-on activities, which has a direct effect on the understanding of any concept taught in Cell Biology and Biology as a whole. Based on the cell biology course reviewed, it indicated that over 40 % of the pre-service educators have poor achievement in the reviewed course. Interest in biology concepts could have caused the poor achievement in BIO 112 – Cell Biology course for NCE 1 pre-service teachers. Due to this, students might not pick up a career in a related field in cell biology thereby not meeting the objective of the biology education programme at the college of education level.

Several other issues has been stated in literature as the cause of this poor achievement and negative interest. These include negative attitudes, lack of good teaching strategies, inadequate teaching materials, and the use of inadequate instructional strategy to teach difficult concepts at the NCE 1 level, which could make students, less interested which then reflects on their achievement. Based on the results from BIO 112 – Cell Biology, it shows that the performance was inconsistent and poor as well as the moderator's report that states that, the performance in the course needs to be improved. The nature of the concept of cell biology has probability related concepts, abstractions and pictorial representation, led to the choice of the two instructional strategies, which is activity-based and hands-on.

Scholars have already experimented with interactive invention instructional strategies at the tertiary level in the physical sciences and experimented it at the post primary level in subjects such as biology, but there seems to be less research carried out on pre-service teachers in biology. While the crossword puzzle teaching technique was tested at the senior secondary school level, less research is found in research on pre-service teachers in biology. The two methodologies are student-centred and include activities such as worksheets and a cell biology puzzle to engage students in the classroom as active learners to improve on pre-service teachers' performance and interest in cell biology.

It on this grounds that the study examined the impact of interactive invention and crossword puzzle-based instructional strategies, and NCE student teachers' performance in and interest in cell biology course. The problem-solving ability and cognitive styles as moderating effects were considered.

1.3 Objectives of the Study

The following objectives guided the study:

1. The study determined the effects of interactive invention and crossword puzzle-based instructional Strategies on pre-service teachers' learning outcomes in Cell Biology.
2. It further examined the effects of problem-solving ability and cognitive styles on learners' performance and interest in Cell Biology.

1.4 Hypotheses

The stated hypotheses were examined at the significance level of 0.05:

H_o1: There is no significant main effect of treatment on pre-service teachers'

(a) Achievement in cell Biology
(b) Interest in cell Biology

H_o2: There is no significant main effect of problem-solving ability on pre-service teachers'

(a) Achievement in cell Biology
(b) Interest in cell Biology

H_o3: There is no significant main effect of cognitive style on Pre-service teachers'

(a) Achievement in cell Biology
(b) Interest in cell Biology

H_o4: There is no significant interaction effect of treatment and problem-solving ability on pre-service teachers'

(a) Achievement in cell Biology
(b) Interest in cell Biology

H_o5: There is no significant interaction effect of treatment and cognitive style on pre-service teachers'

(a) Achievement in cell Biology
(b) Interest in cell Biology

H_o6: There is no significant interaction effect of problem-solving ability and cognitive style on pre-service teachers'

(a) Achievement in cell Biology
(b) Interest in cell Biology

H_o7: There is no significant interaction effect of treatment, problem-solving ability and cognitive style on pre-service teachers'

(a) Achievement in cell Biology
(b) Interest in cell Biology

1.5 Significance of the Study

It is expected that this research provide NCE students the needed information that achievement and interest go hand in hand to achieve the objectives of biology education programme stipulated in the minimum standard by the NCCE for CoE. The

study's findings would also give numerous scientific educators and researchers the necessary empirical knowledge of the efficacy of these approaches to teaching science. The template of instructional guides produced in this study, in particular, would aid Biology educators in instructional delivery by employing interactive invention and puzzle-based instructional strategies in topic teaching in schools and institutions. The findings would additionally provide the learners with a basis from which to interact and use puzzles on a particular topic and prepare for different class activities. This would help them further practice problem-solving and information sharing. The results of the investigation would reveal to both the NCE student teachers and lecturers on the benefits of using hands-on activities that will improve students' interest in biology by awakening in them the curiosity to explore related areas.

The findings would also give lecturers of education science courses (biology) helpful information on essential abilities needed as a teacher and how to make teaching more vivid and adaptable, increasing students' interest. The findings would enable curriculum planners to include the use of the interactive invention and puzzle-based approaches stated by the NCCE minimum standard for CoE for the NCE programme in Nigeria. Finally, the government at all levels which offers science and technology education to people will benefit from this work since it would supply them with sufficient details on how to provide quality STEM education to its citizens using efficient methods of instruction and learning which encourage creativity and collaboration in learning.

1.6 Scope of the Study

The study was delimited to three federal CoE in Southwest Nigeria. It is also delimited to BIO 112 course called the Cell Biology course offered at NCE 1 level in these federal colleges. The study examined the effect of interactive invention and crossword puzzle-based instructional strategies, and NCE student teachers' cell biology achievement and interest in Nigeria's southwest. The problem-solving ability and cognitive styles as moderating effects were also considered on its effect on achievement and interest.

1.7 Operational Definition of Terms

Crossword Puzzle-based Instructional strategy: The technique is an activity-based approach to learning that offers learners the opportunity to utilize the course materials,

encourages student conversation, and permits the exploration of ideas via questions. It further emphasizes students collaborative and interactive approach through brainstorming, presentation of group submissions, and the teachers critical and elaborate expansion of the concept learnt as outlined in the Instructional Guide for Crossword Puzzle-Based Instructional Strategy (IGCPBIS).

Interactive Invention Instructional Strategy: the technique is used for teaching both concepts and skills by integrating the instructor's explanation with learners' practice, creativity, and feedback to educate diverse concepts and skills. It also stresses engaging high student-materials, student-student, and interaction between students and instructors by assessing the learners' prior knowledge. Handing out worksheets, outlining the concepts and skills to be learned, supervising influenced and individual practice that will lead to learners identifying scientific information, and assessing newly acquired skills and knowledge as outlined in the Instructional Guide for Interactive Invention Instructional Strategy (IGIIIS).

Pre-service Teachers' Achievement in Cell Biology: This is the content and body of information which future educators are required to gain in a cell biology test, as measured by the Pre-service Teachers Achievement in Cell Biology Test (PTACBT)

Pre-service Teachers' Cognitive style: explains a person's mental disposition, which reveals how they think, learn, and process information when three pictures are presented and then asked to write, how two of those pictures are related. Their responses are then categorized as Analytical and Non-Analytical as measured by the Pre-service Teachers' Cognitive Styles Test (PTBCST)

Pre-service Teachers' Problem-solving Ability in Cell Biology: It involves the ability to thick critically concerning issues by proffering solutions to diverse challenges in cell biology as measured by the Pre-service Teachers Problem-solving Ability in Cell Biology Test (PTPACBT)

Pre-service Teachers' Interest in Cell Biology: This describes students' expression of dislike or like and negative or positive disposition to learn or be involved in the study of cell biology concepts as measured by the Pre-service Teachers Interest in Cell Biology Questionnaire (PTICBQ).

Learning Outcomes: This describes the expected results of the treatment administered on the pre-service teachers for a period of 8 weeks. It is categorised into achievement and interest in Cell Biology.

CHAPTER TWO

LITERATURE REVIEW

This chapter identifies some available research works and opinions of some scholars to enhance a sharp scholarly focus on this study. The review is divided into the following sections as shown below.

2.1 Theoretical Framework

2.1.1 Constructivist Learning Theory by Jerome Brunner

Bruner (1960), states that the intelligent mind develops an experience that is a generic coding structure, which permits an individual to move above the given facts to novel and potentially successful predictions. As a result, as young children develop they must learn specific techniques to demonstrate the frequent patterns in their world. Bruner's theoretical framework incorporates the core assumption that instruction is a dynamic procedure in which students acquire novel thoughts or ideas from their current or previous expertise. The student selects and modifies knowledge, creates predictions, and makes conclusions while relying on an intellectual structure. An intellectual framework, such as a cognitive model or schema, may help people see the significance and order in their experiences and help them rise beyond the knowledge that is given to them. When it comes to education, the teacher should try to motivate students to discover topics on their own. Active discussion between the instructor and the student is ideal (also known as Socratic learning). The instructor must modify the material to be studied in a way that is appropriate for the student's present comprehension level. The curriculum of the school must be set up in a spiral fashion so that students may build on what they have already learned (e.g. Learning style).

Bruner’s (1966), describes theory of instruction to cover four key areas: learning nature, ways to organise a body of knowledge so that it can be quickly understood by the learner, the best order to present material, and the type and pace of rewards and punishments. Knowledge structuring approaches, that are effective should result in information simplicity, the production of new ideas, and the ability to adapt and extend information. Bruner's key learning outcomes include not just the capacity

to invent the culture's built ideas, categories, and problem-solving procedures, but also the ability to construct these ideas. Brunner believes that the purpose of education should be to generate pupils who can learn on their own. (Alternatively, to put it another way, learning to learn.)

a) Instruction must be engaged not only with experience but also with the circumstances that motivate and inspire students to learn – readiness (Bruner, 1960).

b) Instruction must be layered in a way that allows the learner to quickly understand it – spiral organization (Bruner, 1966).

c) Teaching is supposed to be structured to aid inference by filling gaps – exceeding the knowledge provided (Bruner, 1973).

Bruner gave three aspects from studying children's growth with respect to cognition:

1. Action representation (Doing)
2. Iconic representation (photo)
3. Symbols representation (verbal)

Bruner was of the opinion that when new information/material is given to a learner, the trend of understanding for the learner is to direct it from enactive, then move it to iconic, before adding words to it; he also stated that this can also be applied to grown-ups to this day. Bruner study further states that when an individual at any time can get any knowledge when given the appropriate instruction/training.

Three representation modes by Bruner

Bruner stipulates that this refer to piece of knowledge that remains and retains in the memory of an individual. Contrary to others who ordered stages based on age, this type of illustration are incorporated and are loosely sequenced as it transforms into itself.

Action representation (Enactive) (before age 1)

It is the earliest form of memory. It is used when the child is just one year old. Babies are able to learn when the do it when compared to rather than illustrating it internally because physical action (or thinking) is fully dependent on thoughtful. It has to do with encrypting and keeping kinaesthetic knowledge based recollection in our

brain. A child could remember when a rattle is shaked to be stored as movement in the memory. Other kinaesthetic actions like when being tutored on how to ride a bike, keeps on as the child grows. Many persons are capable of motor actions that are challenging to communicate in graphical or representational (word) form (such as typing, sewing a piece of clothing, or operating a mower).

Photo representation (Iconic) (between age 1 to 6)

Knowledge is represented in the brain in form of photos (icons), most especially the ones they see. There are people that are aware of this and to some there are not aware, to explain this, when diagrams or photos of the concept being taught comes with words helps some learners understand better. Things like touch, smell, or hearing as a form of photo representation also gets used during thinking.

Symbolic (above age 7)

It represents the final stage of development. Here the knowledge, such as language, is stored in different forms like symbol or code. The symbolic stage is acquired between the age six to seven (matching the concrete operational stage of Piaget). The information is generally arranged, in the brain in forms of word structure, numerical symbols, or lines from music and stored during the symbolic stage. At this stage the information stored are adaptable because it can be changed, arranged, categorised etc., allowing the individual to be unconstrained by the various visual information or actions (They are inextricably linked to the thing they symbolize).

Bruner (1960) questioned Piaget's concept of preparedness. He claims that educational institutions lose time attempting to match subject matter difficulty with the developmental phase of a child. It entails that teachers hesitate because some topics are judged too tough for them to grasp and must only be presented at the time the instructor feels the learners have the appropriate intellectual growth to grasp the information.

Discovery Learning

Bruner (1961) stated that learners build knowledge by arranging and classifying facts using a system of coding. Bruner thought that establishing a system of coding was the greatest approach to establishing one's learning rather than being told by a teacher. Students produce their own knowledge, according to the principle of learning by discovery (constructivist technique). It is important that information should

not presented to the learners through rote; it is the responsibility of the instructor to back the process of learning with appropriate instructional materials. This means an instructor prepares lessons in the form that helps learners to connect the information together. To achieve this, instructors should give learners adequate information that will enable them have an understanding but let them arrange them on their own. The learning as a discovery is harnessed with the spiral approach of the curriculum.

Although as commonly acknowledged that the objective of education is not to convey information, it is utilized to enhance a child's problem-solving and cognitive skills, which may subsequently fit into diverse circumstances. The centre of Bruner's study is that learners should actively participate in class as it helps them develop the right knowledge. Bruner believes that no matter the difficulty level of any concept any child can understand any concept effectively when presented to the child in a way he would understand through an honest approach can be done at any developmental age. The notion of a spiral curriculum was used to explain how this was feasible. The approach is that less difficulty concepts are presented first, before being introduced to the difficult topics later. Bruner then suggested that subjects would be delivered in a way it moves from the less difficult aspects to the most difficult areas (spiral approach). Nevertheless, when information is done through this approach it leads to learners being able to solve personal problems.

It is important that students get their information by unifying and categorising the material through a coded system. When one discovers the information by themselves instead of the instructors handed it across, it is the best approach. As a result, learning as a discovery includes how students own knowledge is developed (which is referred to as the constructivist method). He pointed out that the teacher's job is not to impart knowledge through rote; however, the instructor should handle the process of learning effectively. Accordingly, it is anticipated that an excellent instructor is expected to have diverse lessons that helps learners figure out the connection that exist in the information given. For it to be effective, the instructor is expected to provide adequate information in an unorganised format (McLeod, 2019).

How does this theory support this study? This theory supports interactive invention strategy, crossword puzzle-based strategy, achievement, cognitive style, and process skills. According to this phrase, the intelligent mind generates an experience that a general coding system allows one to move beyond the given facts to new and successful predictions. This theory supports the interactive invention instructional

strategy under Bruner's discovery learning. In the interactive invention strategy, learners are expected to construct their knowledge by interacting with others and the materials in the group. Bruner believes that a learner should not be given all the information, but should discover it on their own. This collaborates what steps are taken when engaging students using the strategy. This theory supports the crossword puzzle-based instructional strategy under Bruner's discovery learning. In crossword puzzle-based strategy the students are given clues to factor out the answer by discovery. According to one of Bruner's pedagogical implications, the goal of education ought to be to develop independent learners (learning to learn). This collaborates with the steps used when engaging students using the crossword puzzle-based strategy.

This theory supports students' cognitive styles. Bruner's three modes of representation that students learn using enactive, iconic, and symbolic represent how students learn based on what they see, manipulate, classify, etc. This translates to how they can differentiate and relate the different pictures shown when dealing with cognitive style photos. Thus, showing how analytical and non-analytical there are when shown different photos. This theory supports students' achievement. Bruner's three modes of representation that students learn using enactive, iconic, and symbolic which represents how students learn based on what they see, manipulate, classify, etc. This translates to their knowledge of the subject or course. Thus, leading to their achievement in the course or subject. Lastly, this theory supports students' interest in Bruners' discovery learning. In Bruner's discovery learning, interest is strengthened when one can discover a piece of information by ones' self. By so doing you will want to get more information when there is an interest or when one is trying to solve or a problem, to even solve the problem the individual must be interested. Therefore, this aligns with the students' interests which leads to achievement.

2.1.2 Problem Solving Model of Ashmore, Frazer and Casey

Ashmore, Frazer and Casey in 1979 suggested a four-phase (logical) model which aids in solving problems in chemistry and science. They stated that to be able to solve problems one should combine: a solid background information of the issue, the required materials and tools needed to solve the problem, be able to fuse the information gotten to solve the problem and assessment. The figure below shows the stages and comments of problem-solving ability.

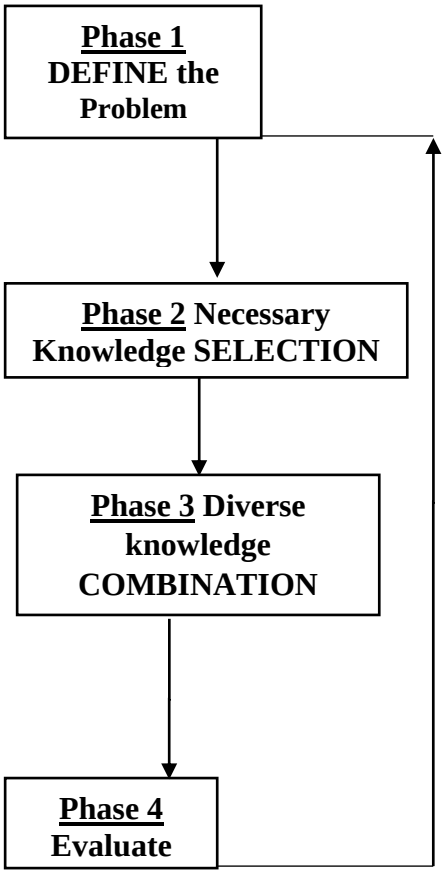
Problem Solving Phases	
Phase	**Comments**
	i. There are failures because people do not understand the aim. ii. Since problems are in sentences. It is better to restate it to have one or numerous questions. iii. There are always needs to rearrange the problems into bits of fewer issues. There is a need to rotate this with phase 3. As you make progress, important biological knowledge might be added so it becomes clear to the individual. i. Problems no matter the size needs merging two knowledge (E and F) to arrive at G solution. ii. Several issues would need a network of issues to reach a conclusion. How the issue is arranged (see phase 1 under comment (iii) gives direction on how to draw the diagram. iii. You rotate phase 2 and 3 until you reach a solution. Always confirm your solution by: (i) Checking that you have solved the issue stated in phase 1: and (ii) Checking that the stated problem conforms to the given information.

Figure 2.1 – The Problem-solving Model by Ashmore, Frazer and Casey 1979

To solve a problem, the individual utilizes these four stages from the model to solve it. The first stage is to define the problem where an individual defines what he/she is trying to solve. Then proceed to stage two, which is to select appropriate information that will enable him to come up with a plan. Stage three is where you combine the separate pieces of information and come up with a plan on go-ahead to execute the plan and lastly stage four has to do with evaluation whereby the executed plan is accessed to be sure it solved what it was supposed to solve.

2.2 Conceptual Review

2.2.1 Cell as the foundation of biological concepts

One of these courses called cell biology covers the following topics: cell and its theories, flora and fauna cells structure; protoplasm together with its properties, Physical processes of the cell like osmosis, diffusion, plasmolysis, haemolysis, and so on; and the cell division, which involves mitosis, and meiosis, where it occurs and its significance to living things. This content has various benefits to the student's understanding of other courses, as it is the foundation of the biological sciences to solving various societal issues. This is why the concept of cell biology is taught at the NCE 1 first semester to help improve the understanding of the other concepts taught at NCE 1 up to NCE 111 levels, respectively (FRN, 2012).

Cell Biology deals with the study of cell structure and its functions; this encompasses the aspect of the cell which is the functional and basic unit of life (Idodo-Umeh, 2011). Cell biology (BIO 112) is a course taught with the following aims and objectives: give students' proper understanding of the cell and cell theory, brief history of cell, comparison between animal and plant cells using their constituents, linking the processes of cell to the real world and understanding the benefits and significance of mitosis and meiosis to all living things. One of the objective include going to new areas for future studies and these new areas include forensic science, microbiology, biochemistry, biotechnology, medicine, pharmacy, biomedical engineering, cytology, and so on (FRN, 2012). In the field of forensic science, the knowledge of cell biology has been used in solving murder cases by using cells such as blood, hair, fingerprints, sperm and so on to carry out a genetic test. Because there are so many rapes, murder, and kidnap cases going on in the country, cell biology knowledge can be used to curtail these crimes. Many crime cases have gone unsolved because forensic science

courses have not been fully utilized in the country. This need must be amplified by teaching cell biology in a way that emphasizes the benefits/usefulness to the society by curtailing these issues.

Many courses and occupations in the biological, medical, pharmaceutical, medical laboratory science, and other related fields are built on the foundation of cell biology. For instance, paternity fraud has been going on in Nigeria for decades now without sufficient answers. To find out a potential father of a child, a swap of the cheek cell is taken from the man to run the DNA test, the same will be done to the mother in case there is a tussle between two mothers (Idodo-Umeh, 2011). The approach taken to teach this concept of cell should be that the students fully understand and can apply it to solve daily life issues. The students may develop interest in studying genetics at the degree and graduate degree levels respectively.

The understanding of Basic biological principles such as osmosis and diffusion will show case its connection to environmental education. For example, to dig a borehole one should understand that it should not be drilled near a soak-away pit. Reasons being that the faecal remnants might diffuse into the borehole, producing a contaminated water. Contaminated water can cause the following diseases: cholera, dysentery, food poisoning, typhoid fever, and other ailments. To solve this, drilled boreholes should be located far away from the soak-away pit so as not to contaminate it (Idodo-Umeh, 2011). Teaching cell biology and linking the knowledge of osmosis and diffusion to real life issues will assist in the decision making as to why these boreholes should not be situated close to the soak-away. It is worthy of note that boreholes should not be situated near an industry as industrial waste such as lead may diffuse into it causing lead poisoning. In the Niger-delta for instance, it should not be drilled near oil companies as oil could spill into the borehole thereby causing serious ailments or death. With these understanding the 2nd and 4th objectives of the NCE biology education programs at the college level would have been met.

Amplifying the benefits of understanding the concept of diffusion in the areas of where to locate the comfort rooms (toilet and bathroom). These comfort rooms should be located far away from the kitchen and dining rooms because the smell from the toilet can diffuse into the kitchen and dining rooms, and these could cause some people to vomit or lose their appetite. These women and girls should avoid using a toilet that has urine or faecal leftovers, which have not been flushed and cleaned because it could evaporate and diffuse into the private parts and cause serious health

problems to the woman (Idodo-Umeh, 2011). Based on the benefits of cell biology stated earlier, the importance of cell biology cannot be overemphasised; as it is the foundation of understanding other concepts in the biological sciences and assist people to solving real life issues. Therefore, the performance in the cell biology course (BIO 112) at the college of education is of immense interest in this study.

2.2.2 Interactive Invention Instructional Strategy (IIIS)

Ukoh (2012) identified IIIS as an approach used for teaching students various abilities and concepts. In the teaching of ideas and procedural skills, it involves the mix of the instructor's description and demonstration with learners practice, creativity, and response. When using an interactive invention technique, learners are required to be proactive in answering the teachers' queries, examining the examples given, and practising skills until they can be employed with minimal cognitive effort. The researcher reported that the interactive invention technique yields higher performance on assessments of elementary abilities more than other approaches. As stated by Ukoh, the interactive invention technique comprises the utilization of continuing modelling by instructors, which is typically followed by less restricted teacher participation and reduced involvement from instructors as students begin to grasp the content. According to Ukoh, 2012, Ogunbowale, 2014, Onifade, 2017, Ukoh and Onifade 2020, the application of the interactive invention technique has helped improve the achievement and practical skills of NCE teachers in higher institutions and students in secondary schools respectively.

Futhermore, Ukoh's (2012) research on NCE students in physics in CoE in south western part of Nigeria showed that interactive invention strategy was found to be effective and proved to affect the performance of the NCE teachers when compared with counterparts in the control group. Ogunbowale's (2014) research on the impact of problem-based approach and interactive invention techniques on the performance of biology learners found that interactive invention technique improved on learners performance in biology though problem-based instruction performed better scores when compared to those in interactive invention. Okurumeh's (2016) research on the discussion and invention technique on the performance of students in chemistry showed that students in invention approach had better retention scores than those in the discussion and traditional methods. Since the two studies carried out by Ukoh and

Okurumeh were in physics in colleges and chemistry in secondary schools; the researcher examined this research at the tertiary level in biology.

2.2.3 Crossword Puzzle-based Instructional strategy

John Spilsbury conceived the puzzle instructional approach in the year 1760. A puzzle-based instructional approach is activity-based, which gives learners advantage to interrelate with the instructional resource, promotes collaborative engagement within the learners and permits examination of abilities using questions (Umoru, Adejoh, and Iji, 2016). Farlex, 2009 in Umoru, Adejoh, and Iji (2016) stated that puzzle is a form of game that needs the player to be ingenious and persevere to solve problems. They do these by utilizing puzzles in the process of instruction is effective with diverse styles of learning exhibited by learners in class. The use of puzzle has shown potency in exciting and maintaining learners' interest in the instruction and produce new strategies to understand abstract concept.

Michalewicz and Michalewicz (2008) stated the various criteria for effective use of good educational puzzles and these include Generality has to do with explaining selected world-wide principles of solving problems. The approach allows people to solve problems that may emanate in the future with the support of the instructor with the introduction and application of problem-solving strategy. Being Simple implies that the problem should be simple to explain and recall which increases the likelihood of recall. Michalewicz and Michalewicz stated that the Ureka factor ought to ignite your curiosity because the outcome is counter-intuitive. It is attained when the proper solution to the riddle is identified. As a result, it should have simple answers that are not evident. The entertainment component should be considered because it is simple to lose interest if it is not entertaining. Puzzle-based approach was defined by Michalewicz and Michalewicz (2008) as the learning that is characterised by difficult, unrestricted tasks; learners engage in small teams, and instructors serve as guides of the instructional process. Michalewicz and Michalewicz stated the importance of puzzle use in education and it helps to persuade learners to see: the useful and interesting part of science; the elementary subject taken are important and it fulfils be in school, get a degree, continue to the society with several problems. Often times students do not appreciate the topics taught to them when still in school; as a result, they cannot connect this topics with societal issues and therefore loose interest (Michalewicz and Michalewicz, 2008).

In recent times, there is a great shift from teacher-dominated classes to student-dominated teaching environments where learners take charge of their learning and the instructor is just to guide the learning process (Derer and Berkant, 2019). However, when foreign languages are taught with the use of puzzle, it serves as an instrument that enables instructors enhance the classroom environment with exciting activities with engages students with difficult and abstract concepts as well (Vaishnav, 2015). When puzzle is used it helps learners develop critical thinking skills. The strategy's objective is to encourage learners to reason various angle to solve the various problems. The plan is to inspire the learners and improve their ability to solve problem through brainstorming the problems given and diverse a means to solve the problem (Meyer, Falkner, Sooriamurthi, and Michalewicz, 2014).

Puzzle-based approach can be utilized at different educational level as well as diverse programmes was shown to have been used in the teaching of languages, mathematics, engineering and other sciences and so on (Derer and Berkant, 2019). The utilization of puzzles improves both the student's ability to solve problems and their abilities to reason critically; however, it improves students' engagement and participation in the classroom. Derer and Berkant gave two motives for the need to include puzzle approach in the curriculum: Puzzles have their aims without relating them to anything and are naturally fun. Puzzles are invariably natural tools, which is utilized to improve abilities that include individual thinking and ability to think critically which forms the foundation for the development of the ability to solve problems that is entertaining. A puzzle instructional strategy as been integrated into the curriculum citing that the lecture method may not give the learners the needed activities to develop skills, experience, and rehearsals to increase their ability to solve problems (Meyer *et al*., 2014).

One importance of puzzles is that solving them by rote is not possible; puzzles are the best bet in making students brainstorm (Thomas, Badger, Ventura-Medina, and Sangwin, 2013; Klymchuk, Thomas, Gulyeav, and Evans 2017). Also that the process of instruction more or less cannot keep the learners active in the learning process so as to keep them interested in the learning.. According Adedoja and Fakokunde (2015), puzzles are an excellent approach to introducing novel concepts to learners and getting them enthused about learning novel concepts and ideas. They identified a number of applications for puzzle-based techniques: incorporating classroom resources,

introducing fresh concepts, displaying procedures, manipulative skill testing, problem raising and novel research.

2.2.4 Conventional Instructional Strategy

The lecture method as a teaching method is criticized mostly because it is still used even in a period of technological advancement among educators. Also, the method is still in use in colleges and universities as the means of instruction in these higher institutions (Kuar, 2011). Abimbola (2013) reported that science in Nigeria from primary to secondary schools is mostly taught using the lecture method. Auta and Maigari (2018) opined that the traditional approach when used in the process of instruction of science employs the use of talk and chalk method in delivering instructions. It is a teacher-centred method in which a little above 79% of the knowledge, facts, concepts, laws, and generalizations will be instructed to the learners using verbal means by the instructor. This is because the teacher speaks while learners are either passive or not actively engaged in the educational process.

There is no opportunity to pose questions or provide comments, rather the teacher speaks and makes notes for learners to scribble down. As a result, this kind of learning does not boost students' knowledge of science. Science is learnt in most post primary schools in the country using the conventional approach, which has proven to be ineffective and has a poor success rate (Abimbola, 2013). Ogundiwin and Ahmed (2015) stated that the use of the conventional approach does not improve students' understanding of science at all levels. However, Olatoye and Adekoya (2010) research showed that when the lecture method is employed it is ineffective in the science educational process. Muhammad and Sabiru (2016) compared science skills, approach and traditional method and report that the former was better in improving students' achievement in chemistry. They started that lecturers in CoEs should employ activitybased and students approach to teaching to improve on students achievement in chemistry and other science related fields.

2.2.5 Students Achievement in Cell Biology

For many years, instructors of education, policymakers, and education stakeholders had been deeply concerned about students' academic performance in biology and cell biology. The course's curriculum material is meant to give biological content that will fulfil the demands of the learners and society as a whole (Wei and Pecheone, 2010; Arum, 2019). Aina's (2013) research shows that students understanding of the diverse subject content has declined, particularly in the courses related to science at higher education institutions in Nigeria. They questioned how practically effective is the performance-based assessment in higher education. It was reported by Ali, Toriman and Gasim (2014) that there is a persistent decline of students' performance in biology and in extension cell biology in the past years. Another study by Owino, Osman and Yungungu (2014) reported some factors such as insufficient source of instruction resources in the form of models, charts and apparatus as difficulties that led to the poor achievement in Biology/Cell Biology. A further consideration of the student teachers' performance in Cell Biology at the CoE selected revealed poor performances as indicated in table 1.1. It revealed that the achievement of the student teachers in BIO 112 (Cell Biology) from two federal and two state CoE in Nigeria's' southwest for a period of five sessions.

The table 1.1 depicts the achievement of pre-service teachers who offered BIO 112 – Cell Biology in four Nigerian colleges of education for five sessions (2014/2015 to 2018/2019). It further indicated the percentages passes of pre-service teachers' who offered cell biology even at an ordinary pass category varied and even fell below the national average. A review of their performance reveals that in nearly all of the colleges studied, some students scored E (40-44) and F (0-39), accounting for roughly 40% to 50% of total student performance. Students' dismal performance in the assessed Colleges of Education needs immediate intervention. The external moderator's evaluation noted that students' performance should be improved, as poor performance can be ascribed to large courses and the lecturer utilising the traditional approach to instructing cell biology.

In place of this, the moderator also proposed using activity-based techniques in delivering the course to increase performance, emphasizing that when lecturers use a teacher-centred approach, students will miss out on hands-on activities that would have reinforced the learnt concept. As a result, individuals would recall only a small portion

of the information presented, which has implications for the concepts' interpretation and possibly comprehension (Danmole, 2012). Olagunju and Babayemi (2014) asserted that when good strategies are lacking in the process of teaching difficult or abstract concepts, this has implications on the students' performance, as such, this will scare students away from studying biology and biology-related disciplines.

To further support the status of cell biology as a difficult course for pre-service teachers, the researcher requested lecturer's views on the difficulty level of cell biology course in 1st semester for NCE 1 see figure 1.1. Figure 1.1 shows the lecturers' perception of the difficulty level of NCE 1 first semester courses, and the results reveal that 52.17% of the teachers regard BIO 112 as a course that is not difficult. On the other hand, 34.78% and 13.04% of lecturers considered the course as difficult and highly difficult respectively. Given the closeness of the perception of difficulty (52.17 not difficult; 47.83 difficult) and the poor achievement of the student teachers' as indicated in table 2.2 calls for concern. Perhaps, lecturers who agreed to the difficulty did so based on students' performance, whilst those who considered the course not difficult did so based on the content's simplicity. The conflict that exists between the simplicity of content and student performance questions the teacher-centred strategy that is widely used for instructional delivery at this level (Muhammad and Sabiru, 2016). Although, pre-service biology teachers are not eligible to impart natural science at the post junior level after graduation, the BIO 112 material is required content to teach Basic Science in the Junior basic school. The course is required for basic biology literacy for a graduate of NCE and it will provide a solid foundation should they want to study Biology in higher education. Studies such as Adekunle and Femi-Adeoye (2016), and Fakolade (2019) have shown a link between interest and achievement, therefore interest is the second dependent variable considered in this research.

Various influences were listed as the reason for the poor achievement and a lack of interest in cell biology. These include the use of a teacher-centred approach/strategy in the teaching of cell biology, fewer hands-on activities, the usage of insufficient instructional approaches in teaching challenging concepts, less student participation and so on as stated in the moderator's report from the colleges of education. Different scholars and researchers have attributed various factors to the lack of interest and poor achievements in Natural science and some associated sciences that cuts through diverse categories of schooling. There include biology content that is overloaded, nonconcrete, and having biology textbooks difficulty (Akingbemisilu,

2017), usage of insufficient instructional approaches for grasping challenging concepts (Okoye and Okechukwu, 2010; Mohammad, Gambari and Ibrahim, 2019), lack of appropriate teaching strategies to teach abstract concepts (Olagunju and Babayemi, 2014). Negative attitude to science (Adeoye, 2011; Tella, 2013), inadequate teaching material or resources, and practical workstations (Aremu and Sangodoyin, 2010; Omilani, Akinyele, Durowoju and Obideyi, 2018), poor success rate when lecture method is used (Ogundiwin and Ahmed, 2015) and insufficient practical skills (Danmole, 2012; Olagunju and Babayemi, 2015).

2.2.6 Interest in Cell Biology

When individuals learn, curiosity is a powerful motivator where if learners lack interest, they will be unable to study successfully because nothing will motivate them to do so (Jakel, 2014; Ates and Saylan , 2015; Gheith and Aljaberi, 2015; Serafin, 2016). In a study by Nwafor and Oka (2018), they indicated that girls had an increased interest in biology and biology related concepts than boys. A study by Fakolade (2019), reported there existed a link between the mean interest rating and mean achievement scores in biology. A separate research by Adekunle and Femi-Adeoye (2016), reported a significant link between students' achievement and interest in biology. Knekta, Rowland, Corwin, and Eddy's (2020) study revealed that students' interest is low at the secondary school level but may tend to increase especially on human biology related courses maybe due to their personal health issues. Holsternmann, Grube, and Bogeholz's (2009) research on activities that are hands-on and its effect on students' interests showed that hands-on activities affected students and were able to influence their interests differently. They argued that hands-on activities should be designed around activities that can influence interest (Khatoon, Alam and Bukhari, 2014). Biology students' interest inventory in secondary schools revealed that when students were asked the extent to which they will choose a cell biology-related career as one of the items, it revealed that most students chose a very small interest in a cell biology-related career. As such if the trend goes on there will be fewer candidates and experts for courses or fields related to biology, and cell biology or cytology in the future (Nwafor and Oka, 2018).

Awoden, Adekunle, and Femi-Adeoye (2016) defined interest as one's feeling of concern or curiosity towards something that catches the attention. Question grid for interest employed for this study, is adapted from Yulinda and Ilma (2018) research,

and it includes learners developing an interest in the learning of science; keeping learners attentive in the science classroom. Student learning activity; preparation of students' learning; having a record of all materials used and being able to summarize learnt materials; getting their views in the testing process, the ability of the lecturer to teach effectively and the result of the learning process. Yulinda and Ilma (2018) used it in their research and found it to be effective as it showed that students' interest in a botany related concept called morphology of plants showed it to be ranging from medium, high to very high. The lack of interest in biology and cell biology has been shown in the achievement of learners in BIO 112 (Cell Biology) taken at different CoEs in Southwest. The poor achievement in the course can be attributed to a lack of interest in biology and cell biology. Which hinder the lecturers and the school of science in actualizing one of the aims of the biology programme, which indicates by the end of the course, graduate teachers of the NCE education should apply the various abilities and learned procedures in fresh ideas and handling daily life situations (fakolade, 2019).

2.2.7 Problem-solving Ability of Student Teachers

Temel (2014) defines problem-solving ability as a process where an individual prevails against the barriers encountered in reaching the target. An issue is said to be a problem as far as the person involved does not have an idea on the way forward, and problem-solving is utilized when an individual does not have any atom of idea on ways to tackle issues. The ability to solve problems therefore aligned by the principles and feedback from an individuals' problem-solving skills as far as issues bothering the environment transpires through an individuals' problem-solving ability. Evaluating one's self regarding how to cope with issues is of immense importance in this regard. It is an approach that assists teachers in self-learn meaningfully as well as assists them in the teaching of the students with proper education knowledge. Teachers build on their problem-solving abilities in other to teach the students using their daily life-related issues. When they handle their issues they can as well show the students how to solve their problems (Gezer, 2015).

Individuals who have acquired the solving problems ability tend to be very sure and self-reliant in their thinking which enables them to handle problems constructively as well as producing adequate cognitive attitudes. Having acquired this knowledge the

students can design channels to solve these current issues which indicate they are at the breast with the problems, proffer probable solutions, incorporate valuable plans and evaluate the outcome (Fitriani, Zubaidah, Susilo and Muhdhar, 2019). The researchers observed that Indonesian learners performance are low in problem-solving and stressed that those students identified in different countries. This implied that they couldn't solve problems because it could be the type of learning used that does not improve or strengthen the problem-solving ability which does not give them space to make use of these ideas which affects finding lasting solutions to the problem. Temel's (2014) work on pre-service teachers' perception of problem-solving showed that students had a medium level of problem-solving as well as problem-based learning and traditional method having a different effect on the way they view the problem-solving approaches. The findings of Karademir (2019) on problem-solving skills showed that it was above the middle value. Based on these studies, it shows that the problem-solving ability in secondary schools is on the median level. As a result, there exists a need to assess the present state of problem-solving abilities among learners in colleges and universities.

The problem-solving ability test follows the Ashmore, Frazer and Casey 1979 problem-solving model. This model has four steps/parts: problem definition, information selection, information combination and evaluation. The problem-solving ability test is a researcher-made test that will be structured based on these four steps. Four different scenarios are inputted into the instrument and responses sort for each of the scenarios using the four steps. The scenarios include narration on tree grafting as one, a narration on an accident scene between a motorbike and a car as two, a narration on a man peeling an orange and injuring himself with a knife as three and a narration of a mango tree with children pushing nails into the tree trunk. Each of the questions will require a short answer response.

2.2.8 Cognitive style of Pre-service Teachers

Definitions, Dimensions and Studies on Cognitive style

Aydin (2015) stated that cognitive style was a concept first formed by Allport in 1937. He stated that a person has a particular style of arranging and retrieving information. He submits that cognitive styles refer to a person's way of responding to diverse situations and it has to do with a person's way that categorises their problem solving, reasoning, recollecting, and perception styles. Ukoh and Orefuwa (2016) defined cognitive style as fairly-fixed characteristics of a person that can be fixed and somewhat inert abilities in an individual. Ukoh and Orefuwa (2016) defined cognitive style as a steady approach, favourites, and attitudes that more or less controls an individual way of getting, recalling, and solving problems. Tella, Adika, and Toyobo (2008) noted that cognitive style is critical to evaluating learner achievement and a major predictor of future performance. More so, Hong, Hwang, Tam, Lai, and Liu (2012) stated that cognitive style is an individual's attributes that encompass combining an array of cognitive controls and that cognitive style could have an effect on achievement and students outcomes based on their problem-solving.

Many aspects of cognitive styles have been postulated throughout the years, some of which are:

1. Field dependence – independence
2. Levelling – Sharpening
3. Reflection – Impulsivity
4. Sensory – Intuitive
5. Analytical – Global/Non-analytical

Ige (1998) opined that cognitive style has been discovered to be bipolar as a dynamic indicator of students' character. This nature demonstrates that persons in each dimension have a high level of some qualities and a low level of others. This bipolar nature does not assign any value judgment in terms of 'good' or 'bad' features to pole, as each pole contains characteristics that might be helpful in certain situations. Under particular learning situations, such features have been shown to benefit students' learning. The main features of the different dimensions are briefly highlighted based

on the aforementioned cognitive style categorizations. In literature, there exists a range of dimensions of cognitive style adopted by different researchers. These include: field dependence-independence, levelling-sharpening, reflection-impulsivity, sensory-intuitive, analytical-global/non-analytical categorizations.

1. Scholars such as Hong, Hwang, Tam, Lai, and Liu (2012), Aydin (2015), Idika (2017), Altinta and Gorgen (2018), and Hussin, Razali, and Agussalim (2021), adopted the field Independent (FI) and Field Dependent (FD) cognitive style categorisation. According to theory, field independent learners can differentiate the aspects of a picture or photo surrounding from the complete (that is, the field) without stress and seldom concentrate on unimportant details. On the other hand, FD individuals are said to be persons who pay more attention to important and unimportant details.

2. Some scholars such as Kozhevnikov (2007) and Shi (2011) have researched on the cognitive styles based on levelling and sharpening. In this dimension, cognitive styles refer to participants' skill or degree of ability to notice similarities and differences between inputs. While levellers prefer to disregard or underestimate the distinctions between items for simplicity, allowing them to generalize more readily, sharpeners tend to maintain and highlight the differences, identifying various elements more clearly.

3. Individual variations in performance on tasks requiring a choice between various responses mirrored cognitive style in this domain. Kegan, Moss and Sigel (1963) classified pupils as 'impulsive' when they are quick to respond to a stimulus scenario and so make many errors, while those who are slow to respond and make few errors are labelled as 'reflective.'

4. On this instance, the cognitive style utilized may alternate between using facts available through the senses and using imagination and intuition to grasp linkages beyond the observable. The sensory style is

based on pre-existing knowledge, but the intuitive style is more focused on spontaneous processing and going beyond what the data has to give.

5. The cognitive style test by Kegan, Moss, and Sigel was developed in 1963. The revised edition by Awolola (2009) as used by Ogundiwin (2013) was adopted by the researcher for this study. The test instrument comprises cards numbered one to twenty. The test helps categorise learners based on how they reason and analyse a pair of photo of items commonly seen around like flora and fauna or artefacts so as to put them into categories. Three pictures in black and white are placed on each card, two of the pictures may have one thing or the other in common. The PTBCST was used to categorise learners into 'Analytical' and 'Non-Analytical' styles based on each student's responses about how they interpreted the photographs. Learners where instructed to pick two pictures from three and indicate how they pair relate to each other or connected. The students' responses about how they interpreted the photographs and grouped any two are divided into three categories;

    a. Analytical-Descriptive (AD)
    b. Categorical-Inferential (CI); and
    c. Relational-Contextual (RC).

Analytic Descriptive Responses

Learners are asked to group items collectively depending on their common features that are easily obvious. For instance, a postcard comprising a pocket watch, a woman, and a rule, responders might group a wristwatch and a man because "the woman’s skin and the wristwatch are made up of leather".

Categorical Inferential Responses

Respondents are expected to place together objects based on superordinate features, which cannot directly be visible (abstract), but assumed. For instance, respondents can place the metre rule and the wristwatch and state that “both are measurement instruments”.

Relational Contextual Responses

Respondents are to put pictures or photo given indicating the relative link that joins them together. It is important to note that the photo do not relate conceptually, however, can get explanation or understanding from each other. Therefore, it is of this note it was contextualised as analytical-global/contextual/holistic model of classification. For instance, respondents are expected to place woman and the metre rule; woman and wristwatch because, the woman uses the ruler to measure distance or length or use the wristwatch to check time.

However, the analytical and non-analytical cognitive style categorisations propounded by Kegan, Moss, and Sigel in 1963 is adopted for this study. Ige (1998) and Ogundiwin (2013) described analytical style learners as those who can distinguish objects or photos based on their shared attributes and superordinate features but weak on the relational link while global/non-analytical style learners distinguish objects or photos based on relational links but weak on shared attributes and superordinate features.

Results from Aydin (2015) on student teachers' when compared with cognitive structures towards technology and cognitive styles, implied that first level students with a FD could associate improved understanding when aligned to their counter-part on the FI learners. Idika (2017) reported on the cognitive style influence on performance of chemistry learners' and it showed FI learners had better mean score in achievement than those in FD cognitive style levels. Hong, Hwang, Tam, Lai, and Liu (2012) research on cognitive style showed that cognitive style relying on field independence could forecast scores based on digital jigsaw. In Altintas and Gorgen (2018) research intending teachers, in general, possess a field-dependent cognitive style showed genders of intending educators, academic success and cognitive scores showed no difference. Findings by these researchers show that it is inconsistent which then calls for this study.

2.3 Empirical Review

2.3.1 Interactive invention Instructional strategy and pre-service teachers' achievement in biology

Onifade's (2017) study on the impact of weekly formative assessment and pre-lesson assignments approaches on poor performing physics students' achievement and their habit when studying in Oyo. It was an quasi-experimental design with participants from low achieving students in-between the 201 SS2 physics learners gotten from 6 schools in Ibadan southwest LGA, Oyo state. 7 research instruments were used for the study. ANCOVA, EMM and Bonferroni Post-Hoc analysis were used. The treatment groups were exposed to Pre-lesson assignments and weekly formative assessment strategies and the interactive approach was taught to the control group. Results shows that treatment were found significant effects on students' achievements in physics. Students in treatment groups had better achievement when compared to those in the conventional group. It further shows interaction of the approaches and self-efficacy was significant on performance.

Nsofor's (2019) study on the impact of interactive and problem based approach on student teachers performance and practical skills in biology. The study adopted the pre-test posttest control group quasi-experimental design. The participants were 190 NCE III biology students from six tertiary institutions in southeast Nigeria. Seven research instruments were used. ANCOVA, EMM and Bonferroni was used to analyse the data collected. The results indicates the impact of treatment on learners' performance and acquisition of practical skills. It further shows the learners in problem based approach had better post-performance scores when compared to the learners in interactive invention approach.

Ukoh's (2022) study on the Interactive-invention approach and learners' performance in secondary schools in some physics concepts in Ibadan. Mixed method approach with a sample of one hundred and twenty-five students as participants in 3 secondary schools were used for the study. 3 instruments with the instructional guides and intact classes were used. The findings revealed that treatment had a significant impact on learners achievement in physics. Physics teachers were encouraged to embrace interactive invention approach in the process of instructing physics especially on electromagnetism concepts in physics.

Ukoh (2021) researched on interactive-invention approach on learners' learning outcome in some physics concepts. It utilized one hundred and twenty-five students from SS2 in 3 schools and quasi-experimental design was used. Experimental and control group with their intact classes were the sample and participated. Interviews and worksheets on physics concepts were used to collect data. The findings shows an improved achievement in learners' in interactive-invention strategy than the conventional strategy. An in-class interview should that students enjoyed learning the concepts as a result of the hands-on experience and preferred to be taught with interactive-invention instructional strategy. It was recommended that hands-on/activity-based strategies be embraced by instructors to improve the learning of electromagnetism.

Ukoh and Onifade (2020) researched on formative and pre-lesson assignments approaches combined with interactive invention approach on physics poor performing learners. The study used 90 SS2 learners and experimental design. Pre-lesson assignments Data were analysed using ANCOVA. Results shows treatment had significant impact on poor performing learners in some physics concepts. It also shows that those exposed to pre-lesson assignments had a higher achievement score, followed by formative, while interactive invention came last. Recommendations that teachers identify low achievers early by using combined strategies to assist them.

Ukoh's (2012) research on problem-based technique and instructional techniques based on interactive innovation on NCE Achievement of Physics students' principles and practical skills acquisition. The study employed the quasi-experimental design. Results were analysed using ANCOVA. Findings indicated that treatment improved on NCE students achievement in physics. It further indicated that interactive invention strategy was better than the conventional method. The two strategies were recommended for lecturers for use at the colleges of education.

Ogunbowale's (2014) study focused on the problem based and interactive invention approach on the attitude of biology learners. The participants comprised 201 SS2 biology students drawn from 6 co-educational and employed experimental design. The study utilized 3 instruments to collect data and teachers instructional guide was used for instruction. ANCOVA was used to test the 3 hypotheses. Results from the study showed a treatment was able to improve on the performance of learners in biology. Problem-based instruction improved the performance better, then the interactive invention and lastly by the conventional method.

Okurumeh's (2016) research on discussion method and invention techniques on retention of chemistry concepts. The study used 224 SS2 chemistry students from nine schools and employed experimental design. The instruments used for the study were 2 and an instructional guides. Quantitative data were caculated with ANCOVA while the significant difference was explained using Scheffe posthoc analysis. Findings showed treatment to be potent in improving learners retention abilities based on gender. The result showed that invention and discussion approach was able to improve learners' retention better than the traditional approach. The two strategies were therefore recommended for use in schools.

All the cited researches were carried out in physics to ascertain its effect on achievement on biology school students and at CoE physics programmes. It was also trial tested in school biology. The results shows that it improved on the performance of the learners. This study focuses on IIIS on students teachers performance in cell biology at the college of education level for the NCE 1 biology education programme.

2.3.2 Interactive invention Instructional strategy and pre-service teachers' Interest in biology

Ukoh's (2022) study on the Interactive-invention technique and the performance of students in some physics concepts in Ibadan. One hundred and twenty-five students comprised the participants gotten from 3 schools anchored on a mixed method approach. The experimental groups worked with motor/generator learning kits while the conventional approach was used for the control. Three physic instruments and a guide on discussion was used. Results showed the impact of the approaches on attitude and improve on their performance in the physics concept. Teachers in teaching various concepts in physics were therefore encouraged to use the Interactive invention strategy in teaching.

Ukoh's (2012) research on problem-based technique and instructional techniques based on interactive innovation on NCE Achievement of Physics students' principles and practical skills acquisition. The study employed the quasi-experimental design. Results were analysed using ANCOVA. Findings indicated that treatment improved on NCE students achievement in physics. It further indicated that interactive invention strategy was better than the conventional method. The two strategies were recommended for lecturers for use at the colleges of education.

Ukoh's (2013) study on the effectiveness of the activity-based approach called interactive-invention approach and Gender on NCE students' knowledge acquisition. Findings indicate the treatment have an effect on students teachers acquiring practical skills. Those taught with interactive-invention approach had better practical skills when compared to conventional lecture approach. Teachers were encourage to use the approach to teach students in physics as it was able to improve practical skills acquisition in physics at the NCE level.

Ogunbowale's (2014) study on the impact of interactive-invention and problem based approach on learners' attitude to biology. Two hundred and one participants in SS2 biology class from 6 schools and experimental approach were used. Three instruments were used and there include: Biology Achievement Test (BAT), Students Biology Self Efficacy Questionnaire (SBSQ), and Teachers instructional Guides. Three hypotheses were stated to guide and the collected data were alalysed with ANCOVA. Results indicates that treatment could improve on students' performance in biology. Problem-based instruction had the higher performance in biology scores when compared to those in the interactive invention and conventional method.

All the cited researches were carried out in physics to ascertain its effect on attitude on biology school students and at CoE physics programmes. It was also trial tested in school biology. The results shows that it improved on the attitude of the learners. This study focuses on IIIS on students teachers interest in cell biology at the college of education level for the NCE 1 biology education programme.

2.3.3 Crossword Puzzle-based Instructional strategy and pre-service teachers' achievement in biology

Samuel and Iliyasu's (2020) research on the use of puzzle (crossword picture) learning technique on the performance of student in basic science in Nasarawa. It employed a quasi-experimental design. One hundred and twelve junior basic school students were used for experimental and the control were 62. Two schools were selected and data was collected using Basic Science Achievement Test (BSAT) instrument and ANCOVA were used for analysis. Result showed those taught with cross-picture puzzle approach had higher achievement when compared with the control approach. Crossword-picture puzzle learning achieved the better performance than their counterpart in the conventional approach. Teachers were encouraged to utilise crossword-picture puzzles at the secondary school level to improve their performance.

Ajayi and Ogbeba's (2020) research on three-aspect of puzzle approach to improve achievement and engagement in chemistry. Employed quasi-experimental design with a sample of one hundred and forty-three learners. Two instruments were utilised and data were analysed inferentially. Results shows that the three-aspects puzzle approach engaged the learners better and improved on their achievement than those in the discussion approach. Teachers were encouraged to employ the three-aspects puzzle approach in the teaching of chemistry.

Olumide's (2018) research on puzzle (digital) and computer simulation packages on learners performance, problem-solving and attitude to biology. It employed a quasi-experimental design. Four randomly selected LGA, two schools were purposively selected, and 6 schools were used for treatment with intact classes. The instruments used include students' achievement test, students' problem-solving test, attitude and self-efficacy scale, mental ability test and digital packages. Collected data were analysed using ANCOVA. Finding shows that treatment was able to improve performance, attitude and problem-solving in genetics and ecology concepts in biology. The teachers were encouraged to adopt the digital packages for use in teaching various biology concepts.

Ogundare's (2014) research on maze and logic mechanical puzzle-based techniques on the learners learning outcomes in Integrated Science in Ondo. The sample comprised 296 JSS2 learners from 6 schools, and it employed and experimental design. Statistical analyses was employed and graphs were also utilized. Results showed that treatment improved learners' performance, attitude and problem-solving ability. Logic mechanical puzzle improved students' performance the better than the maze puzzle-based and the control. Results indicates that treatment and gender interacted to cause and effect on learners performance in Basic science. Findings shows that treatment and PEB interacted to cause an effect on learners performance. It was recommended amongst others that logic mechanical and maze puzzle-based instructional techniques be used to teach integrated science at junior schools to help improve the performance, problem-solving in and attitude.

Amosun and Ayo-Vaughan's (2016) research on effects of the case and puzzle-based learning students' achievement in and attitude to civic education and social studies concepts. A quasi-experimental design was employed. A sample of 265 intact JSS2 classes in 6 schools. A total of two instruments and instructional guides were used. Hypotheses were tested and analysed using statistical tools. Findings revealed

that treatment improved on learners performance in value leadership concepts. Teachers were encouraged to teach value leadership related subjects with problem and case based approach.

Ogundiwin's (2013) research on the impact of puzzle strategy and pre-theoretic intuition quiz (PTI) on learners performance, attitude and practices in environment in some biological concepts. Quasi-experimental design, sample of 451 students were used. Instruments used for the study were validated and reliability carried out. Statistical analyses were carried out using ANCOVA. Results showed that treatment was able to improve on learners' performance in some concepts related to the environment. It further indicated an interaction of gender and cognitive style on attitude. Female learners' had the better score and the male students had the least score when cognitive style interacted with gender. It further indicated an interaction between cognitive style gender and treatment when attitude of students were considered. Analytical cognitive female students scores was better in PTI followed by analytical male students; non-analytical female students scores was higher in PBL followed by non-analytical male students scores. Finally, non-analytical female students scores had a higher in control than male analytical students. The two strategies were therefore recommended for use by teachers to improve studetns learning outcomes.

Babayemi and Akinsola's (2014) research on mental ability and puzzle strategy (crossword-picture) on the integrated science performance of learners. A sample of 389 participants in JSS were with an experimental design in southwest. Teachers guides, performance and mental ability test were used. Hypotheses were tested and data analysed. Findings indicates that students performance were improve through the treatment. It further shows that students performance was affected by mental ability. The crossword-picture puzzle strategy was recommended amongst others to be adopted by Basic Science and technology teachers as well as curriculum planners.

A research carried out by Olagunju and Babayemi (2014) on the impact of crossword picture and gender on learners performance in integrated science. Quasi-experimental research design and three hundred and eighty-nine students were randomly picked. Teachers guides, and students performance test were used. ANCOVA was used to analyse the collected. Findings from the study shows that treatment was able to improve learners' performance significantly. Teachers were encouraged to amongst others that integrated Science at junior secondary schools adopt the use of this strategy and also included in the curriculum.

A research carried out by Adodo and Ogundare (2016) on two puzzle based approach (maze and logic mechanical) and background of parents of JSS learners' performance in some concepts in integrated science. It adopted an experimental design of the quasi type, and sample were selected at random. Instruments such as performance test and instructional guides were validated and used for the study. The findings of the study indicated that treatment improved on students achievement in integrated science. They recommended the two puzzle-based strategies to teachers for use in the teaching of integrated science.

Adesina, Adegoke and Ogundiwin (2015) research on puzzle approach (PBL), cognitive style and gender on learners' achievement in biology. The study adopted the experimental design of the quasi type. Sample were selected purposively and the schools were selected at random. Instruments such as performance scale, CST and instructional guides were validated and used for the study. The results indicates that treatment (PBL and control) improved on learners performance in biology related concepts. They recommended that teachers should improve learners performance through the use of PBL in Biology.

All the cited researches were carried out in basic science to ascertain its effect on performance JSS. It was also trial tested in school biology. The results shows that it improved on the performance of the learners. This study focuses on CPIS on students teachers performance in cell biology at the college of education level for the NCE 1 biology education programme.

2.3.4 Crossword Puzzle-based Instructional strategy and pre-service teachers' interest in biology

Umoru, Adejoh and Iji's (2016) research on improving biology learners' attitude through the use puzzles approach Wukari. It employed an quasi-experimental design of the non-randomized type. 210 learners from SS1 were used. Instruments used for the study include the Students Attitude towards Ecology Inventory (SAEI). Collected data were analysed. Results show that the puzzle-based learning strategy was able to improve on learners attitude to biology. The study encouraged curriculum planners that puzzle-based learning strategy be incorporated into the biology curriculum and teachers of biology were informed that it improves students attitudes.

Stetzik, Deeter, Parker, and Yukech's (2015) research on the impact of traditional aaproach and puzzle strategy on learners performance in physiology and human anatomy in undergraduate at the University of Akron, Ohio, USA. Half of the learners' were instructed through traditional approach for the earlier half of the semester while the remaining half were instructed with puzzle approach while the other half were taught in reverse. Results shows improvement in performance between the approaches, while quiz had 2.1 % increase while test had 0.4 % increase in their performance by learners in puzzle.

All the cited researches were carried out in biology to ascertain its effect on attitude in SSS. It was also trial tested at the university on anatomy and physiology lab II course. The results shows that it improved on the attitude of the learners. This study focuses on CPIS on student teachers' interest in cell biology at the college of education level for the NCE 1 biology education programme.

2.3.5 Problem-solving ability and pre-service teachers' achievement and interest in biology

Kaur and Kaur (2021) impact of cooperative approach on learners performance in mathematics with respects to their problem-solving ability. Sample consisted two hundred learners, three instruments and quasi-experimental design was utilised. Results shows that there is a variation with the performance of learners with respect to their problem-solving ability in mathematics. It further shows an effect of problem-solving ability on the learners performance in mathematics.

Smitha and Manoj (2018) research on the impact of problem solving ability and performance motivation of physics learners. The study utilised one hundred and thirty-four learners and two instruments were used to collect data. Result shows that there are various levels of problem solving ability amongst learners with 17% having low, 69% having average and 15% having high level performance motivation.

Sung (2017) research on visual propensity and problem solving on pupils performance. The study utilised two hundred and twenty-three respondents. It was a survey design.Findings indicates there existed no influence of problem solving ability on pupils performance in the study.

Jayanthi and Tholappan (2017) research on the impact of problem-solving ability on learners performance in mathematics. Descriptive design and three hundred

and sixty respondents and two instruments were utilised for the study. Result shows that higher learners in secondary level has a medium level of problem-solving ability. Teachers were encouraged to include different problems to learners so they can solve as it relates to their performance improvement.

Malik, Shah, Iqbal, and Rauf (2010) research on the effect of problem-solving technique on primary science learners. It adopted a quasi-experimental design. 60 students made up the sample. Attitude scale was used as the instrument and collected data were analysed. Findings shows that students had a positive attitude to learning science when compared to their counter in the traditional approach. It was therefore recommended that problem-solving be infused in their teaching and learning process to improve students' attitudes to science.

Achuonye (2010) research on the impact of problem and lecture approach on the motivation of learners to science. A total of 810 SSII science students were used and the Students Interest Inventory (SII) and t-test were used for analysis in the study. Findings indicate problem-based approach motivated learners to learn when compared with those in lecture-based learning. Also, it shows that problem-based learning students though mainly male would take responsibility for their learning.

Nnorom (2019) research the effect of the problem-solving technique on the performance of students in biology. It employed quasi-experimental research design with non-randomised equivalent type. One hundred and fifty SSI students participated and BAT instrument was used. Collected data was analysed. Results indicate that learners performed better in problem-solving techniques than those in control. Teachers were encouraged to use problem-based technique to teach biology so as to improve students performance.

Ogundare (2014) research on effects of the maze and logic mechanical puzzle-based technique on the attitude, performance and problem-solving ability in integrated science in Ondo. It employed an experimental design with 296 participants from JSS2 in six schools. Inferential statistics were used for data analysis. Findings shows that treatment was able to improve on the learning outcomes (attitude, performance, and problem-solving ability) of students in integrated science. Findings shows that logic mechanical puzzle technique improved students performance better than maize puzzle technique and the control. It was recommended amongst others that logic mechanical and maze puzzle-based technique be used to teach integrated science.

Olumide (2018) research on puzzle (digital) and computer simulation packages on learners' performance, problem-solving skills and attitude to biology. It employed a quasi-experimental design. Four randomly selected LGA, six schools were purposively selected and intact classes used. The instruments used include students' achievement test, students' problem-solving test, attitude and self-efficacy scale, mental ability test and digital packages. Inferential statistics were used for analysis. Finding shows that treatment was able to improve performance, attitude and problem-solving in genetics and ecology concepts in biology. The teachers were encouraged to adopt the digital packages for use in teaching various biology concepts.

Temel (2014) research on the impact of problem-based technique on student teachers' critical thinking dispositions and perceived problem-solving ability. Forty-nine participants, experimental approach and inventory were used. Results showed that treatment determined that students had low critical thinking disposition and perception at the medium value. It indicated that conventional method and problem-based technique had different impact problem-solving ability perception.

Son and Li (2020) research on Exploring the Relationship between Pre-service Teachers Conceptions of Problem Solving and Their Problem-Solving Performances. They examined 96 pre-service elementary teachers' problem-solving conceptions and performances by getting them to define and create metaphors that could be used to solve problems and evaluate the association amongst achievement in problem-solving and conception. It indicated that bulk of the pre-service elementary teachers were able to define problem-solving as solution means and made metaphors end-product and related conceptions problem-solving.

The study of Saputro, Irwanto, Atun, and Wilujeng (2019) investigated the effect of problem-solving technique on the performance and practical skills of prospective elementary teachers. The design employed was an experimental design. Forty-eight students in their first year of attending the Basic Science concept course at the Department of Elementary School Education, Muhammadiyah University of Ponorogo, Indonesia were used. The instrument include performance test, and practical skills scale. Data were analysed using descriptive and inferential statistics. Results indicated that there existed a difference in performance, practical skills when the treatment and control is concerned which tilted to the experimental group, and their result showed a relationship between the variables. It was recommended among others

that the lecturers should utilize Problem Solving Instruction to enhance learners knowledge to respond to the learning in the 21st century.

Usman and Sule (2017) research on the impact of problem-solving as a mode of instruction on physics learning outcomes in Jos. The research design used was a true experimental. Two secondary schools and 60 students offering physics participated. Instruments utilized include the Physics Students' Problem Solving Achievement Test (PSPSAT) and Physics Students Problem Solving Attitude Rating Scale (PSPSARS) and it was a researcher-made. Collected data were tested using descriptive statistics. The results show that the achievement levels after treatment shows that male learners had a significantly improved achievement when compared to the other group. Problem–solving strategies provided a better performance when compared to those in the conventional group. The students in private schools had better performance when taught using problem-solving strategies than their counterparts in government schools. It was encouraged by the authors that teachers should infuse problem-solving illustrations so they can meet problem-solving strategy criteria.

All the cited research was carried out in basic science to ascertain its effect problem-solving ability and problem-based technique on achievement and attitude in JSS. It was also trial tested at the SSS Biology and physics. This study focuses on problem-solving ability on student teachers' achievement and interest in cell biology at the college of education level for the NCE 1 biology education programme.

2.3.6 Cognitive style and pre-service teachers' achievement and interest in biology

Hussin, Razali, and Agussalim (2021) researched the relationship between cognitive style and learners' performance at economics faculty, national university of Malaysia. One hundred first-year students in the university took part in the study. The cognitive style examined were the field independent or field independent. The following instruments were used: students' background, performance test and cognitive style as well as indicators that could affect performance. Results indicates that the cognitive style learners in the filed independent styles had better performance than FD learners.

Agu and Samuel (2019) researched on the impact of cognitive styles on the performance of college students in science and technical in Nasarawa. Survey design was used and it comprised of two hundred and sixty two out of a population of one

hundred and thirty seven thousand college learners. Cognitive Style Checklist (CSC), and Science and Technology Achievement Test (STAT) were used to collect data. The reliability of CSC was determined through test-retest and the reliability of STAT was determined using kuder-Richardson formula 20 (KR_{20}). Data were analysed using descriptive statistics such as mean and standard deviation in answering the research questions while to test the hypothese, Z-test was used.

Results shows that field independent (FI) cognitive style science and technical students performed better than their counterpart in the field dependent (FD) cognitive style. Therefore male and female science and technical learners had no significant difference in the learners' achievement in both groups. It was recommended that teachers of science and technical colleges be trained through seminars on the benefits of creating enabling environments to address different cognitive style levels of the students to bring about meaningful learning.

Abubakar and Haruna (2019) researched on the impact of cognitive styles on the performance of learners' in Katsina. Survey design and two hundred and ninety one respondents from a population of one thousand two hundred and two were randomly selected. Two instruments were used for the study. Each instrument were validated and the reliability obtained. The 2018/2019 qualifying examination results in biology was used. PPMC was the statistical tool used for analysis. Results showed there existed a correlation between FI and their achievement in biology. There was no relationship existed between FD learners and performance. Teachers were encouraged to organize their learning to handle individual learning abilities based on cognitive styles.

Atsuwe and Mtoh (2019) researched on the influence of cognitive style on physics retention and performance of learners in Benue. Using an ex-post facto design. The respondents comprised of 150 physics students selected from a population of one hundred and fifteen student of SSI 2016/2017 academic year from the 29 schools in Gwer-west LGA in Benue state. Collected data were analysed using descriptive and inferential statistics. Results shows that filed independent cognitive style learners had better performance when compared to FD learners. The result further showed that FI cognitive style students had a higher retention memory when compared to FD cognitive style learners. Finally, it showed that when gender is involved male learners had a better performance than those in the female category. Recommendations were to

the teachers to further take note of their cognitive style levels in class to bring about achievement.

Asikhia (2019) researched on the cognitive styles and students' achievement in secondary schools in Ogun. Descriptive survey design was used while two hundred SS2 students from 5 colleges in Ijebu-ode took part. Converger cognitive style questionnaire and accommodator cognitive style questionnaire (CCSQ and ACSQ). Collected data were analysed with multiple regression. Findings showed that the four indicators Converger, accommodator, gender and area of specialization) were able to predict the academic performance of students. Some recommendations were made.

Okoye and Onwuachu (2018) researched on the influence of cognitive style and students' academic achievement of students' interest in biology. Ex-post facto design and a sample of five hundred and forty students of biology (275 females and 265 males) drawn from Onitsha education zone, comprising of two uban and two rural schools in Anambra state. GEFT and BIIS were used to access cognitive style and interest. The GEFT instruments reliability was checked using test-re-test while BIIS was analysed using cronbach alpha formula. Findings revealed the effect cognitive style and school location has on learners' interest and performance in biology. Some recommendations were highlighted.

Wulandari, Widayati and Suryobroto (2016) researched on influence of creative quality and cognitive style on learners' performance of university undergraduates in Indonesia. The research was done in two universities. The sample consisted of 234 learners from diverse programmes (life science, engineering, social and physical sciences). The lastest indeks prestasi kumulatif (IPK) was used as achievement, cognitive reflection test (CRT) and creative personality scale (CPS). Data were analysed using linear model. Findings shows that analytical thinking students had better scores and it tilted to the life science programme. However, learners would require materialise their creativeness to reach higher performance in tedious classes especially in final year.

Agboghoroma (2015) researched on impact of cognitive style and instructional mode on learners' performance in basic science. Learners in JSSIII made up of 360 divided into field dependence/independence cognitive style levels took part in the study. It employed the quasi-experimental design with the non-equivalent type. Two instruments were used to collect data. Data were analysed using ANCOVA to test the hypotheses. For significant main effect, MCA was used. Results shows instructional

mode and cognitive style were able to; interactively improve on the students' performance in basic science. Recommendations were made.

Musa and Samuel (2019) researched on impact of gender and cognitive styles on learners' performance in mathematics in upper basic III in Keffi. A population of 1890 learners from 25 schools. A sample of two hundred and forty-five students from 6 intact classes were used. Disproportionate stratified sampling techniques were used. Cognitive style checklist (CSC) and performance test in mathematics were utilized. Descriptive statistics and Z-test were used for analysis. Results shows that students with Field Independence (FI) showed to have better performance scores than those in Field Dependence (FD). It further showed that FI and FD males students showed better performance than females in FI and FD. Recommendation were made.

Jantan (2014) researched on the impact of cognitive style on mathematics learners' achievement in primary schools. Descriptive design and GEFT instrument were used. The type of cognitive styles used in the study were divided into field-dependent (FD) or field-independent (FI). One hundred (150) pupils in grade six from particular schools made up the study's sample. Data were analysed. Results shows that one hundred and twelve (112) students made up of FD and thirty-eight (38) FI. It revealed a weak positive relationship between learners' cognitive styles and mathematical knowledge. There existed a significant difference between boys and girls with their cognitive styles. Recommendations were made with respect to teachers, and students'.

Tinajero, Lemos, Araujo, Ferraces, and Paramo (2012) researched learning strategies and cognitive style and its effect on learners' performance in Brazilian University. Three hundred and thirteen students who are in their first year in the university participated in the study. The Group Embedded Figures Test (GEFT) and academic achievement for their first year were employed for the study. Findings show that when the cognitive style is combined with learning strategies it can significantly contribute to students' academic achievement.

Okoye (2016) researched on the relationship between gender and cognitive styles on learners' performance in Biology. It employed a causal comparative design and 12, 000 Senior school 2 learners in biology in 64 government schools. Two hundred and sixty-five biology students broken down into 124 females and 141 males from 2 girls and 2 boys only schools. GEFT and BPT instruments were used. The GEFT was classified as either field dependent or field independent. To address

research questions and hypotheses, descriptive and inferential statistics were used. Gender and cognitive styles had no significant effect on biology achievement among learners, according to the findings. Recommendations were made.

Oludipe (2014) studied senior secondary school students' cognitive style profiles and physics performance in Ogun. Ex-post facto design and one hundred and seven SSIII physical learners' were employed to participate. Siegel's Cognitive Style Test (SICOST) was one of the instruments employed in the study. Findings show that analytic style learners accounted for 69% of the total achievers when compared to their counterparts in the non-analytical style. There is a considerable difference preferring analytical boys to non-analytic boys.

Ukoh and Orefuwa (2016) conducted study on cognitive style, self-concept, and numerical competence as predictors of learners' performance in physics in Ibadan. The study used a correlational descriptive survey approach. Thirty-five senior secondary schools were purposefully chosen for this investigation. Physics performance exam, physics cognitive style test, self-concept questionnaire, and numerical ability test were among the instruments employed. At the 0.05 level of significance, five study questions were addressed. Data were evaluated using mean and standard deviation descriptive statistics. Multiple regression analysis and the ANOVA test were utilised to offer responses to the study questions.

Result showed that Analytic Descriptive (AD) cognitive style is more predominant among the students. The combined impact of self-concept, cognitive style, and numerical skill on students' physics achievement was considerable. As a result, when the three variables self-concept, cognitive style, and numerical ability are combined, they may predict 19.9% of the students' physics achievement. There existed difference between cognitive style, numerical ability, and students' physics achievement, with a relative contribution of 10.2% (for cognitive style) and 17.6% (for numerical ability). Finally, cognitive style and numerical ability can predict students' physics performance.

Idika (2017) conducted a study on the effects of gender and cognitive style on chemistry learners' attitude and performance. The research included 208 chemistry students. Three measures were used: a cognitive style checklist, a chemistry achievement test, and a questionnaire about students' attitudes towards chemistry. There were four hypotheses proposed. Descriptive statistics were used to analyse data. Findings demonstrated the difference between FD and DF learners in chemistry. Pupils

with field-independent cognitive style levels outperformed their peers with field-dependent cognitive style levels in chemistry achievement. It was recommended amongst others that students' dominant cognitive style categories be known by the teachers as it could ensure adequate learning and also assist the teachers on the teaching methods selection.

Hong, Hwang, Tam, Lai, and Liu (2012) research on effects of cognitive style on digital jigsaw puzzle performance: A GridWare analysis. The researchers worked on Cognitive style as well as a personal characteristic using FD and FI on achievement. GEFT was used and data analysed. The result from findings showed FI had effect on jigsaw scores. Digital jigsaw puzzle scoring showed it was positively correlated with FI. It means that FI learners had better scores than FD learners.

Ogundiwin (2013) examined the effects of puzzle technique and pre-theoretical intuition quizzes on learners' attitude, performance and environmental practices in biology on some selected environmental topics. A quasi-experimental design was utilised. The study involved 451 SS2 students chosen at random from nine Oyo State senior secondary schools. Among the instruments used are instructional guides for instructors, Learners performance test, attitude scale, environmental practises scale and cognitive style. Descriptive and inferential statistics were utilised.

Results showed that treatment was able to improve on learners' performance in life sciences. It further indicated based on attitude there existed an interaction between cognitive style and gender. Female learners had the better score and the male students had the least score when cognitive style interacted with gender. It further indicated an interaction between cognitive style gender and treatment when attitude of students were considered. Analytical cognitive female students scores was better in PTI followed by analytical male students; non-analytical female students scores was higher in PBL followed by non-analytical male students scores. Finally, non-analytical female students scores had a higher in control than male analytical students. The two strategies were therefore recommended for use by teachers to improve studetns learning outcomes.

Altintaş and Gorgen (2018) conducted a study on the cognitive styles of student teachers in respect to learning approaches. Within the scope of the main goal, the study seeks to determine whether there are significant disparities in characterising intending instructors' cognitive styles and learning techniques, as well as demographic characteristics. It was prepared using the correlational survey approach and carried out

at Mugla Sitki Kocman University's Education Faculty during the 2014–2015 session. The Group Embedded Figures Test, which was used to assess potential instructors' cognitive styles in the study. Revised Two Factor Study Process Questionnaire" was used, however, to show potential instructors' learning styles. The findings revealed that prospective instructors had a field-dependent cognitive style in general. There was, however, a significant difference in branch and cognitive style ratings. As a result, it is argued that as prospective teachers' cognitive styles approach field independence, their desire for deep learning approaches decreases.

Olagunju and Ogundiwin (2008) conducted a study on impact of cognitive style and three modalities of teaching on learners' attitudes to pollution in biology. The study employed a quasi-experimental design. The research included 240 students and 7 instruments. Inferential statistics were used to analyse data. The findings demonstrated that instructional styles had a significant influence on environmental attitudes regarding pollution in biology. In biology, cognitive style indicated a significant effect on environmental attitudes towards pollution. It was suggested that teachers use customised teaching approaches to meet students' diverse cognitive processes.

Okoye (2011) conducted a study on the impact of learners cognitive styles and interaction patterns in class on biology performance in Anambra. Ex-post facto design and 265 senior secondary II biology students were chosen using a simple random sample procedure. Three instruments were used and all instrument used was face and content valid and reliability measures ran on each of them.The findings reveal that classroom interaction patterns influenced biology learners' performance. The findings further showed that cognitive style influenced learners' performance in biology. Teachers were encouraged to incorporate classroom interactions and cognitive style in daily instruction.

Demir, Aksut, Yener, Adyin, Sabasi, Fidan, and Aygun, (2017) research on the influence of cognitive styles on student teachers attitudes to astronomy. Survey design and 64 fourth-year undergraduates from the Department of science education at Abant Izzet Baysal University participated in the study's sample collection. Group Embedded Figure Test (GEFT) and Astronomy Attitude Scale (AAS) were used to collect data. The findings shows that efforts should be made to increase student teachers attitude with respect to astronomy not minding their cognitive styles and improve on their developed skills.

All the cited research was carried out in integrated science to ascertain the impact on performance and attitude in JSS. It was trial tested in senior secondary school level in Biology, chemistry, physics and mathematics. It was trial tested in biology for undergraduate students at the university level. This study focuses on cognitive style on student teachers' interest and achievement in cell biology at the CoE level for the NCE 1 biology education programme.

2.4. Conceptual framework of the Study

These provide an overview of the relationships that exist between the variables in the research. This figure indicate the impact of the variables (Independent (IV) and moderators (MVs)) on the depending variables (DVs) (cell biology achievement and interest). As a result, the conceptual framework explains the connections that exist in improving pre-service students' learning outcomes (performance and interest) in cell biology through the utilisation of student-centred teaching approaches (interactive invention instructional strategy and cross-word puzzle-based instructional strategy) and traditional instructional strategy. The research is based on the premise that learners create their own knowledge by organising and categorising data using a coding system. According to the notion, establishing one's learning was most effectively accomplished by developing a coding system rather than by receiving information from an instructor. The idea of discovery learning—also referred to as a constructivist approach suggests that students produce their own knowledge. In cell biology, the effects of moderator factors on the link between IV and DVs were studied. These variables included problem-solving ability (high, and low) and cognitive style (analytical and non-analytical). The interacting effect that exist between the IV and MVs combined with the moderator variables were also examined. Figure 2.2 illustrates the main and interaction effect of the IV, DVs and MVs respectively.

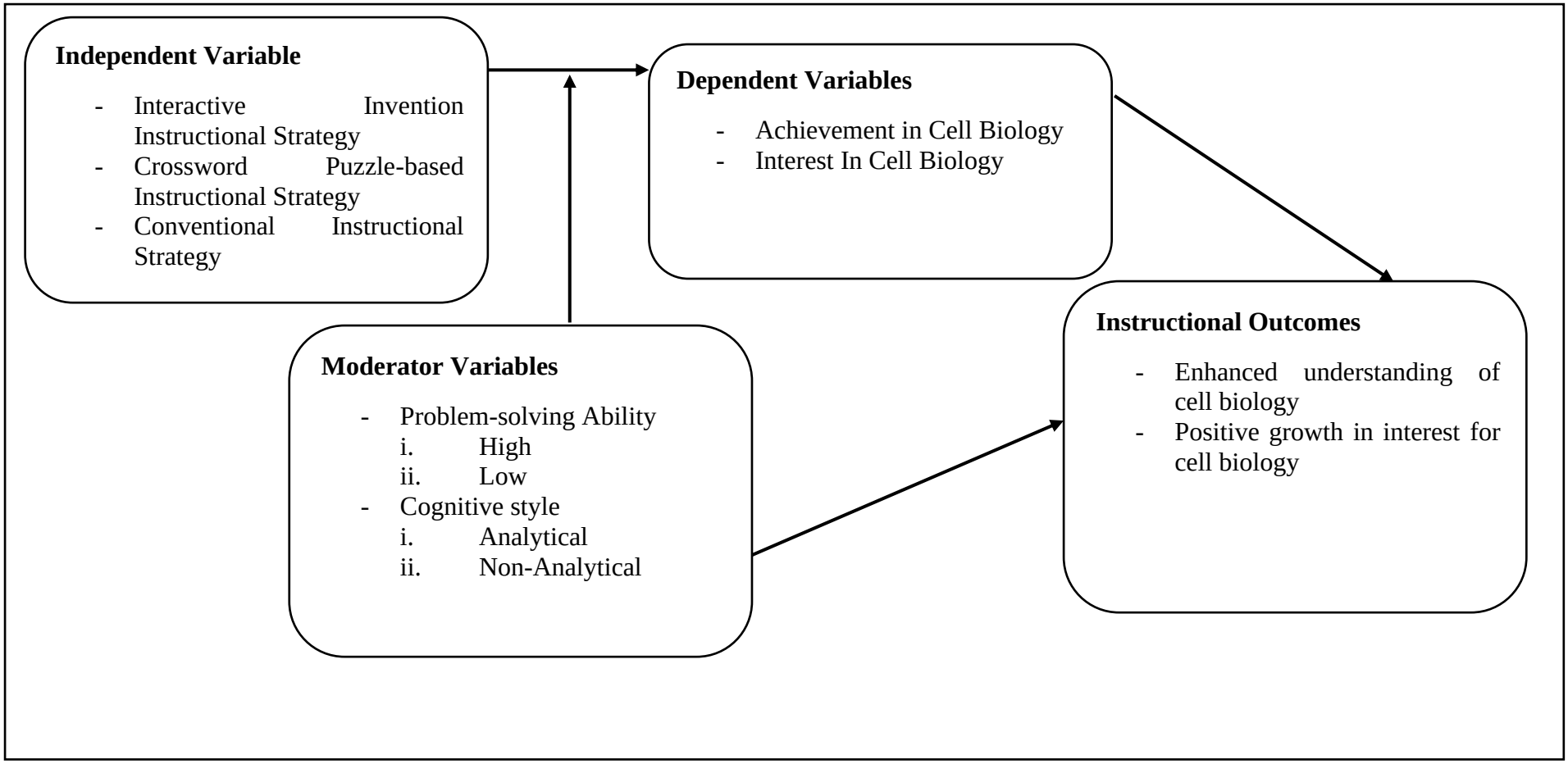


Figure 2.3: Studies Conceptual framework

Source: Fieldwork, 2022

2.5 Appraisal of literature review

The literature review was conducted using a theoretical framework, a conceptual analysis, an empirical analysis and a conceptual framework. The theoretical framework examined Jerome Bruner's theory as well as the Ashmore, Frazer, and Casey models, which were relevant to the concepts of interactive invention strategy, Crossword puzzle-based strategy, achievement, interest, cognitive style, and problem-solving abilities. It also demonstrates various academics' points of view on the application of the interactive invention and puzzle-based instructional strategies, the low level of biology performance and interest among student teachers, and the impact of problem-solving ability and cognitive style as the moderators on how people approach problems and analyse images/pictures.

Numerous academics and researchers have identified a variety of causes for these poor results and a lack of interest in biology and other related fields. The following factors have been identified: the use of ineffective teaching techniques for comprehending difficult concepts, a lack of effective teaching techniques, a negative attitude towards science, a lack of adequate teaching materials or resources, laboratory equipment, reagents, chemical storage space, and a lack of practical skills that could be enhanced by a student's capacity for problem-solving and cognitive style.

Therefore, this study utilized interactive intervention and puzzle-based instructional strategies to determine the impact of student teachers' achievement and interest, moderated by problem-solving ability and cognitive style in cell biology.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

This research employed the pretest-posttest control group quasi-experimental design of the 3×2×2 factorial matrix for the study. It featured a three-level treatment that is also known as an instructional strategy, as well as two-level consideration of student teachers' cognitive style and problem-solving skills.

The structure of the plan is described thus:

Experimental Group	1	L_1	Z_1	L_4
Experimental Group	2	L_2	Z_2	L_5
Conventional Group	3	L_3	C	L_6

The pre-test scores for the two experimental groups and the control group are L1, L2, and L3, and the post-test scores for the two experimental groups and the control group are L4, L5, and L6.

Z_1, and Z_2 are the Interactive Invention Instructional Strategy; Crossword Puzzle-based Instructional Strategy and C stands for the Conventional Strategy.

Table 3.1: 3 × 2 × 2 factorial matrix

Treatment	Cognitive Style	Problem-Solving ability	
		High	Low
Interactive Invention Instructional Strategy	Analytical		
	Non-Analytical		
Crossword Puzzle-based instructional Strategy	Analytical		
	Non-Analytical		
Conventional Instructional Strategy	Analytical		
	Non-Analytical		

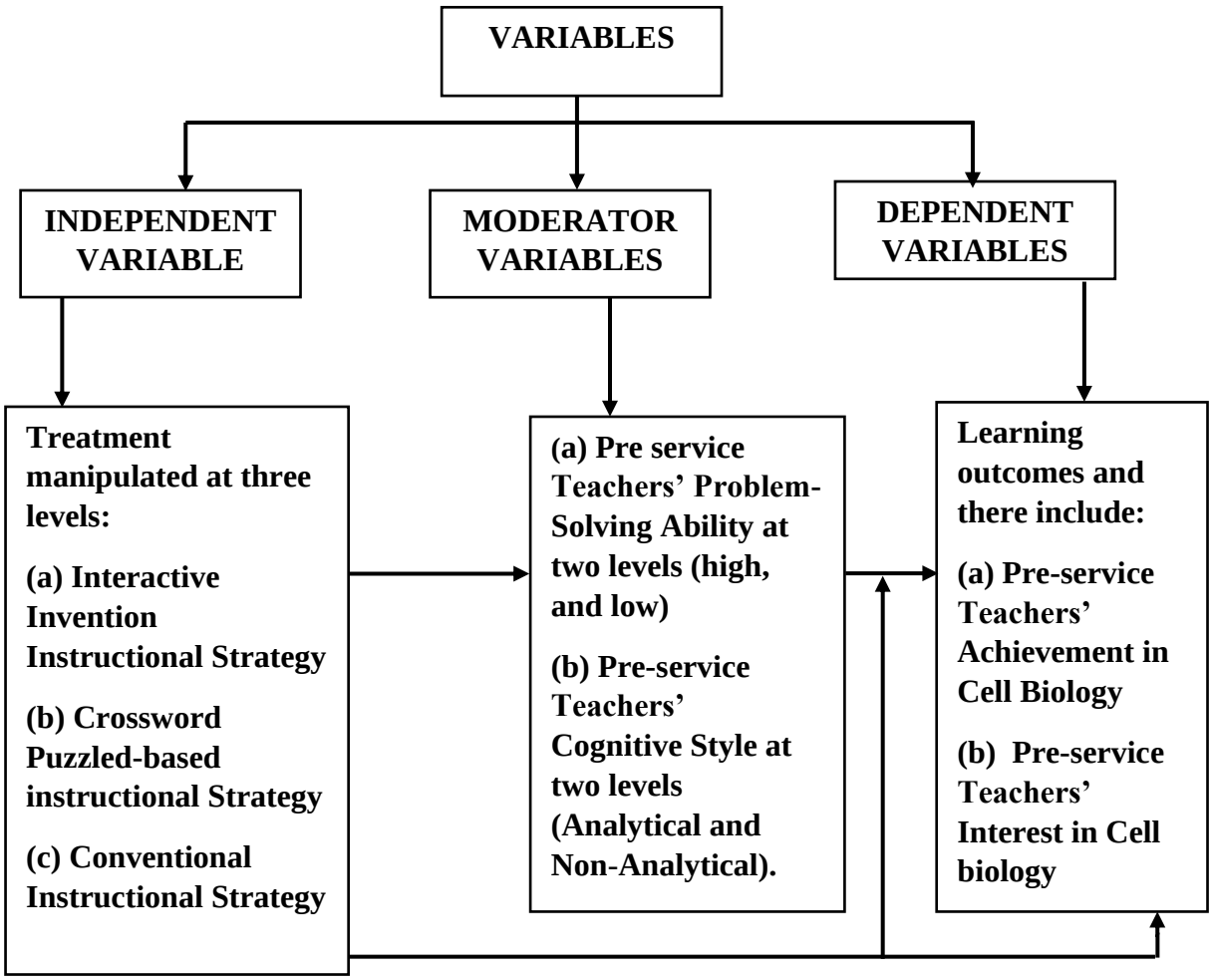


Figure 3.1 Variables of the study.

3.2 Variables of the study

Independent Variable

The treatment is the instructional strategy, manipulated at three levels:

1. Interactive Invention Instructional Strategy
2. Crossword Puzzled-based instructional Strategy
3. Conventional Instructional Strategy

Moderator Variables

These include:

1. Pre-service Teachers' problem-solving ability at two levels (high and low)
2. Pre-service Teachers' Cognitive Style at two aspects (Analytical and Non-Analytical).

Dependent Variables

This is the learning outcomes and there include:

1. Achievement of Pre-service teachers in Cell Biology
2. Interest of Pre-service Teachers in Cell Biology

3.3 Population and Sampling technique

All six hundred and seventy-five (675) N.C.E. I student teachers studying biology in federal CoEs in Southwestern part of Nigeria made up the study's population. All four (4) federal CoEs in six (6) states in southwest Nigeria were included in the research for the purpose of equality.

3.3.1 Selection of Participants

In the southwest of Nigeria, three federal colleges of education were selected using a purposive sampling technique based on equality in terms of equipment, laboratories, teaching staff and material resources. The three (3) federal CoEs were assigned into control, experiment 1, and experiment 2 at random. College X, College Y, and College Z are the three randomly chosen colleges (see Appendix I). One college was taught using interactive invention strategy, another was taught using crossword puzzle-based strategy, and the last institution was taught using the usual conventional instruction. In all colleges of education, intact classes of biology student

teachers in NCE I were used for the study and there are college X had 146 pre-service teachers, college Y had 134 while college Z had 124 pre-service teachers'.

3.3.2 Selection of Contents

The performance of students in BIO 112 titled Cell Biology at NCE level 1 informed the choice of the contents. It could be seen that students' performance shown seems to be inconsistent year after year. The content chosen is some of the topics taught in the Biology Education course with the course code BIO 112, Cell Biology, is one of the courses in the minimum standard by NCCE is offered by NCE I student teachers in Nigerian CoEs. The concepts utilized include:

a. Cell and cell theory
b. Cell Organelles
c. Physical processes of cell and
d. Cell division

3.4 Research Instruments

There include:

A. Stimulus Instruments

1. Instructional Guide for Interactive Invention Instructional Strategy (IGIIIS)
2. Instructional Guide for Crossword Puzzle-based Instructional Strategy (IGCPBIS)
3. Instructional Guide for Conventional Instructional Strategy (IGCIS)

B. Response Instruments

4. Pre-service Teachers Cell Biology Achievement Test (PTCBAT)
5. Pre-service Teachers Interest in Cell Biology Questionnaire (PTICBQ)
6. Pre-service Teachers Cell Biology Problem-solving Ability Test (PTCBPAT)
7. Pre-service Teachers' Cognitive Styles Test (PTCST)

3.4.1. Instructional Guide for Interactive Invention Instructional Strategy (IGIIIS)

This approach was developed by Ukoh (2012) and is adapted for this study. it has 3 phases and 7 activities.

Phase 1: Presentation

Phase 2: Practice

Phase 3: Monitoring and Assessment

Experimental Group 1: Interactive Invention Instructional Strategy

Phase I: Presentation

Activity I: Students are handed worksheets as the lecturer analyses prior assignments and asks them some questions on the material covered in the previous class.

Activity II: An Instruction of the lesson

1. Introduction on the lesson. The What.
2. Explains why the topic is important. The Why.
3. Explanation of the topics
4. Lecturer ask questions to ascertain understanding.

Phase II: Practice

Activity I: Guided practice: Students are instructed to practise and are divided into groups of eight to enhance competence by completing assigned assignments and clarifying any unclear concepts.

Activity II: Students continuous Practice: Here, the students are free to work continually in groups on the topics they have learned, reinforcing their mastery of the learned content.

Activity III: Review periodically: Students ask questions to get reviews on learned concepts, to reinforce concept(s) and skill(s) proficiency.

Phase III: Monitoring and Evaluation

Activity I: Daily Assessment: student teachers' materials are assessed are checked to offer corrections and instructions as the need arises.

Activity II: Summative Assessment (Mastery): student teachers' worksheets are checked each week. Feedbacks are handed in to the student teachers, these is to sustain the learning.

A copy of the guide can be found in Appendix II

3.4.2. Instructional Guide for Crossword Puzzle-Based Instructional Strategy (IGCPBIS)

Crossword Puzzle-based instructional strategy is designed to break down the concept of cell biology (Cell Biology) into sub-topics such as Cell and cell theory, physical processes of cell and cell division using a the crossword puzzle and the key as a guide.

The cell biology puzzle with the clues were adapted from Ogundiwin (2013) environmental puzzle.

Experimental Group 2: Crossword Puzzle-based Instructional Strategy

Step I: In order to capture students' attention and activate their prior knowledge of the subject, the lecturer starts the course by posing theoretical questions.

Step II: Students are given a quiz, which is the cell biology puzzle with clues/keys, which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single puzzle from their individual puzzles for presentation.

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

Step VIII: The instructor concludes by assigning a task to further evaluate the learned abilities.

A copy of the guide can be found in Appendix III

3.4.3. Instructional Guide for Conventional Instructional Strategy (IGCIS)

The lectures were based on the usual ways of writing lecture notes. The **steps** involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

A copy of the guide can be found in Appendix IV

To guarantee their dependability, all of the instruments utilised in this study underwent trial usage. The focus of the expert lecturer's attention was directed on determining the validity by looking at how well the concepts and techniques applied were suited to the intended audience. These experts' opinions, suggestions, and contributions were taken into account while creating the final draught of the instrument.

3.4.4 Pre-service Teachers Cell Biology Achievement Test (PTCBAT)

The PTCBAT instrument was developed to measure student teachers' Achievement on some cell Concepts in Biology at the CoEs in BIO 112 course titled Cell Biology.

Part I – Consist of the students' personal information.

Part II – Consist of multiple-choice questions of BIO 112 (Cell Biology) with options lettered A – D.

Seventy (70) multiple-choice items with four options labelled A–D made up the Test items initially. Three expect lectures in science education were given the instrument and there were to determine the validity (face and content) on the following criteria: appropriateness, relevance, language, adequacy, and so on. My supervisor was then handed the last round of multiple-choice questions to review and edit. The remaining 60 items were given to 30 pre-service teachers at a different college that wasn't included in the study. The PTCBAT underwent trial testing, and Kuder-Richardson 20 (KR20) measure was used and an index of 0.75 was gotten. The discrimination indices of 0.39 – 0.56 and difficulty index of 0.30 – 0.79 was obtained. The surviving 30 items were used for the study. A copy of the instrument could be found in Appendix V (A – D).

Table 3.2 Specification Table for PTCBAT

Topics	Knowledge	Comprehension	Reasoning	Total
Concept of cell and cell theory	(1,6,13,16,18,19,22)	(10,15,28,30)	(3,7,14,17,26)	**16**
Physical Processes of cell	(23,25,27)	(5,12)	(11,21)	**7**
Cell division	(20,29)	(2,4)	(8,9,24)	**7**
Total	**12**	**8**	**10**	**30**

3.4.5 Pre-service Teachers Interest in Cell Biology Questionnaire (PTICBQ)

The instrument Pre-service Teachers Interest in Cell Biology Questionnaire (PTICBQ) is adapted from Yulinda and Ilma (2018) question grid which was designed to assess pre-service teachers' interest in cell biology. The instrument is divided into two sections, A and B; section A was designed to get the demographic information of the pre-service teachers. Section B is made up of (24) items, placed on a Likert Scale of four points SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree. The scale has both positive and negative statements. The positive statement was graded as follows:

Strongly Agree	4
Agree	3
Disagree	2
Strongly Disagree	1

The negative statement were graded as:

Strongly Agree	1
Agree	2
Disagree	3
Strongly Disagree	4

Thirty-three (33) items were first created, and to verify these items, three specialists lecturers from science education department were consulted for professional opinions on the validity (face and content) of the instrument using the following standards: language level, difficulty, applicability. Their suggestions and recommendations were effected. Final adjustments were made by my supervisors to produce the final copy. After then, 30 N.C.E. I pre-service teachers of which they were not used for the main study were chosen and given the remaining 30 items. Using Cronbach Alpha statistics, an instrument's reliability index was determined, and it came out to be 0.82. The surviving 24 items were then used for the study.

A copy of the instrument could be found in Appendix VI

3.4.6 Pre-service Teachers Cell Biology Problem-solving Ability Test (PTCBPAT)

Pre-Service Teachers Cell Biology Problem-solving Ability Test (PTCBPAT) is a researcher-developed instrument following the four steps of Ashmore, Frazer and Casey 1979 problem-solving model, which includes problem definition, information selection appropriately, information combination and evaluating to measure students' problem-solving ability in related concepts in cell biology for its development. The instruments are categorized into two aspects

Section A: respondents' demographics

Section B: contains four (4) scenarios of different problems to test their problem-solving ability in cell biology-related concepts. The problem-solving ability test is divided into two sections; the first section has the scenario stating the problems while the second part has the questions on how the individual will go about identifying the problem. Selecting the pieces of information that are needed to solve the problem, combining the information by coming up with a plan to solving the problem and evaluating the solution to the problem to see if the problem has been solved. The problem-solving ability has scenario 1 that has a narration of a gardener having an issue of space but wants to have two citrus fruit planted on the same spot by considering grafting. Scenario 2 has the narration of an accident scene where a motorbike and a car collided and there is a broken bone and bleeding on the affected area. Scenario 3 has a narration of a man peeling an orange and mistakenly injuring his finger and finding solutions to the bleeding and finally, scenario 4 has a narration of a blocked vascular bundle by children pushing nails into a mango tree trunk. The model of choice is that developed by researchers employing the four phases of Ashmore, Frazer, and Casey's (1979) approach. The questions are broken down into four sections: problem definition, information selection appropriately, merging the various bits of information, and evaluation.

Scoring of PTCBPAT

Each student is allowed to earn a maximum of 122 points. Students who received a score of 0 to 61 were placed in the low problem-solving ability group, while those who had a score of 62 or more were placed in the high problem-solving ability group. The scoring is as follows:

i. Being able to state the problem ----------2 marks for each point
ii. Stating the pieces of information ----------2 mark for each point
iii. Coming up with a plan and solving the problem -------2 marks for each point
iv. Evaluating the solution appropriately ----------2 marks for each point

Three expert lecturers in the Science and Technology Education Department were given the Pre-Service Teachers Cell Biology Problem-solving Ability Test (PTCBPAT) for validation in order to ascertain the suitability, language level, and the instrument overall validity (face and content). Following that, corrections were made based on their academic feedback. The instrument was eventually verified by an evaluation expert from the Institute of Education. The expert examined the instrument to determine the readability, context, and appropriateness and decided that it was appropriateI also gave the document to my boss, who read it and made the last adjustments. PTCBPAT was given to 30 students teachers who were not part of the study. The reliability measure used was the split-half analysis and a coefficient of 0.79 was achieved. A copy of the instrument can be found in Appendix VII

3.4.7 Pre-service Teachers' Cognitive Style Test (PTCST)

The cognitive style test by Kegan, Moss, and Sigel was developed in 1963. For this study, the researcher adopted the revised edition by Awolola (2009) as used by Ogundiwin (2013). The test instrument comprises of twenty (20) cards. It seeks to test the reasoning of the students based on the images of everyday items, creatures, or artefacts with the express intent of identifying them. Three pictures in black and white are placed on each card; two of the pictures may have one thing or the other in common. PTCST was used to categorise the students into "Analytical" and "Non-Analytical" styles based on each student's remarks of the given pictures. The are expected to note done on each card how a pair from a set of three images fit together or are connected in any way. Three categories may be drawn from the students' comments about how they interpreted the images and grouped any two together;

d. Analytical-Descriptive (AD)
e. Categorical Inferential (CI); and
f. Relational Contextual (RC).

Analytic-Descriptive Responses

On the basis of their clear shared or common traits, students are requested to group objects together. For instance, in this situation, respondents may combine a human and a wristwatch and state that they are both made of leather on a specific card that had "a wristwatch, a man, and a metre rule."

Categorical Inferential Responses

Respondents are required to group things based on superordinate traits that are implied rather than plainly observable (abstract). As an illustration, responders could pick a metre rule and a wristwatch and state that both are for measurement.

Relational Contextual Responses

In this situation, respondents will group things or things that happen together based on characteristics that relate them in some way. Despite conceptual independence between the two stimuli or objects in this instance, they both have meanings. As a result, this classification method is also sometimes referred to as a global, holistic, or contextual model. Respondents are asked to group each item together, such as wristwatch and a human relating it with a man using the watch to measure time or the ruler and a human and stating that humans use the metre rule to measure length.

Scoring of PTCST

Participants who scored above the median on the PTCST's CI and AD and below median on RC responses will be classified as analytical style participants in this study. Participants who used a non-analytical approach, on the other hand, had scores higher than middle value in RC and lower for CI and AD responses.

Three experts from the Departments of Guidance and Counselling and Science and Technology Education were asked to evaluate the booklet's applicability and overall validity (face and content). The items were administered to thirty NCE I students teachers that did not feature in the main study and split-half analysis was used and the resulting reliability index of 0.86 was obtained. A copy of the instrument can be found in Appendix VIII.

Table 3.3 Scoring guide for preparing PTCST

S/N	Subject category	Their Answers	Quantity of Items
1.	Answers on Analytic Descriptive	Arranging items or images with similar elements together	7
2.	Answers on Categorical Inferential	Grouping items based on superordinate properties that can only be inferred and not physically seen	6
3.	Answers on Relational Contextual	Combining items or events depending on characteristics to create a relational relationship between them.	7
	Total		20

Source: Ogundiwin (2013)

3.5 Research Procedure

As indicated in Table 3.4, the work schedule for data collection were divided into five phases: the stage of visitation, the stage of training for research assistants, the stage of pre-treatment, the stage of treatment, and the stage of post-treatment.

Table 3.4 Research Procedure

Week	Description
1st and 2nd week (2 weeks)	Visitation
3rd and 4th week (2 weeks)	Training of Research Assistant
5th week (1 week)	Administration of Pretest Instruments/prior treatment instruments: a. Interest Questionnaire b. Achievement Test c. Problem-solving Ability Test d. Cognitive Style Test
6th to 13th week (8 weeks)	Treatments a. Group 1 - Experimental b. Group 2 - Experimental c. Conventional Group
14th week (1 week)	Administration of Posttest Instruments: a. Interest Questionnaire b. Achievement Test
14 weeks	**Total**

3.5.1 Pre-treatment Stage:

The duration of this phase was five (5) weeks. Visiting and acquainting oneself with the colleges that were selected are part of this stage, as is pilot testing the instrument. A formal letter received and signed by the Acting Head, Science and Technology Education Department, UI, was used as the introductory letter to the various college heads. Before the commencement of the treatment, the guides and the biology facilitators had a two-week training programme. A pretest was also given. To help the researcher correctly arrange the data collection, copies of the chosen NCE I Biology timetables were sought and received.

Visitation Stage

This involves visiting and getting authorisation from the Biology Department Head and the consent of the lecturers involved in the lecturing of the Cell Biology Course from three selected Colleges of Education in Southwest, Nigeria. At this stage, familiarization was done and debriefing of what the researchers study entailed and how it was carried out. This stage lasted for about two weeks.

Training of Teachers/ Facilitators

The researcher spent two (2) weeks training the facilitators in the experimental groups on how to teach BIO 112 (Cell Biology) with the IIIS and CPIS. The facilitators were instructed by the researcher on how to utilise the treatment guide. To ensure that the guidelines were used successfully for the specific purpose for which they were intended, the researcher thoroughly explained any areas of difficulty and assessed the facilitators' understanding of how to use the instructions. For emphasis further re-training of the Facilitators were done so that they meet the required standard to remove further disparities.

3.5.2 Pretest/Prior treatment

The pretest lasted for one (1) week in all the selected federal colleges. The response instruments were administered to both control and experimental colleges. The following order was used to administer the response instruments: At first, the Pre-Service Teachers Interest in Cell Biology Questionnaire (PTICBQ) was given. Before taking the Pre-service Teachers Cell Biology Achievement Test (PTCBAT), candidates took the Pre-service Teachers Cell Biology Problem-solving Ability Test (PTCBPAT). The Pre-service Teachers Cognitive Styles Test (PTCST) was given last.

3.5.3 Treatment Stage

In the first semester of the school year 2021–2022, this stage lasted for eight (8) weeks. The IIIS were taught to experimental group I, the Experimental Group II were taught using the CPIS, and the traditional approach was used to teach the control group.

Experimental Group 1: Interactive Invention Strategy

Phase I: Presentation

Activity I: Students are handed worksheets as the lecturer analyses prior assignments and asks them some questions on the material covered in the previous class.

Activity II: An Instruction of the lesson

a. Introduction on the lesson. The What.
b. Explains why the topic is important. The Why.
c. Explanation of the topics
d. Lecturer ask questions to ascertain understanding.

Phase II: Practice

Activity I: Guided practice: Students are instructed to practise and are divided into groups of eight to enhance competence by completing assigned assignments and clarifying any unclear concepts.

Activity II: Students continuous Practice: Here, the students are free to work continually in groups on the topics they have learned, reinforcing their mastery of the learned content.

Activity III: Review periodically: Students ask questions to get reviews on learned concepts, to reinforce concept(s) and skill(s) proficiency.

Phase III: Monitoring and Evaluation

Activity I: Daily Assessment: student teachers' materials are assessed are checked to offer corrections and instructions as the need arises.

Activity II: Summative Assessment (Mastery): student teachers' worksheets are checked each week. Feedbacks are handed in to the student teachers, these is to sustain the learning.

Experimental Group 2: Crossword Puzzle-based Instructional Strategy

Step I: In order to capture students' attention and activate their prior knowledge of the subject, the lecturer starts the course by posing theoretical questions.

Step II: Students are given a quiz, which is the cell biology puzzle with clues/keys, which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single puzzle from their individual puzzles for presentation.

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

Step VIII: The instructor concludes by assigning a task to further evaluate the learned abilities.

Control Group:

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork

7. The lecturer assign marks to the students work.

8. The lecturer gives an assignment.

3.5.4 Administration of Posttest:

It took two (2) weeks to complete this phase. The post-test instruments titled Pre-service Teachers Interest in Cell Biology Questionnaire (PTICBQ) was administered first to get their interest in cell biology concept followed by Pre-service Teachers Cell Biology Achievement Test (PTCBAT) in all the treatment groups (IIIS, CPIS and CIS).

3.6 Procedure for Data Analysis

Pre-test scores were utilised as covariates in the analysis of the data, which was done using inferential statistics like Analysis of Covariance (ANCOVA). Estimated Marginal Means (EMM) was employed when there existed significant main effects. The Bonferroni Post-hoc Analysis was utilised to further explain the origins of the significant differences. Graphical representations were utilised to describe significant interaction effects in cases where they existed.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Demographic Data

4.1.1 Participants Demographics from the Treatment (IIIS, CPIS and CIS), Problem-solving and Cognitive Style

Table 4.1 shows participants demographics from the study's treatment.

Table 4.1: Participants Distribution by Instructional Strategy (Treatment), Problem-solving and Cognitive Style

Variables	N	%
Treatment		
Interactive Invention Instructional Strategy (IIIS)	146	36.1
Crossword Puzzle Based Instructional Strategy (CPBIS)	134	33.2
Conventional Instructional Strategy (CIS)	124	30.7
Total	**404**	**100**
Problem-solving Ability		
High	216	53.5
Low	188	46.5
Total	**404**	**100**
Cognitive Style		
Analytical	105	26.0
Non-Analytical	299	74.0
Total	**404**	**100**

Table 4.1 indicates 146 (36.1) of the pre-service teachers who were the participants were in the Interactive Invention Instructional Strategy (IIIS) (Experimental Group 1), 134 (33.2) were in the Crossword Puzzle-based Instructional Strategy (CPIS), and then 124 (30.7) were in the Conventional Instructional Strategy (Control group). It revealed that 216 (53.5) pre-service teachers were classified in the high problem-solving ability aspects while 188 (46.5) pre-service teachers were classified as low problem-solving ability. The table further revealed that 105 (26.0) pre-service teachers were classified as analytical cognitive style learners while 299 (74) pre-service teachers were classified as non-analytical cognitive style learners.

4.2 Null Hypotheses Testing

4.2.1 Hypothesis 1a: There is no significant effect of treatment on pre-service teachers' achievement in Cell Biology

Table 4.2 shows the ANCOVA table for the main effects of treatment, problem-solving ability and cognitive style and the two-way and three-way interaction effects on pre-service teachers' achievement in Cell Biology.

Table 4.2: Analysis of Covariance (ANCOVA) of Post-Achievement by Treatment, Problem-solving Ability and Cognitive Style

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1671.690	12	139.307	17.910	0.000	0.355
Intercept	2402.706	1	2402.706	308.904	0.000	0.441
PreAchievement	984.313	1	984.313	126.548	0.000	0.245
Treatment	587.695	2	293.847	37.779	0.000*	0.162
Problem Solving Ability	12.858	1	12.858	1.653	0.199	0.004
Cognitive Style	22.412	1	22.412	2.881	0.090	0.007
Treatment x Problem Solving Ability	5.670	2	2.835	0.365	0.695	0.002
Treatment x Cognitive Style	46.301	2	23.151	2.976	0.052	0.015
Problem Solving Ability x Cognitive Style	0.019	1	0.019	0.002	0.961	0.000
Treatment x Problem Solving Ability x Cognitive Style	62.232	2	31.116	4.000	0.019*	0.020
Error	3041.261	391	7.778			
Total	111752.000	404				
Corrected Total	4712.950	403				

R Squared = 0.36 (Adjusted R Squared =0.34) *indicates the level of significance at $p<0.05$

Table 4.2 indicated a significant main effect of treatments on pre-service teachers' achievement in cell biology ($F_{(2, 402)} = 37.78$; $p<0.05$, partial $\eta^2 = 0.162$). The effect is 16.2%. This demonstrates that the significant main effect of the treatments accounted for 16.2% of the total difference in pre-service teachers' post-achievement in cell biology teaching and learning in this model, rejecting hypothesis 1a. The estimated marginal means is used to explain the magnitude of the significant main effect of treatment groups. Table 4.3 shows the result for EMM.

Table 4.3: Estimated Marginal Means of Post-Achievement by Treatment and Control Group

			95% Confidence Interval	
Treatment	Mean	Std. Error	Lower Bound	Upper Bound
Interactive Invention Instructional Strategy (IIIS)	17.75	0.269	17.223	18.280
Crossword Puzzle-based Instructional Strategy (CPIS)	17.17	0.297	16.588	17.756
Conventional Instructional Strategy (CIS)	14.12	0.330	13.475	14.774

According to Table 4.3, Cell Biology pre-service teachers who participated in the Interactive Invention Instructional Strategy (IIIS) treatment group had better adjusted mean score in their post-achievement in cell biology (17.75), trailed by student teachers in the Crossword Puzzle-based Instructional Strategy (CPIS) treatment group (17.17), and their peers who participated in the Conventional Instructional Strategy (CIS) control group (14.12). It is represented as IIIS>CPIS>CIS. The groups were analysed using Bonferroni post-hoc to determine which group was responsible for the treatment's effect on student teachers' performance in cell biology. Thus, Table 4.4 shows the Bonferroni Post-hoc analysis on the effect of treatment.

Table 4.4: Bonferroni Post-hoc Analysis of Post-Achievement by Treatment and Control groups

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Sig.
Interactive Invention Instructional Strategy (IIIS)	Crossword Puzzle-based Instructional Strategy (CPIS)	0.580	0.435
	Conventional Instructional Strategy (CIS)	3.627*	0.000
Crossword Puzzle-based Instructional Strategy (CPIS)	Interactive Invention Instructional Strategy (IIIS)	-0.580	0.435
	Conventional Instructional Strategy (CIS)	3.048*	0.000
Conventional Instructional Strategy (CIS)	Interactive Invention Instructional Strategy (IIIS)	-3.627*	0.000
	Crossword Puzzle-based Instructional Strategy (CPIS)	-3.048*	0.000

*. The mean difference is significant at the 0.05 level.

According to Table 4.4, the post-achievement means scores of pre-service teachers who were taught through the Interactive Invention Instructional Strategy (IIIS) were not different significantly than those in the Crossword Puzzle-based Instructional Strategy (CPIS), but differs significantly from those taught through the conventional Instructional Strategy (CIS). As shown in Table 4.3, the student teachers who were taught using the Crossword Puzzle-based Instructional Strategy (CPIS) and their counterparts who were taught using the Conventional Instructional Strategy (CIS) had significant different post-achievement mean scores. These findings suggest that, when it comes to the student teachers post-achievement scores, changes in the ANCOVA result are caused by differences between the treatment groups and the control groups, rather than between the treatment groups themselves.

Hypothesis 1b: There is no significant main effect of treatment on pre-service teachers' interest in Cell Biology

Table 4.5 shows the ANCOVA table for the main effects of treatment, problem-solving ability and cognitive style and the two-way and three-way interaction effects on pre-service teachers' interest in Cell Biology.

Table 4.5: Analysis of Covariance (ANCOVA) of Post-Interest by Treatment, Problem-solving Ability and Cognitive Style

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14178.307	12	1181.526	35.389	0.000	0.521
Intercept	7011.892	1	7011.892	210.022	0.000	0.349
PreInterest	7753.131	1	7753.131	232.223	0.000	0.373
Treatment	3659.691	2	1829.846	54.808	0.000*	0.219
Problem Solving Ability	108.203	1	108.203	3.241	0.073	0.008
Cognitive Style	41.577	1	41.577	1.245	0.265	0.003
Treatment x Problem Solving Ability	124.150	2	62.075	1.859	0.157	0.009
Treatment x Cognitive Style	83.939	2	41.970	1.257	0.286	0.006
Problem Solving Ability x Cognitive Style	117.038	1	117.038	3.506	0.062	0.009
Treatment x Problem Solving Ability x Cognitive Style	78.984	2	39.492	1.183	0.307	0.006
Error	13054.136	391	33.387			
Total	2578229.000	404				
Corrected Total	27232.443	403				

R Squared = 0.521 (Adjusted R Squared = 0.51) *shows the significance at $p<0.05$

Table 4.5 indicates there is a significant main effect of treatment on the interest in cell biology of pre-service teachers ($F_{(2, 403)} = 55.00$; $p>0.05$, partial $\eta^2 = 0.219$). The outcome is 21.9%. According to this, the treatment's significant main effect accounts for 21.9% of the total difference in pre-service teachers' post-interest in cell biology teaching and learning in this model. So, hypothesis 1b was rejected. The estimated marginal means was used to explain the effect and difference of each treatment groups and the results are shown in table 4.6. This was done to investigate the size of the significant main effect across treatment groups.

Table 4.6: Estimated Marginal Means for Post-Interest by Treatment and Control groups

			95% Confidence Interval	
Treatment	Mean	Std. Error	Lower Bound	Upper Bound
Interactive Invention Instructional Strategy (IIIS)	82.25	0.555	81.154	83.336
Crossword Puzzle-based Instructional Strategy (CPIS)	80.90	0.621	79.679	82.120
Conventional Instructional Strategy (CIS)	73.52	0.670	72.204	74.838

Table 4.6 showed that the Conventional Instructional Strategy (CIS) control group (73.52) was the least with an adjusted mean score in post-interest in cell biology. The pre-service teachers taught with the Interactive Invention Instructional Strategy (IIIS) treatment group 1 had the better adjusted mean score in post-interest in cell biology (82.25), trailed by those taught with Crossword Puzzle-based Instructional Strategy (CPIS) treatment group 2 (80.90). It is represented as IIIS>CPIS>CIS. The Bonferroni post-hoc analysis is used to identify which group is responsible for this significant main effect of treatment across groups as shown in table 4.7.

Table 4.7: Bonferroni Post-hoc Analysis of Post-Interest by Treatment and Control Groups

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Sig.
Interactive Invention Instructional Strategy (IIIS)	Crossword Puzzle-based Instructional Strategy (CPIS)	1.346	.330
	Conventional Instructional Strategy (CIS)	8.724*	.000
Crossword Puzzle-based Instructional Strategy (CPIS)	Interactive Invention Instructional Strategy (IIIS)	-1.346	.330
	Conventional Instructional Strategy (CIS)	7.378*	.000
Conventional Instructional Strategy (CIS)	Interactive Invention Instructional Strategy (IIIS)	-8.724*	.000
	Crossword Puzzle-based Instructional Strategy (CPIS)	-7.378*	.000

*. The mean difference is significant at the 0.05 level.

According to Table 4.7, the post-interest means scores of pre-service teachers who were taught through the Interactive Invention Instructional Strategy (IIIS) were not different significantly than those in the Crossword Puzzle-based Instructional Strategy (CPIS), but differs significantly from those taught through the conventional Instructional Strategy (CIS). Table 4.7 showed that student teachers who taught using Crossword Puzzle-based Instructional Strategy (CPIS) had a significantly different post-interest mean scores than those taught using the Conventional Instructional Strategy (CIS). This demonstrates that the significant difference between the treatment groups (Interactive Invention and Crossword Puzzle-based Instructional Strategies) and the control group, as measured by students' post-interest in cell biology, is not the result of differences between the treatment groups themselves but rather between the treatment groups and the control group.

4.2.2 Hypothesis 2a: There is no significant main effect of problem-solving ability on pre-service teachers' achievement in cell biology

Table 4.2 reveals that there is no significant main effect of problem-solving ability on pre-service teachers' achievement in cell biology ($F_{(2, 403)} = 1.65$; $p>0.05$, partial $\eta^2 = 0.004$). Therefore, hypothesis 2a was not rejected. This suggests that the achievement of pre-service teachers in cell biology is unaffected by their capacity to solve problems.

Hypothesis 2b: There is no significant main effect of problem-solving ability on pre-service teachers' interest in cell biology.

According to Table 4.5, the main effect of problem-solving ability on pre-service teachers' interest in cell biology is not statistically significant ($F_{(2, 403)} = 0.07$; $p>0.05$, partial $\eta^2 = 0.008$). As a result, hypothesis 2b was not rejected. This suggests that pre-service teachers' interest in cell biology is unaffected by their capacity to solve problems.

4.2.3 Hypothesis 3a: There is no significant main effect of cognitive style on pre-service teachers' achievement in cell biology

The achievement of pre-service teachers in cell biology ($F_{(2, 403)} = 2.88$; $p>0.05$, partial $\eta^2 = 0.007$) is not significantly impacted by cognitive style, according to Table 4.2. So, 3a was not rejected. This implies that pre-service teachers' performance in cell biology is unaffected by their cognitive style.

Hypothesis 3b: There is no significant main effect of cognitive style on pre-service teachers' interest in cell biology.

According to Table 4.5, there is no significant main effect of cognitive style on the interest of pre-service teachers in cell biology ($F_{(2, 403)} = 0.27$; $p>0.05$, partial $\eta^2 = 0.003$). As a result, hypothesis 3b was not disproved. This implies that pre-service teachers' interest in cell biology is unaffected by their cognitive style.

4.2.4 Hypothesis 4a: There is no significant interaction effect of treatment and problem-solving ability on pre-service teachers' achievement in cell biology

According to Table 4.2, there is no significant interaction effect of treatment and problem-solving ability that might affect pre-service teachers' achievement in cell biology ($F_{(2, 403)} = 0.37$; $p>0.05$, partial $\eta^2 = 0.002$). As a result, 4a was not rejected. This suggests treatment and problem-solving ability could not cause a significant interaction effect on pre-service teachers' achievement in cell biology.

Hypothesis 4b: There is no significant interaction effect of treatment and problem-solving ability on pre-service teachers' interest in cell biology.

According to Table 4.5, there is no significant interaction effect of treatment and problem-solving ability that might affect pre-service teachers' interest in cell biology ($F_{(2, 403)} = 0.16$; $p>0.05$, partial $\eta^2 = 0.009$). Thus, hypothesis 4b was not rejected. This suggests treatment and problem-solving ability could not cause a significant interaction effect on pre-service teachers' interest in cell biology.

4.2.5 Hypothesis 5a: There is no significant interaction effect of treatment and cognitive style on pre-service teachers' achievement in cell biology

According to Table 4.2, there is no significant interaction effect of treatment and cognitive style that might affect pre-service teachers' achievement in cell biology ($F_{(2, 402)} = 2.98$; $p<0.05$, partial $\eta^2 = 0.015$). Thus, hypothesis 5a was not rejected. This suggests treatment and cognitive style could not cause a significant interaction effect on pre-service teachers' achievement in cell biology.

Hypothesis 5b: There is no significant interaction effect of treatment and cognitive style on pre-service teachers' interest in cell biology.

According to Table 4.5, there is no significant interaction effect of treatment and cognitive style that might affect pre-service teachers' interest in cell biology ($F_{(2, 402)} = 0.29$; $p>0.05$, partial $\eta^2 = 0.006$). Thus, hypothesis 5b was not rejected. This suggests treatment and cognitive style could not cause a significant interaction effect on pre-service teachers' interest in cell biology.

4.2.6 Hypothesis 6a: There is no significant interaction effect of problem-solving ability and cognitive style on pre-service teachers' achievement in cell biology

According to Table 4.2, there is no significant interaction effect of problem-solving ability and cognitive style that might affect pre-service teachers' achievement in cell biology ($F_{(2, 403)} = 0.002$; $p>0.05$, partial $\eta^2 = 0.00$). Thus, hypothesis 6a was not rejected. This suggests problem-solving ability and cognitive style could not cause an interaction effect on student teachers' achievement in cell biology.

Hypothesis 6b: There is no significant interaction effect of problem-solving ability and cognitive style on pre-service teachers' interest in cell biology.

According to Table 4.5, there is no significant interaction effect of problem-solving ability and cognitive style that might affect pre-service teachers' interest in cell biology ($F_{(2, 403)} = 0.06$; $p>0.05$, partial $\eta^2 = 0.009$). Thus, hypothesis 6b was not rejected. This

suggests problem-solving ability and cognitive style could not cause a significant interaction effect on pre-service teachers' interest in cell biology.

4.2.7 Hypothesis 7a: There is no significant interaction effect of treatment, problem-solving ability and cognitive style on pre-service teachers' achievement in cell biology

The effects of treatment, problem-solving ability, and cognitive style on the achievement of pre-service teachers in cell biology ($F_{(2, 402)} = 4.00$; $p>0.05$, partial $\eta^2 = 0.02$) were shown in Table 4.2 to be significant. 2.0% is the effect size. This demonstrates the interaction effect of treatment, problem-solving ability, and cognitive style accounts for 2.0% of the variation in pre-service teachers' achievement in cell biology. Therefore, hypothesis 7a was disproved. This suggests that pre-service teachers' achievement in cell biology is influenced by the interaction of treatment, problem-solving ability, and cognitive style. Table 4.8 below shows the mean score level for the treatment, problem-solving ability and cognitive style interaction effect.

Table 4.8: Shows the Post-achievement Mean Scores of the Interaction Effect of Treatment, Problem-solving Ability and Cognitive Style

Treatment	Problem-solving Ability	Cognitive Style	Mean Score
Interactive Invention Instructional Strategy	High	Analytical	18.61
		Non-analytical	16.68
	Low	Analytical	18.23
		Non-analytical	17.48
Crossword Puzzle-based Instructional Strategy	High	Analytical	16.91
		Non-analytical	16.58
	Low	Analytical	16.89
		Non-analytical	18.30
Conventional Instructional Strategy	High	Analytical	13.76
		Non-analytical	14.23
	Low	Analytical	15.43
		Non-analytical	13.08

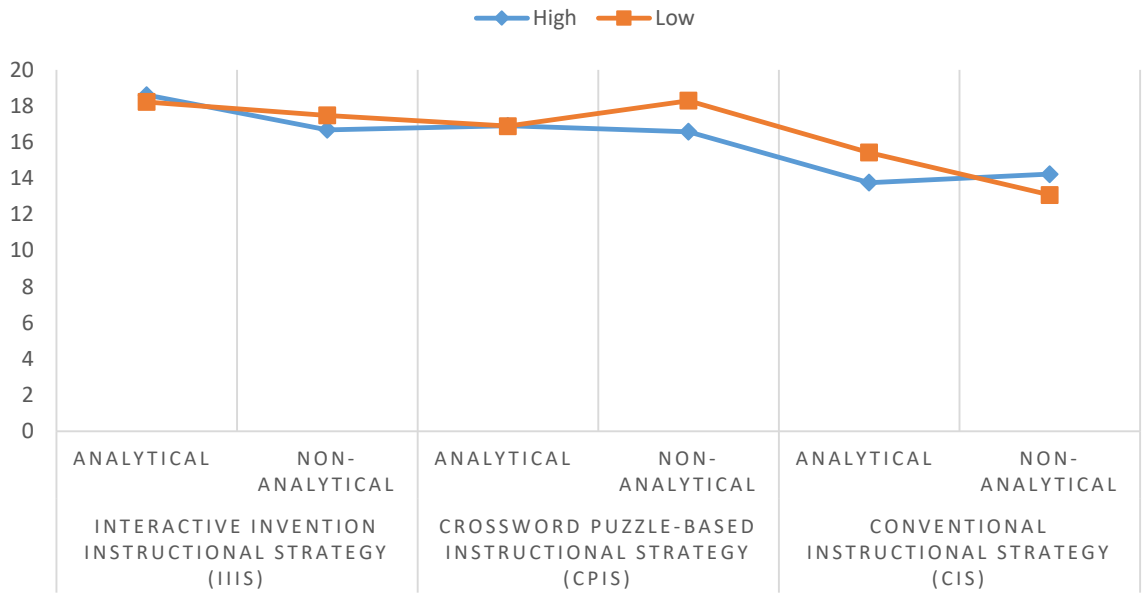


Figure 4.1: Interaction Effect of Treatment, Problem-solving Ability and Cognitive Style on Pre-service Teachers' Achievement in Cell Biology

Figure 4.1 revealed better post-achievement mean scores in cell biology (18.61) of pre-service teachers with high problem-solving ability and analytical cognitive style in the interactive invention instructional strategy. Followed by pre-service teachers with low problem-solving ability and non-analytical cognitive style in crossword puzzle-based instructional strategy (18.30). Pre-service teachers with low problem-solving ability and analytical style in interactive invention instructional strategy (18.23), pre-service teachers with low problem-solving ability and non-analytical cognitive style in interactive invention instructional strategy (17.48), pre-service teachers with high problem-solving ability and analytical cognitive style in crossword puzzle-based instructional strategy (16.91). Pre-service teachers with low problem-solving ability and analytical cognitive style in crossword puzzle-based instructional strategy (16.89), pre-service teachers with high problem-solving ability and non-analytical cognitive style in interactive invention instructional strategy (16.69). Pre-service teachers with high problem-solving ability and non-analytical cognitive style in crossword puzzle-based instructional strategy (16.58), pre-service teachers with low problem-solving ability and analytical cognitive style in conventional instructional strategy (15.43). Pre-service teachers with high problem-solving ability and non-analytical cognitive style in conventional instructional strategy (14.23), pre-service teachers with high problem-solving ability and analytical cognitive style in conventional instructional strategy (13.76). Pre-service teachers with low problem-solving ability and non-analytical cognitive style in conventional instructional strategy (13.08). The interaction is disordinal. The treatment (IIIS and CPIS) have different impact on different groups. For example, The IIIS enhances the performance of high problem-solving ability and analytical cognitive style pre-service teachers while the CPIS enhanced the performance of low problem-solving ability and non-analytical cognitive style pre-service teachers.

Hypothesis 7b: There is no significant interaction effect of treatment, problem-solving ability and cognitive style on pre-service teachers' interest in cell biology.

According to Table 4.5, there existed no significant interaction effect of treatment, problem-solving ability and cognitive style that might affect pre-service teachers' interest in cell biology ($F_{(2, 403)} = 0.31$; $p>0.05$, partial $\eta^2 = 0.006$). Thus, hypothesis 7b was not rejected. This suggests treatment, problem-solving ability and cognitive style

could not cause a significant interaction effect on pre-service teachers' interest in cell biology.

4.3 Discussion of Findings

4.3.1 Main Effect of Treatment on Pre-service Teachers' Achievement in Cell Biology

The findings indicates that treatment improved student teachers' performance in cell biology. This demonstrates that learners in the Interactive Invention Instructional Strategy (IIIS) recorded better post-achievement mean scores and that their mean is significantly different from the pre-service teachers' post-achievement mean score in the Crossword Puzzle-Based Instructional Strategy (CPIS) and the traditional method respectively. The reason why the interactive invention and crossword puzzle-based instructional strategies outperformed the traditional instructional strategy in raising pre-service teachers' post-achievement scores in cell biology is because both of them gave students the opportunity to collaborate in groups and come up with solutions to the problems they were given. Interactive invention instructional strategy has worksheets that meant pre-service teachers where placed in groups to find the solutions to the problems, and further repeat the already solved concept to help in retention of the concept. The lecturers does a periodic review of the content already learnt to help them know the correct answers.

Crossword puzzle-based instructional strategy has a puzzle where the pre-service teachers' answers the questions asked at the beginning of the lecture, solves the puzzle individually. They worked in groups and then present their answers as a group and the lecturers does a further elaborate analysis of the content for retention are the features that improved on pre-service teachers' achievement in cell biology. It is important to note that both strategies placed emphasis on a collaborative teaching style, pre-service teachers' active participation, and an activity-based approach to instruction. To ensure that the learners had a thorough comprehension of the concept of cell biology, the nature of the strategy emphasis that the pre-service teachers take responsibility for their own learning while the lecturer facilitates the learning process.

The results from the study reinforces the position of the constructivist theory which states that, for proper understanding of a concept, students/pre-service teachers should construct their own knowledge. Bruner (1961) stated that the best method to create a coding system is to figure it out on your own rather than having it lectured to

you. This enforces what Bruner's constructivist theory says that rather than being informed by a teacher the most efficient method is that the students' should establish their learning. He suggested that, in discovery learning pupils create their own knowledge. In essence, the lecturers' duty should not be to impart material through rote learning, but rather to promote the learning process. Bruner believes that the premise was that students are active learners and should be able to construct their knowledge and interact with others and the materials in the group. Bruner's educational implications states that education should be designed to develop independent learners (learning to learn). The two instructional strategies IIIS and CPIS had activities that upheld the position of the Bruner as learners discovered the answers to the worksheets and puzzle on their own before the instructor reviewed and gave feedbacks that enabled understanding of the concept taught.

Onifade (2017) stated that interactive invention strategy (IIS) is a technique used to instruct students in both concepts, and skills. In order to handle skills and concepts, a mix of the instructors teaching and practice by the learners, inventiveness, and feedback is used. When using an interactive invention instructional strategy, students are expected to actively participate in answering questions from the teachers, examining the provided examples, and developing abilities to the point where they can be employed with little to no thought (Nsofor, 2019). In comparison to other strategies, the researcher found that employing the interactive invention strategy results in higher test scores when standardized tests of fundamental skills are utilized. Ogunbowale (2014) indicated that interactive innovation entails the use of continual modelling by teachers, which has receding lecturer's participation and involvement as the learners practice and master the learned content. In the colleges of education, learners performance have improved thanks to the use of the interactive invention strategy, according to different scholars (Ukoh 2012; Ogunbowale, 2014; Onifade 2017).

Puzzle-based instructional strategy is an activity-based approach to instruction, which gives learners advantage to collaborate others and the instructional materials, promotes brainstorming, and allows exploration of concepts through interrogation (Umoru, Adejoh, and Iji, 2016). Farlex (2009) and Umoru, Adejoh, and Iji (2016) defines puzzles as a game that needs creativity and persistence in solving various problems. There stated that utilizing puzzles as an instructional approach may be effective in response to diverse learning styles exhibited by students. Puzzles show

potency in exciting and maintaining students' attitude in learning and generate new ideas to learn difficult concepts. Both strategies are activity-based, hands-on, student centred approach to teaching that helped students become active learners in the classroom. The worksheets and the puzzle helped the students to work individually as well as in groups giving them the opportunity to collaborate with others by brainstorming on the problem.

More so, the results indicates that pre-service teachers in the interactive invention instructional strategy had the highest achievement in cell biology. This may be explained by the fact that the method encourages recurrent learning to promote knowledge and assimilation. It is an activity-based strategy with a worksheet and is practical in nature. The practise component of the course is kept interesting for the students by the interactive invention instructional strategy, which emphasises frequent interaction between pre-service teachers and the materials (Ukoh, 2021; Onifade, 2017). The fact that students worked initially alone and then in groups, honing their teamwork and collaboration abilities, could also be considered a contributing factor. The worksheet also allowed the pre-service teachers to readily review what had already been taught, allowing them to interact with the course materials regularly.

This conclusion is consistent empirically with Ukoh (2022) research on the effectiveness of the Interactive-invention approach and learners' performance in electromagnetic concepts in physics in the Ibadan North Local Government Area. The results showed that in the experimental groups, the treatment had a significant main effect on the academic achievement of the learners. The results do not support those of Onifade (2017), who found that students who used interactive invention strategies in physics did worse than those who used pre-lesson assignments and weekly formative assessments. The findings aligns with Ukoh (2021) research on the impact of interactive-invention approach on the learning outcomes in physics. The findings revealed that learners interactive invention approach had a better performance than those in conventional. An in-class interview showed that students enjoyed learning the concepts because of the hands-on experience and preferred to be taught with interactive-invention instructional strategy.

Ukoh and Onifade's (2020) research on pre-lesson assignments and formative assessment on low achievers in physics buttressed the effectiveness of interactive invention strategy. Results indicated the impact of the approach on physics low-achieving learners. Ogunbowale's (2014) study on the impact of problem-based and

interactive invention approaches on secondary school students' attitudes towards biology provided support for this. The main effect of the treatment group on the performance of biology students was seen in the study's results. Research by Okurumeh (2016) on secondary school students' retention of chemistry concepts in Delta State, Nigeria, revealed that discussion and invention methods of instruction were superior to the lecture method in terms of helping students remember chemical topics. The results are consistent with Ukoh (2012) investigation into the effects of interactive invention and problem-based learning on NCE student teachers' performance. Student teachers' knowledge of practical skills and their mastery of physics principles showed that the treatment had a significant main effect on their performance in physics concepts.

The study's findings showed that a crossword puzzle-based instructional strategy (CPIS) had a better effective than the traditional instructional strategy in the improvement of student teachers' performance in cell biology at colleges of education. This could be ascribed to the strategy being an activity-based approach in which puzzles are used in teaching and learning. This could also indicate that CPIS encouraged the development of confidence, problem-solving ability skills, team spirit, and collaboration talents, all of which are required to tackle real-life challenges.

The results are also consistent with Samuel and Iliyasu's (2020) study on the impact of a crossword-picture puzzle learning approach on basic science students' performance in Nigeria's Nasarawa state. The outcome demonstrates significant differences between students taught using the crossword-picture puzzle learning strategy and those taught using the conventional approach in terms of mean achievement scores. When compared to their counterparts taught using the traditional way, crossword puzzle learning produced greater achievement scores. Results from Olumide (2018) revealed that treatment was able to improve learners performance, ability to solve problems, and attitude to some biological concepts. According to Ogundare's (2014) research, treatment improved learners performance, attitude, and ability to solve problems in basic science subject.

Ogundiwin's (2013) research on puzzle approach improved learners' achievement scores in some concepts in Biology more than the traditional approach when compared to Pre-Theoretic Intuition Quiz (PTI) and PTI-based learning outcomes in selected biology concepts related to the environment. Babayemi and Akinsola's (2014) research on the use of the crossword-picture puzzle teaching

strategy and mental ability improved learners' performance in integrated science in junior school. Olagunju and Babayemi's (2014) study on the impact of gender and the picture puzzle approach on learners' basic science achievement revealed that the intervention improved learners' performance in concepts in integrated science.

4.3.2 Main Effect of Treatment on Pre-service Teachers' Interest in Cell Biology

The results showed a significant main effect of treatment on the interest in cell biology among pre-service teachers. It also showed that the CIS, the control had the least score in post-interest. Whereas pre-service teachers taught with IIIS, treatment group 1 had the better post-interest in cell biology, trailed by those in the CPIS treatment group 2. The effectiveness of the interactive invention and crossword puzzle-based instructional strategies over the conventional instructional strategy in improving pre-service teachers' post-interest scores in cell biology could be because both strategies has materials that kept them interested in cell biology. Particularly, pre-service teachers' in interactive invention instructional strategy has a worksheet that meant that they would interact with the materials as well as interact with others within their group. Continuous practice of the already learnt continue meant a revisit of the concept, which kept them interested in the cell biology course. The pre-service in crossword instructional strategy has a puzzle where students had to find the solution individually. They further found the solution in groups through brainstorming to produce a copy, which they used to present the group answers and the instructors review and elaborate analysis of the concept kept them interested in the cell biology concept, which has shown in the improvement in their post-interest scores. The group interactions amongst the student teachers had an effect on their affective domain of learning more than other innate abilities, which in turn affected how cell biology is taught at the tertiary level.

According to constructivist theorist Jerome Bruner, the intelligent mind develops an experience that is a coding process, that enables an individual to venture above what was given as data to fresh and likely successful guesses (Bruner, 1960). Learners must therefore learn specific techniques to demonstrate the recurring patterns in their environment as they grow. The key principle of Bruner's theoretical framework is a process where learners are actively involved in the learning and are required to produce new concepts or ideas tapping the information from previous knowledge or existing information. They are expected to have a cognitive framework to pick and

adjust the information given, before generating wise guesses and finally passing judgement. When it comes to instruction, the instructor is expected to motivate the learners to discover new ideas or concepts by them selves. Active discussion between the learners and the teacher is ideal (also known as Socratic learning). It is the responsibility of the instructor to modify the knowledge to be learned in a way that is appropriate for the learner's current comprehension level. For a pre-service teacher to perform effectively he/she must be interested in what is being taught. The two experimental strategies, the interactive invention instructional strategies and crossword puzzle-based instructional strategies are both hands-on and activity based strategy that makes learners active participants in the learning process. This active process could have helped improve students' interest to the concept of cell biology being taught by the lecturer.

Presently, there has been calls for the usual teacher dominated classrooms to learner dominated learning environments where learners are responsible for what they learn while the instructor serves as the facilitator or guide (Derer and Berkant, 2019). Puzzle strategy is the introductory method to developing intellectual skills. The strategy's objective is to encourage learners to decipher ways to solve various issues. The essence is to stimulate the learners in a way that can improve their ability to solve different problems through brainstorming using their various worksheets and puzzles (Meyer, Falkner, Sooriamurthi, and Michalewicz, 2014). These activities could been what helped increased their interest in cell biology. Having to actively solve the worksheets individually and in groups, solve the puzzle individually and in groups plus brainstorming and presenting the answers to the rest of the class could have helped improve their interest in the cell biology course.

This result collaborates the research on improving learners' attitude by teaching using puzzle approach in biology in Wukari. The outcomes demonstrate that the puzzle-based learning technique was able to significantly change the attitudes of the learners (Umoru, Adejoh and Iji, 2016). Similarly, Ukoh (2022) findings showed attitude and performance was improved when learners were taught using interactive invention approach in some electromagnetic topics.

4.3.3 Main Effect of Problem-solving Ability on Pre-service Teachers' Achievement and interest in Cell Biology

The results showed that problem-solving skills have no significant main effect on student teachers' performance and interest in cell biology. This suggests that student teachers' performance and interest in cell biology are unaffected by their ability to solve problems. This finding means that problem-solving ability was not able to cause an effect on achievement and interest in cell biology. The problem-solving ability test was characterised by solving cell biology related problem and this problem did not directly cause an effect on student teachers' interest and performance in cell biology. This indicate that no aspect of problem-solving ability test caused an effect on student teachers' performance and interest in cell biology. The problem-solving ability as a psychological cognitive variable is by nature independent of a particular content. They used their problem-solving skills to factor in their responses when given worksheets and puzzles to complete, but the content provided by the strategies brought about the improvement, therefore this had no impact on their performance and interest in cell biology. The findings disagree with Nnorom's (2019) research on the impact of problem-solving strategies on biology achievement in secondary schools. Findings showed that students taught with problem based-Solving techniques had a better performance than those in the traditional approach. The results also disagrees with a study on problem-solving teaching on learners' performance and practical skills abilities in future elementary teachers. The results demonstrated significant differences between experimental and control groups in terms of academic achievement and science process skills (Saputro, Irwanto, Atun, and Wilujeng, 2019).

The findings of Usman and Sule (2017) study on the impact of the problem-solving approach on physics learners' attitude and performance in Jos North, are in direct opposition to the conclusions of this study. The findings indicate that, following treatment, male learners' performance levels with their attitudes were much better than the females. The finding does not align to Smitha and Manoj (2018) research that shows that there is a link between problem solving ability and performance achievement. It does not align with the finding of Jayanthi and Tholappan (2017) whose study shows a relation between problem-solving ability and achievement. The finding disagrees with the research of Kaur and Kaur (2021) on the impact of cooperative approach on learners performance in mathematics with respects to their

problem-solving ability. Results shows that there is a variation with the performance of learners with respect to their problem-solving ability in mathematics. It further shows an effect of problem-solving ability on the learners' performance in mathematics. It agrees with the research of Sung (2017) on the visual propensity and problem solving on pupils performance. It utilised two hundred and twenty-three respondents. It was a survey design. Findings indicates there existed no influence of problem solving ability on pupils performance in the study.

4.3.4 Main Effect of Cognitive Style on Pre-service Teachers' Achievement and Interest in Cell Biology

The findings indicate that cognitive style could not influence pre-service teachers' performance or interest in cell biology. This suggests that the way learners can analyse pictures or images does not affect their performance and interest in Cell Biology. The nature of the cognitive style as a psychological cognitive variable is independent of a particular content. When they were given worksheets and puzzles to complete, they used their cognitive styles to factor in their answers where there were pictures present, but the information taught by the strategies brought about the improvement, so this did not affect their performance and interest in cell biology. The results do not agree with those of Hussin, Razali, and Agussalim (2021) research on learners performance being influenced by cognitive style in Economics course showed that, FI learners outperformed FD learners in terms of achievement scores. The results also go against Agu and Samuel (2019) research on the impact of cognitive learning approaches on learners' performance in scientific and technical colleges in Nigeria's Nasarawa state. Results shows that field independent (FI) cognitive style science and technical students performed better than their counterpart in the field dependent (FD) cognitive style. This finding does not replicate Idika (2017) research on learners performance and attitude to chemistry being influenced by cognitive style and gender. The result shows that there existed a significant difference between field dependent and field independent students' achievement in chemistry. It also does not support the findings of Olagunju and Ogundiwin (2008) study on the use of cognitive style with three approaches of teaching on learners attitudes to pollution. The findings of the study indicates that cognitive style was able to improve on the learners attitude to some environmental concepts in biology.

4.3.5 Interactive Effect of Treatment and Problem-solving Ability on Pre-service Teachers' Achievement and interest in Cell Biology

The findings revealed that there existed no interaction effect of treatment and problem-solving ability on pre-service teachers' performance and interest in cell biology. This suggests that there is no interaction between treatment and the ability to solve problems and pre-service teachers' achievement and interest in cell biology. This demonstrates that the intervention (IIIS, CPIS and CIS) had no impact on pre-service teachers' achievement or interest in cell biology when combined with high and low problem-solving ability. The psychological variable problem-solving ability, when combined with the two strategies, suggests that it was insufficient to have an interaction effect on student teachers' interest and achievement in cell biology because it is independent of the subject matter of cell biology. Malik, Shah, Iqbal, and Rauf (2010) study on the impact of a problem-solving method of instruction on eighth-grade learners' attitudes towards science shows the opposite. In contrast, to the learners in the control group, the findings showed that pupils in the treatment had a favourable attitude towards learning science.

4.3.6 Interactive Effect of Treatment and Cognitive Style on Pre-service Teachers' Achievement and Interest in Cell Biology

The findings indicated that there existed no interaction effect between treatment and cognitive style on learners' performance and interest in cell biology. This suggests that there is no significant interaction effect between treatment and cognitive style on pre-service teachers' academic performance and interest in cell biology. This indicates that the effectiveness of the treatment and cognitive style (analytical and non-analytical) interaction effect had no impact on the academic performance and interest in the cell biology of pre-service teachers. It shows that cognitive style (analytical and non-analytical) pre-service teachers' do not differ when exposed to treatment. However, the results show that when the two strategies were combined with cognitive style, a psychological variable, it was not enough to have an interaction effect on student teachers' achievement and interest in cell biology due to the fact that the variable was independent of the subject matter. In contrast, Abubakar and Haruna's (2019) study on the subject of the influence cognitive types has on learners performance in Katsina quality assurance found no such relationship. Their

findings indicate that there was an influence of cognitive style with respect to FI learners and performance in biology.

4.3.7 Interactive Effect of Problem-solving Ability and Cognitive Style on Pre-service Teachers' Achievement and Interest in Cell Biology

The results indicated there was no interaction effect between cognitive style and problem-solving abilities on the performance and interest of pre-service teachers. This suggests that cognitive style and problem-solving ability have no interactive effect on student teachers' academic performance and interest. The research demonstrates that the connection between cognitive style and problem-solving ability has no impact on learners' academic performance and interest. This means that no aspect of the problem-solving ability and cognitive style could interact to cause an effect on achievement and interest in cell biology. It also shows that problem-solving ability and cognitive do not differ in achievement and interest when applied. However, the findings indicates that when the two psychological variable are by nature independent of a particular content. The two instructional strategies brought about the understanding of the concepts taught in cell biology course. This is inconsistent with Asikhia's (2019) study on the academic performance learners being influenced by cognitive styles in Ogun. The findings demonstrated that the four indicators (converger, accommodator, gender, and area of specialization) could accurately predict students' academic achievement. This is particularly inconsistent with Okoye and Onwuachu's (2018) research with respect to cognitive style and learners performance and interest in biology their findings indicated that learners interest in and achievement in biology were significantly influenced by their cognitive style and the location of their school.

4.3.8 Three-way Interactive Effect of Treatment, Problem-solving Ability and Cognitive Style on Pre-service Teachers' Achievement in Cell Biology

The findings indicated that there existed an interaction effect between treatment, ability to solve problems, and cognitive style on pre-service teachers' cell biology achievement was shown in Table 4.2. This suggests that treatments, ability to solve problems, and cognitive style have an impact on pre-service teachers' cell biology achievement. This research indicated that student teachers who had high problem-solving ability and analytical cognitive style in the interactive invention

teaching strategy had better post-achievement mean scores in cell biology. It further revealed that pre-service teachers with low problem-solving ability and non-analytical cognitive style in crossword puzzle-based instructional strategy have the second better post-achievement mean score in cell biology.

The findings' implication is that in order for students to benefit from the interactive invention instructional strategy, lecturers should collect data on their pre-service teachers' problem-solving abilities and cognitive styles before grouping them. As they had the greatest achievement mean score, the results demonstrate that IIIS is a favoured strategy for problem-solving ability with high problem-solvers and cognitive style with analytical style learners. This suggests that the worksheets promote strong problem-solvers and analytical cognitive style learners as pre-service teachers engage with them individually and in groups. This means that lecturers should pay close attention to pre-service teachers with the high problem-solving ability and those with analytical cognitive styles when using the IIIS because they benefited more and performed better in the achievement test.

The implications of the findings indicates that lecturers who adopt crossword puzzle-based instructional strategy should take note of some parameters of the pre-service teachers which enables them benefit from the strategy. The findings shows that CPIS is a preferred strategy for problem-solving ability with low problem-solvers and cognitive style with non-analytical style learners as they had the second highest achievement mean score. It means that as pre-service teachers interact with the puzzles individually and in groups, it favours low problem-solvers and non-analytical cognitive style learners. It can be deduced that when lecturers are utilizing the Interactive invention instructional strategy they should pay close attention to pre-service teachers with low problem-solving ability and those with non-analytical cognitive styles as they benefited more and had the second highest achievement mean score in the achievement test.

The implications of this findings is that when pre-service teachers problem-solving ability and cognitive style is combined with instructional strategies they lay a foundation for them to be actively involved in the learning by collaborating, brainstorming, interacting and solving various problems that enhances their achievement in cell biology. The IIIS and CPIS are both learner-centred approach to teaching where this pre-service teachers took charge of their learning by solving various puzzles and worksheets in the instructional strategies. This meant that there

were solving this problems and analysing various pictures in both materials making them responsible for their own learning outcomes.

4.3.9 Interactive Effect of Treatment, Problem-solving Ability and Cognitive Style on Pre-service Teachers' Interest in Cell Biology

The findings indicated that there was no interaction effect between treatment, problem-solving ability, and cognitive style on student teachers' interest in cell biology, according to Table 4.5. This indicates that when treatment, problem-solving ability and cognitive style where combined there could not cause an impact on the student teachers' interest in cell biology. This means that problem-solving ability (high and Low) and cognitive style (analytical and non-analytical) do not differ in the interest to cell biology when exposed to the treatment. However, the results show that when the two strategies were combined with problem-solving ability and cognitive style, two psychological variables, it was not enough to have an interaction effect on student teachers' interest in cell biology because the moderator variables were independent of the subject matter.

4.4 Summary of Findings

1. Findings showed that IIIS and CPIS improved student teachers' performance in cell biology.
2. Findings showed that IIIS and CPIS improved pre-service teachers' interest in cell biology.
3. Findings showed that problem-solving ability had no impact on the achievement of pre-service teachers in cell biology.
4. Findings showed that problem-solving ability had no impact on the interest of pre-service teachers in cell biology.
5. Findings showed that student teachers performance in Cell Biology was not impact by cognitive style.
6. Findings showed that cognitive style had no impact on the interest of pre-service teachers' in cell biology.
7. Findings showed that the interaction between IIIS, CPIS and problem-solving ability did not affect the achievement of pre-service teachers' in cell biology.
8. Findings showed that IIIS, CPIS and problem-solving ability has no significant interaction effect on pre-service teachers' interest in cell biology.

9. Findings showed that IIIS, CPIS and cognitive style has no significant interaction effect on pre-service teachers' achievement in cell biology.
10. Findings showed that IIIS, CPIS and cognitive style has no significant interaction effect on pre-service teachers' interest in cell biology.
11. Findings showed that problem-solving ability and cognitive style has no significant interaction effect on pre-service teachers' achievement in cell biology.
12. Findings showed that the interaction between problem-solving ability and cognitive style has no effect on the pre-service teachers' interest in cell biology.
13. Findings showed that the interaction between IIIS, CPIS, problem-solving ability and cognitive style was effective in improving pre-service teachers' achievement in cell biology.
14. Findings showed that the interaction between IIIS, CPIS, problem-solving ability and cognitive style has no effect on the interest of pre-service teachers in cell biology.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The focus of the chapter is the summary of findings, drawn conclusions and recommendations.

5.1 Summary of the Study

The study sort to investigate the impact of Interactive Invention and Crossword Puzzled-based Instructional Strategies on student teachers' achievement and interest in cell biology amongst college of education students in southwest, Nigeria while problem-solving ability and cognitive styles were the moderating effects. The study further presented the gap in pre-service teachers' interest and performance in cell biology. The effectiveness of the interactive invention and crossword puzzle-based strategies as an activity based approach and hands-on technique was also highlighted. The background further presented the inconsistencies and the effect of problem-solving ability and cognitive style on pre-service teachers when the instructional strategies are utilized. Chapter 1 further presented the study problems, implication and scope. The terms highlighted in the study were sufficiently defined and linked to the different instruments used in the study.

The chapter two highlights the theory used, review of the various concepts and empirical studies. The theory utilized in this study is the Jerome bruner theory of learning, which highlights that learners are to discover information on their own rather than being told by the instructor or teacher. The problem-solving model used in the study is the Asmore, Frazer and Casey model propended in 1979. It stipulates the four phases one should follow in solving a given problem. The various concepts were considered and there are pre-service teachers' achievement and interest in cell biology, Interactive Invention Instructional Strategy (IIIS), Crossword Puzzle-Based Instructional Strategy (CPIS), problem-solving ability and cognitive style. Various empirical studies were highlighted on the impact of the IV and MV on learners' achievement and interest in cell biology. The appraisal of literature was also highlighted.

The study employed a pretest posttest control group quasi-experimental research design. The study has an instructional strategy manipulated at three aspects namely Interactive Invention Instructional Strategy (IIIS), Crossword Puzzle-Based Instructional Strategy (CPIS) and the Conventional Instructional Strategy (CIS), two moderator variables were considered namely the problem-solving ability and cognitive style, and two dependent variables were highlighted and there are interest and achievement of student teachers. The colleges used in the study were chosen using the simple random sampling technique. Eight research instruments (four stimuli and four response) were developed, validated and reliability indices ascertained. The researcher also developed the cell biology problem-solving ability test using the Ashmore, Frazer and Casey's model. The significance level of 0.05 was used to test seven null hypotheses. Collected data were examined using statistics such as analysis of covariance ANCOVA, were there existed significant main effect the Estimated Marginal Means (EMM) was used and Bonferroni Post-hoc analysis was used to explain the sources of the significant differences.

The study's findings indicated that interactive invention and crossword puzzle-based strategies, problem-solving ability, and cognitive style have an impact on the performance of student teachers' in cell biology. It shows that interactive invention and crossword puzzle-based instructional strategies are capable of improving pre-service teachers' achievement and developing positive interest in cell biology course. The strategies can help pre-service teachers improve their practical skills, public speaking, presenting, and problem-solving abilities. The research has also demonstrated that learners are more motivated to learn when they are engaged in problem-solving, active learning, and classroom instruction. The results of the investigation showed that there is an interaction effect of treatment, problem-solving ability and cognitive style on student teachers' performance in cell biology. Interactive invention and crossword puzzle-based strategies has an impact on the performance of student teachers' achievement in cell biology. Interactive invention and crossword puzzle-based strategies has an impact on the interest of student teachers in cell biology.

On pre-service teachers' achievement and interest in cell biology, there is no significant effect of problem-solving ability and cognitive. These could as result of the fact that the problem-solving ability and cognitive style are both psychological variables that are independent of the content of Cell Biology. Hence, the strategies brought about the improvement in their learning outcomes. There existed no

interaction effect between problem-solving ability and cognitive style on the interest of student teachers in cell biology. There is no two-way interaction effect of pre-service teachers' achievement and interest in cell biology. There existed no interaction effect between interactive #invention and crossword puzzle-based strategies, problem-solving ability and cognitive on the interest of student teachers' in cell biology because problem-solving ability and cognitive style are psychological variables and are independent of the treatment. The treatment however brought about the improvement in the student teachers learning outcomes in Cell Biology based on the nature of the activities in the two instructional strategies.

5.2 Conclusion

The study's conclusions showed that the improvement in achievement of pre-service teachers in cell biology was affected by the combination of interactive invention and crossword puzzle-based instructional strategies) problem-solving ability, and cognitive style. Findings indicates that pre-service teachers with high problem-solving ability and analytical cognitive style learners benefitted most, when interactive invention instructional strategy was utilized. It further showed that pre-service teachers with low problem-solving ability and non-analytical cognitive style learners benefitted most, when crossword puzzle-based instructional strategy was utilized. The study's conclusions also showed that the two instructional strategies improved pre-service teachers' interest and academic performance. The study effort was to improve the conventional learning objectives by focusing on student-centred and activity-based approach to teaching by improving pre-service teachers' problem-solving ability by utilizing the worksheets and puzzles in cell biology.

5.3 Educational Implications of the Study

The choice of learning or teaching strategy must be done in line with their problem-solving abilities and cognitive style. This study's finding has shown the importance of adopting student centred, interactive, hands-on, and activity-based strategies for classroom instruction. The study findings has shown that when using interactive invention and crossword puzzle-based instructional strategy they should be mindful that the strategies interacts with problem-solving ability and cognitive style. Pre-service teachers with high problem-solving and analytical cognitive style learners benefited most when interactive invention instructional strategy is utilized. Pre-services teachers with low problem-solving ability and non-analytical cognitive style

learners benefited most when crossword puzzle-based instructional strategy was used as it showed on their mean achievement score. This is because the strategies employed active participation from all pre-service teachers during the learning process with different class activities in form of the worksheets and the crossword puzzle. To handle the abstract aspect of the cell biology concept, active participation, collaboration, hands-on and activity-based approach should be incorporated into the learning process. This will eliminate pre-service teachers' perception about the concept of cell being a difficult and abstract concept in biology. This shows that biology content must be practically driven and contextualised to further draw out the best from the pre-service teachers every instructional situation.

5.4 Limitations of the Study

The study was limited by the following:

1. The various CoEs used for the study had diverse resumption dates, which elongated the duration of the study that was supposed to be done concurrently.
2. Some student teachers that initially participated in the pretest were transferred to other departments during their screening, which then reduced the sample used for the study and it did not affect the result of the study in anyway.

5.5 Recommendations

The study's findings led to the following recommendations.

1. Interactive invention instructional strategy improves student teachers' performance and favours high problem solving ability, and analytical cognitive style learners therefore lecturers are encouraged to utilise this approach in the learning of the Cell Biology course.
2. Lecturers are encouraged to utilize crossword puzzle-based instructional strategy to improve pre-service teachers' achievement and be mindful as it favours low problem solving ability and non-analytical cognitive style learners in the Cell Biology course.
3. Lecturers are encouraged to utilize the interactive invention instructional strategy as it improves on student teachers' interest in the Cell biology course.
4. The crossword puzzle-based instructional strategy improves on student teachers' interest in cell biology so therefore, lecturers are encouraged to utilise the approach in the learning of the Cell Biology course.

5. In the 21st century society today, problem-solvers are needed to address the existing problems that we have in the society by bringing up concrete solutions.

5.6 Contributions to Knowledge

The knowledge gap as a result of the study's conclusions is as follows:

1. The study provides the effectiveness of interactive effect of interactive invention and crossword puzzle-based instructional strategies, problem-solving ability and cognitive style on the improvement of student teachers' achievement in cell biology.
2. It establishes the effectiveness of interactive invention and crossword puzzle-based instructional strategies for improving pre-service teachers' achievement in cell biology.
3. It highlights the effectiveness of interactive invention and crossword puzzle-based instructional strategies for improving pre-service teachers' interest in cell biology.
4. It establishes that Interactive invention and crossword puzzle-based instructional strategies encourages, collaborative, hands-on, practical, activity-based and student centred learning amongst pre-service teachers in cell biology.
5. In the cause of the study it was necessary to develop a problem-solving ability test to assess the problem-solving ability of pre-service teachers in Cell Biology.

5.7 Suggestions for Further Studies

The following ideas are offered for additional research:

1. This study should be expanded to private colleges of education and can be replicated at other geo-political zones.
2. The effectiveness of other collaborative, student centred and activity-based teaching techniques on student teachers' achievement and interest should be considered.
3. Moderating variables such as school location, gender, school types of the participants should be incorporated in future when the two strategies are employed.

References

Abimbola, I. O. 2013. The Misunderstood Word in Science Towards a Technology of Perfect Understanding of All. *123rd Inaugural Lecture of University of Ilorin, Unilorin Press* 22-31

Abubakar, S. and Haruna, M. 2019. Relationship Between Cognitive Styles and Students' Academic Performance in Katsina Zonal Education Quality Assurance, Katsina State. *FUDMA Journal of Educational Foundations (FUJEF)* 2.3: 235 – 242.

Achuonye, K. A. 2010. A Comparative Study of Problem-based and Lecture-based Learning in Secondary Schools Students' Motivation to Learn Science. *International Journal of Science and Technology Education Research* 1.6: 126 – 131.

Adedoja, G. O. and Fakokunde, J. B. 2015. Effects of Computer-Based Instructional Puzzle on Students' Learning Outcomes and Retention in Social Studies. *International Journal of Humanities and Social Science* 5.11: 181 – 187.

Adekunle, R. F. and Femi-Adeoye, K. O. 2016. Students' Attitude and Interest as Correlates of Students' Academic Performance in Biology in Senior Secondary School. *International Journal for Innovation Education and Research* 4.3: 1 – 6.

Adeoye, T. O. 2011. Effects of Pictorial and Written Advance Organizers on Students' Achievement in and Attitude to Biology in Selected Senior Secondary Schools in Ibadan, Nigeria. Project. Science, Education. University of Ibadan

Adesina, A. E., Adegoke, A. I. and Ogundiwin, O. A. 2015. Puzzle-based Critical Thinking Motivation Strategies, Gender and Cognitive Style on Students' Practices Towards Environment-related Concepts in Biology. *Journal of Education Research and Behavioural Sciences* 4.11: 288 – 297.

Adodo, S. O, and Ogundare, S. A. 2016. Two Puzzle Models-Based Instructional Strategies' Efficacy and Parental Educational Background of Junior Secondary School Students' Achievement in Selected Concepts in Basic Science. *International Journal of Social Sciences and Humanities*, 1.1: 29 – 39.

Agboghoroma, T. E. 2015. Interaction Effects of Cognitive Style and Instructional Mode on Students' Knowledge of Integrated Science. *European Journal of Research and Reflection in Educational Science* 3.1: 47 – 54.

Agu, A. P. and Samuel, I. R. 2019. Influence of Cognitive Learning Styles on Achievement of Science and Technical College Students' in Nasarawa State, Nigeria. *East African scholars Journal of Engineering and Computer Sciences* 2.9: 232 – 238.

Aina, J. K. 2013. Effective Teaching and Learning in Science Education through Information and Communication Technology (ICT). *IOSR Journal of Research and Method in Education* 2: 43 – 47.

Akhtar, A., Fuchs, E., Mitchison, T., Shaw, R. J., Johnston, D. S., Strasser, A., Taylor, S., Walczak, C., and Zerial, M. 2011. A Decade of Molecular Cell Biology: Achievements and Challenges. *Nature Review Molecular Cell Biology* 12: 669 – 674.

Akingbemisilu, A. A. 2017. Effects of Animation and Video-based flipped Classroom Strategies on Pre-Degree Students' Learning Outcomes in Practical Biology in South-Western Nigeria. Thesis. Science, Education. University of Ibadan. xiv + 191

Ajayi, V. O. and Ogbeba, J. 2020. Possibility of Improving Students' Engagement and Academic Performance in Chemistry Using Three-Dimensional Puzzle-Based Instructional Startegy: A Field Report. *Kogi Journal of Education and Pedagogy (KJOEAP*) 1.1: 141 – 152.

Ali, A. R, Toriman, M. E. and Gasim, M. B. 2014. Academic Achievement in Biology with Suggested Solutions in Selected Secondary Schools in Kano State, Nigeria. *International Journal of Education and Research* 2.11: 215 – 224.

Aloovi, O. A. 2016. Biology Teachers' Lived Experiences of the Namibian Senior Secondary Certificate (NSSC) Curriculum. Thesis. Curriculum Studies, Education. Stellenbosch University. xiv + 199.

Altintas, S and Gorgen, I. 2018. The Effects of Pre-service Teachers' Cognitive Styles on Learning Approaches. *International Journal of Evaluation and Research in Education (IJERE)* 7.4: 285 – 293.

Amosun, P. A. and Ayo-Vaughan, A. F. 2016. Effects of Case and Puzzle-based Learning Students' Achievement in and Attitude to Leadership Value Concepts in Social Studies and Civic Education. Advancing Education through Technology. Eds. C. O. O. Kolawole, R. O. Akinbote, T. A. Ige, G. O. Adedoja, A. S. Aremu. A Book of Readings. Chapter 42: 677 – 696.

Anany, L., and Mary, A. P. 2002. Using Puzzles in Teaching Algorithms. *Proceeding of 23 SIGLSE Technical Symposium on Computer Science Education Antinnati, Kentuky.*

Aremu A. and Sangodoyin A. 2010. Computer Animation and the Academic Achievement of Nigerian Senior Secondary School Students in Biology. *Journal of the Centre for Educational Technology* 6.2: 148 – 161.

Arum, J. N. 2019. Design, Development, and Validation of Computer Simulation and Tutorial Mode of Instruction for Effective Teaching of Biology at Senior Secondary School. *Conference Proceedings of the AITIE 3rd International Conference and Workshop on Innovation, Technology and Education (ICWITE). Association for Innovative Technology Integration in Education* 172 – 186.

Ashmore, A. D., Frazer, M. J. Frazer and Casey, R. J. 1979. Problem Solving and Problem Solving Networks in Chemistry. *Journal of Chemical Education* 56.6: 377 – 379

Asikhia, O. A. 2019. Cognitive Styles and Academic Performance of Senior Secondary School Students in Ogun State, Nigeria. *Journal Psychology* 10.1-2: 1 – 12.

Ates, H., and Saylan, A. 2015. Investigation of Pre-Service Science Teachers' Academic Self-Efficacy and Academic Motivation toward Biology. *International Journal of Higher Education* 4.3: 90–103.

Atsuwe, B. A. and Mtoh, T. T. 2019. Effect of Cognitive Style on Students' Achievement and Retention in Physics in Senior Secondary Schools in Gwer-West Local Government Area, Benue State, Nigeria. *International Journal of Advance Research and Innovation* 7.2: 73 – 78.

Auta, A. and Maigari, A. U. 2018. Comparative Effect of Cooperative Learning Strategy and Lecture Method on the Academic Achievement of N.C.E Students in Electrolysis. *Network for Research and Development in Africa (NRDA) International Journal of Pure and Applied Science Research* 11.4: 1 – 10.

Awodun, A. O., Adekunle, R. F., and Femi – Adeoye, K. O. 2016. Students' Attitude and Interest as Correlates of Students' Academic Performance in Biology in Senior Secondary School. *International Journal of Innovation Education and Research* 4.3: 200 – 216.

Awolola, S. A. 2009. Impact of Brain-Based Instructional Strategy on Students Learning Outcomes in Senior Secondary School Mathematics in Selected Local Government Area in Oyo State, Nigeria. Thesis. Science, Education. University of Ibadan.

Aydin, F. 2015. The relationship between pre-service science teachers' cognitive styles and their cognitive structures about technology. *Research in Science and Technological Education* 1 – 23.

Babayemi, J. O. and Akinsola, M. K. 2014. Effects of Crossword-Picture Puzzle Teaching Strategy and Mental Ability on Students' Achievement in Basic Science in Southwestern Nigeria. *IOSR Journal of Research & Method in Education (IOSR-JRME*) 4.4: 08 – 13.

Bruner, J. S. 1960. The Process of Education. Cambridge, MA: Harvard University Press.

Bruner, J. S. 1961. The Act of Discovery. *Harvard Educational Review* 31: 21 – 32.

Bruner, J. S. 1966. Towards a Theory of Instruction. Cambridge, MA: Harvard University Press.

Bruner, J. S. 1973. Going Beyond the Information Given. New York: Norton.

Danmole, B. T. 2012. Biology Teachers View on Practical Work in Senior Secondary Schools of South Western Nigeria. *Pakistan Journal of Social Sciences* 9, 2: 69 – 75.

Demir, N. S., Aksut, P., Yener, D., Aydin, F., Sabasi, O.,Fidan, H., and Aygun, M. 2017. Attitudes towards Astronomy among the Pre-Service Teachers' Different

Cognitive Styles: Alternative Course Sample. *Journal of Baltic Science Education* 16.3: 200 – 207.

Derer, O. K., and Berkant, H. G. 2019. The Effect of Puzzle-Based Learning on Secondary School Students' Attitudes and their Self-Efficacy Beliefs in English Lessons. *Kuramsal Eğitimbilim Dergisi – Journal of Theoretical Educational Science* 13.1: 205 – 231.

Fakolade, B. A. 2019. Relationship between Achievement and Interest of Senior Secondary School Biology Students and their Learning Styles in Benue State, Nigeria. Thesis. Curriculum and Teaching, Education. Benue State University. xv + 201

Farlex, M. 2009. The Online Dictionary. Retrieved from http://www.thefreedictionary.com27 on August 2012.

Federal Republic of Nigeria, 2012. Nigeria Certificate in Education Minimum Standard for Sciences. National Commission for Colleges of Education (NCCE). 2012 Ed. Abuja: Tetfund Project.

Fitriani, A., Zubaidah, S., Susilo, H. and Muhdhar, M. H. I. A., 2019. The Integrated Problem Based Learning and Predict, Observe, Explain (PBL-POE) to Empower Students' Problem-Solving Skills. *ICEMT Association for Computing Machinery (ACM)* 375 – 379.

Franklin, S., Peat, M., and Lewis, A. 2003. Non-Traditional Interventions to Stimulate Discussion: The Use of Games and Puzzles. *Journal of Biological Education* 37.2: 79 – 84.

Gezer, S. U. 2015. A Case Study on Pre-Service Science Teachers' Laboratory Usage Self-Efficacy and Scientific Process Skills. *Elsevier – Procedia - Social and Behavioural Sciences* 174: 1158 – 1165.

Gheith, E. M., and Aljaberi, N. M. 2015. Pre-service Classroom Teachers' Attitudes toward Graphs and their Ability to Read and interpret them. *International Journal of Humanities and Social Science* 5.7: 113 – 124.

Holstermann, N., Grude, D. and Bogeholz, S. 2009. Hands-on Activities and their Influence on Students Interests. *Res Sci Edu Springer* 40: 743 – 757.

Hong, J.-C., Hwang, M.-Y., Tam, K.-P., Lai, Y.-H., and Liu, L.-C. 2012. Effects of Cognitive Style on Digital Jigsaw Puzzle Performance: A Grid Ware Analysis. *Elsevier - Computers in Human Behavior* 28: 920 – 928.

Hussin, M., Razali, N. M., and Agussalim, M., SE, M. 2021. Influence of Cognitive Style on Students' Academic Achievement at Faculty of Economics, National University of Malaysia. *International Journal of Academic Research in Business and Social Sciences* 11.3: 762 – 771.

Idika, M. I. 2017. Influence of Cognitive Style and Gender on Secondary School Student's Achievement in and Attitude to Chemistry. *Advances in Social Sciences Research Journal* 4.1: 129 – 139.

Idodo-Umeh, G. 2011. Idodo-Umeh College Biology. I4th ed. Benin City: Idodo-Umeh Publishers Ltd.

Ige, T. A and Oke, O. A. 2019. Practical Teaching for Skill Acquisition and Innovation in Science and Technology Education in Higher Education System for National Development in Ogun, South-West, Nigeria. *Proceedings of STAN Conference (Oyo State)* 83 – 97.

_____. 1998. Concept Mapping and Problem-solving Teaching Strategies as Determinants of Learning Outcomes in Secondary School Ecology in Nigeria. Thesis. Science, Education. University of Ibadan. xv + 306.

Jakel, L. 2014. Interest and Learning in Botanics, as Influenced by Teaching Contexts. *E-Book Proceedings of the ESERA 2013 Conference of Science Education Research For Evidence-based Teaching and Coherence in Learning* 1–12.

Jantan, R. B. 2014. Relationship Between Students Cognitive Style (field-dependent and Field-Independent Cognitive Styles with their Mathematics Achievement in Primary School. *International Journal of Humanities Social Sciences and Education (IJHSSE)* 1.10: 88 – 93.

Jayanthi, D. and Tholappan, A. 2017. Mathematical Problem Solving Ability and Academic Achievement Among Higher Secondary Students. *Shanlax International Journal of Education* 5.4: 20 – 25.

Kagan, J., Moss, H. A., and Siegel, J. E. 1963. Psychological Significance of Styles of Conceptualization: Basic Cognitive Process in Children. *Monograph of Society for Research in Child Development* 28.1: 73 – 112.

Karademir, C. A. 2019. Pre-Service Teachers' Problem-Solving Skills and Curiosity Levels. *International Journal of Educational Methodology* 5.1: 151 – 164.

Kaur, G. 2011. Study and Analysis of Lecture Model of Teaching. *International Journal of Educational Planning and Administration* 1.1: 9 – 13.

_____, and Kaur, L. 2021. Effectiveness of Coperative Learning Strategy on Achievement in Mathematics in Relation to Problem Solving Ability. *SHODA.* 107 – 124.

Khatoon, Z., Alam, M. T., and Bukhari, M. A. 2014. In-service Teachers' Perception about their Competencies in the Delivery of Biology Lessons. *International Journal of Asian Social Science* 4.7: 820 – 834.

Klymchuk, S., Thomas, M., Gulyeav, S and Evans, T. 2017. Enhancing Generic Thinking Skills of Tertiary STEM Students through Puzzle-Based Learning. *Northern Regional Hub-funded Project. Project Report* 1 – 21.

Knekta, E., Rowland, A. A., Corwin, L. A. and Eddy, S. 2020. Measuring University Students' Interest in Biology. Evaluation of an Instrument Targeting Hidi and Renninger's Individual Interests. *International Journal of STEM Education* 7.23: 1 – 16.

Kozhevnikor, M. 2007. Cognitive Styles in the Context of Modern Psychology: Toward an Integrated Framework of Cognitive Style. *Psychological Bulletin* 133.3: 464 – 481.

Malik, M. A., Shah, Z. A., Iqbal, Z. and Rauf, M. 2010. Effect of Problem-Solving Teaching Strategy on 8th-grade Students' Attitude towards Science. *Journal of Education and Practice* 1.3: 16 – 27.

McLeod, S. A. 2019. Bruner - Learning Theory in Education. *Simply Psychology*. Retrieved Nov. 07, 2021 from www.simplypsychology.org/bruner.html

Meyer, E. F., Falkner, N., Sooriamurthi, R., and Michalewicz, Z. 2014. Guide to Teaching Puzzle-Based Learning. 1st Ed. London: Springer London.

Michalewicz, Z. and Michalewicz, M. 2008. Puzzle Based Learning: An Introduction to Critical Thinking, Mathematics, and Problem-Solving. *Teaching Mathematics and Computer Science* 6.2: 415 – 420.

Mohammed, A. N, Gambari, A. I. and Ibrahim, I. K. 2019. Assessment of Colleges Of Education Students' Behavioural Intention Towards Whatsapp Utilization For Learning Biology In Niger State. *AITIE 3rd International Conference and Workshop on Innovation, Technology and Education (ICWITE) – Association for Innovative Technology Integration in Education.* 187 – 197.

Muhammad, B. A. and Sabiru, D. Y. 2016. Effects of Science Process Skills Approach and Lecture Method on Academic Achievement of Pre-service Chemistry Teachers in Kaduna State, Nigeria. *ATBU Journal of Science, Technology and Education (JOSTE)* 4.2: 68 – 72.

Musa, D. C. and Samuel, I. R. 2019. Influence of Cognitive Styles and Gender on Upper Basic III Mathematics Students Achievement in Keffi, Nasarawa State, Nigeria. *International Journal of Scientific and Research Publications* 9.8: 566 – 576.

Nnorom, N. R. 2019. Effect of Problem Based-Solving technique on Secondary School Students Achievement in biology. *International Journal of Scientific and Engineering Research* 10. 3: 1025 – 1029.

Nsofor, G. J. 2019. The Effect of Problem-based Learning and Interactive Invention Instructional Strategies on Pre-service Teachers Students Achievement and Acquisition of Science Process Skills in Biology. Project. Science, Education. University of Ibadan. xv +

Nwafor, C. E. and Oka, O. O. 2018. Secondary School Students' Interest Inventory in Biology. *International Journal of Humanities Social Sciences and Education (IJHSSE)* 5.3: 44 – 59.

Ogunbowale, N. B. 2014. Effects of Interactive-invention and Problem-based Instruction Strategies on Students Attitudes to Biology. *Journal of Education and Leadership Development* 6.2:86 – 104.

Ogundare, S. A. 2014. Effects of Maze and Logic Mechanical Puzzle-based Instructional Strategies on Junior Secondary School Students' Learning

Outcomes in Basic Science in Ondo State, Nigeria. Thesis. Science, Education. University of Ibadan.

Ogundiwin, O. A. 2013. Effects of Pre-Theoretic Intuition Quiz and Puzzle-based Critical Thinking Motivation Strategies on Students' Learning Outcomes in Selected Environment-Related Concepts in Biology. Thesis. Science, Education. University of Ibadan. xiv + 260.

_____, and Ahmed, A. A. 2015. Effects of Meaning Focus, Practice and Invention on Strategies on Problem-solving Skills of Secondary School Students in Ecology. *Journal of Education and Policy Review* 7.1: 28 – 48.

_____, and Oladipo, A. J. 2019. Critical Thinking Motivation Strategies as Innovative Classroom Practices for Sustainable Environmental Development in South-Western Nigeria. *KIU Journal of Humanities* 4.2: 209 – 219.

Okenyi, C. I. 2015. The Problems of Biology Education Development in Nigeria Beyond 2020. *Knowledge Preview,* 33.1: 1 – 6.

Okoye, N. S and Okechukwu, R. N 2010. Effects of Concept Mapping and Problem-Solving Strategies on Achievement in Biology among Nigerian Secondary School Students. *African Journal of Educational Studies in Mathematics and Sciences* 4: 93 – 98.

Okoye, P. O. 2011. Influence of Classroom Interaction Patterns and students Cognitive Styles on Achievement in Biology in Senior Secondary Schools in Anambra State. Thesis. Science, Education. University of Nigeria.

_____. 2016. Influence of Gender and Cognitive Styles on Students' Achievement in Biology. *International Journal of Science and Technology (STECH)* 5.1: 59 – 65.

_____, and Onwuachu, W. C. 2018. Influence of Cognitive Styles and School Location on Academic Achievement of Students Interest in Biology. *IAA Journal of Scientific Research* 4.1: 1 – 8.

Okurumeh, E. A. 2016. The Effect of Discussion and Invention Teaching Strategy on Secondary School Students Retention in Chemistry Concepts in Delta State, Nigeria. *International Journal of Science and Research (IJSR)* 5.3:1739 – 1744

Olagunju, A. M and Babayemi, J. O. 2015. A Survey of Pre-service Teachers' Skills for Improving Educational Resources for Effective Instruction in Basic Science. *African Journal of Educational Research* 19.1 & 2: 0303 – 3872.

_____, and Babyemi, J. O. 2014. Effects of Enhanced Explicit Teaching (Explicit Teaching + Peer-tutoring) Strategy and Gender on Students' Attitude to Basic Science. *Proceedings of the 3rd Interdisciplinary International Conference*, 3.3: 51 – 65.

_____, and Ogundiwin, O. A. 2008. The Impact of Three Modes of Instruction and Cognitive Style on Students Environmental Attitude Towards Pollution in Biology. *African Journal of Educational Research* 12.2: 160 – 167.

_____, and Babayemi, J. O. 2014. Effects of Crossword-Picture Puzzle Teaching Strategy and Gender on Students' Achievement in Basic Science. *Journal of Education and Leadership Development* 6.1:43 – 54.

Olatoye, R. A. and Adekoya, Y. M. 2010. Effects of Project-Based, Demonstration and Lecture Teaching Strategies on Secondary School Students Achievement in an Aspect of Agricultural Science. *International Journal of Educational Research and Technology* 1.1: 19 – 29.

Oludipe, B. D. 2014. Cognitive Style Profiles and Physics Achievement of Senior Secondary School Students in Ogun State, Nigeria. *Journal of Education and Practice* 5.8: 69 – 79.

Olumide, O. J. 2018. Computer Simulation and Digital Puzzle Packages Determinants of Students' Learning Outcomes in Ecology and Genetics in senior Secondary Schools in Oyo State. Thesis. Science, Education. University of Ibadan. xii + 190.

Omilani, N. A., Akinyele, S. A., Durowoju, T. S. and Obideyi, E. I. 2018. The Effect of the Assessment of Practical-Based Work on Pupils Problem Solving and Achievement in Basic Science and Technology in Odeda Local Government of Ogun State, Nigeria. *International Journal of Primary, Elementary and Early Years Education* 3.13: 1 – 13.

Onifade, S. A. 2017. Impact of Pre-lesson Assignments and Weekly Formative Tests Assessment Strategies on Low-Achieving Physics Students' Achievement and

Study Habit on Oyo State. Project. Science, Education. University of Ibadan. xv + 145.

Owino, O. A., Osman, A. and Yungungu, A. 2014. An Investment of Factors that Influence Performance in KSCE Biology in Selected Secondary Schools in Nyakach District, Kisumu Country Kenya. *Journal of Education and Human Development* 3.2: 957 – 977.

Samuel, I. R. and Iliyasu, A. 2020. Effect of Crossword-Picture Puzzle Learning Strategy on Basic Science Students' Achievement in Nasarawa State, Nigeria. *International Journal of Innovative Education Research* 8.4: 42 – 47.

Saputro, A. D., Irwanto, I., Atun, S. and Wilujeng, I. 2019. The Impact of Problem-Solving Instruction on Academic Achievement and Science Process Skills Among Prospective Elementary Teachers. *Elementary Online* 18.2: 496 – 507.

Serafin, C. 2016. The Re-Conceptualization of Cooperative Learning in an Inquiry Oriented Teaching. *In Procedia-Social and Behavioural Sciences* 217: 201–207

Shi, C. 2011. A Study of the Relationship Between Cognitive Styles and Learning Strategies. *Higher Education Studies* 1.1: 20 – 26.

Smitha, R., and Manoj, P. G. 2018. Problem Solving Ability and Achievement Motivation Among Secondary School Students. *Indian Journal of Applied Research* 8.10: 66 – 68.

Son, J. W. and Li, M. Y. 2020. Exploring the Relationship Between Pre-service Teachers Conceptions of Problem Solving and Their Problem-Solving Performances. *International Journal of Science and Mathematics Education* 1 – 22.

Stetzik, L., Deeter, A., Parker, J. and Yukech, C. 2015. Puzzle-based Versus Traditional Lecture: Comparing the Effects of Pedagogy on Academic Performance in an Undergraduate Human Anatomy and Physiology II Lab. *BMC Medical Education* 15.107: 1 – 11.

Sung, E. 2017. The Influence of Visualisation Tendency on Problem-Solving Ability and Learning Achievement of Primary School Students in South Korea. *Thinking Skills and Creativity* 26: 168 – 175.

Tella, A. 2013. The Effect of Peer Tutoring and Explicit Instructional Strategies on Primary School Pupils Learning Outcomes in Mathematics. *Bulgarian Journal of Science and Education Policy (BJSEP)* 7.1: 5 – 25.

_____, Adika, L. O. and Toyobo, M. O. 2008. Relationship Among Demographic Variables and Pupils Reasoning Ability. *Electronic Journal of Research in Educational Psychology* 6.16: 709 – 728.

Temel, S., 2014. The Effects of Problem-Based Learning on pre-Service Teachers' Critical Thinking Dispositions and Perceptions of Problem-Solving Ability. *South African Journal of Education* 34.1: 1 – 20.

Thomas, C., Badger, M., Ventura-Medina, E. and Sangwin, C. J. 2013. Puzzle-based learning of mathematics in engineering. *Engineering Education* 8.1: 122 – 134.

Tinajero, C., Lemos, S. M., Araujo, M., Ferraces, M. J. and Paramo, M. F. 2012. Cognitive Style and Learning Strategies as Factors that affect the Academic Achievement of Brazilian University Students. *Psicologia: reflexao e Critica* 25.1: 105 – 113.

Ugwu, T. U. 2014. The Effect of Guided Inquiry Methods on Students' Achievement and Interest in Basic Science. Thesis. Science, Education. University of Nigeria. Thesis. Science, Education. University of Nigeria. +202

Ukoh, E. E. 2012. Effect of Problem-Based Learning and Interactive Invention Instructional Strategies on Pre-Service Teachers' Achievement in Physics Concepts and Acquisition of Science Process Skills. Thesis. Science, Education. University of Ibadan. viii + 205

_____. 2013. Determining the Effect of Interactive Invention Instructional Strategy and Gender on NCE Pre-service Teachers' Acquisition of Science Process Skills. *African Research Review: An International Multidisciplinary Journal Ethiopia* 7.3: 143 – 155.

_____. 2021. Teaching Electromagnetism Using Interactive-Invention Instructional Strategy and the Learning Outcome of Secondary School Students. *Momentum: Physics Education Journal* 6.1: 10 – 18.

_____. 2022. Interactive-invention Instructional Strategy and Secondary School Students' Achievement in Selected Electromagnetic Concepts in Ibadan North Local Government Area, Nigeria. *European Scientific Journal- ESJ* 18.14: 38 – 55.

_____, and Onifade, S. A. 2020. Pre-lesson Assignments and Formative Assessment Strategies with Interactive Invention Instruction on Low Achievers in Physics. *Momentum: Physics Education Journal* 4.1: 49 – 56.

_____, and Orefuwa, O. 2016. Self-concept, Cognitive Style and Numeric Ability as Correlates of Students Achievement in Physics in Ibadan Metropolis. Education in Nigeria: Looking Beyond the 21st Century. *A Book of Reading in Honour of Professor Oluremi-Ayodele Bamisaiye.* Eds. Kolawole, C. O. O., Bagudo, A. A., Moronkola, O. A., Akinkuotu, A. O., Babarinde, S. A., Ojedokun, I. M. and Meroyi, S. I. Ibadan. 437 – 456.

Umoru, E. S., Adejoh, M. J. and Iji, C. O. 2016. Enhancing Senior Secondary Students' Attitude through Puzzle-Based Learning Strategy in Biology in Wukari Metropolis. *ATBU, Journal of Science, Technology & Education (JOSTE)* 4.4: 202 – 208.

Usman, I. S. and Sule, H. 2017. Effects of Problem-Solving Strategy on Secondary School Physics Students Attitude and Academic Achievement in Jos North L. G. A., Plateau State, Nigeria. *KIU Journal of Social Sciences* 3.2: 365 – 376.

Vaishnav, H. 2015. Learning a Language -en Route Puzzles and Games. *International Journal of English Language, Literature and Humanities* 3.3: 550 – 559.

Wei, R. C. and Pecheone, L. R., 2010. 'Assessment for Learning in Pre-service Teacher Education: Performance-based Assessments'. Teacher Assessment and the Quest for Teacher Quality. Eds. M. M. Kennedy. San Francisco, CA: Jossey Bass. 69 – 132.

Wulandari, N. H., Widayati, K. A. and Suryobroto, B. 2016. Cognitive Style and Creative Quality: Influence on Academic Achievement of University Students in Indonesia. *Hayati Journal of Biosciences* 121 – 124.

Yulinda, R. and Ilma, S. 2018. Learning Interest of Biology Pre-Service Teachers on Contextual Based Plant Morphology Course. *Indonesian Journal of Biology Education* 4.2: 171-178.

Appendix I

LIST OF COLLEGES OF EDUCATION

List of colleges in the Background of the Study.

S/N	Code	Colleges of Education
1	College A	Adeyemi College Education, Ondo
2	College B	Osun State College Education, Illesa
3	College C	Federal college of Education (Special), Oyo
4	College D	Ekiti State college of Education, Ikere, Ekiti

List of Colleges used for the study

S/N	Code	Colleges of Education
1	College X	Federal college of Education (Special), Oyo
2	College Y	Federal College of Education Osiele, Abeokuta
3	College Z	Adeyemi College of Education, Ondo.

Appendix II

INSTRUCTIONAL GUIDE FOR INTERACTIVE INVENTION INSTRUCTIONAL STRATEGY (IGIIIS)

LESSON: ONE

THEME: CELL AND CELL THEORY

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Onion cell, cheek cell.

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. Define the term cell theory

2. State the cell theory

3. List the different cell theorist and their discoveries

4. State the similarities and differences between flora and fauna cell

5. Draw and label a typical flora and fauna cell

Entry behaviour: The students have been taught the concept of

1. Cell

Phase 1: Presentation

Activity l:

Review: Review prior knowledge and outline the lesson's objectives for the day. The lecturer discusses the cell concept, outlining the theory of cell as well as the theorists and their findings. He then outlines the lesson's objectives for the day and writes them on the board.

Activity 2:

Overview: The concept of the cell as the fundamental structural and functional unit of life is presented by the teacher. The instructor gives the students examples of various cell types, such as plant and animal cells, and writes these on the board. He continues by stating the cell theory, which holds that all living things are composed of one or more cells, that cells serve as the structural and functional basis for all living things,

and that cells divide to create new ones. The teacher list different cell theorist and their discoveries and their contribution to the study of cells. The teacher discusses the plant and animal cell and uses the microscope to view the animal and plant cells. The teacher illustrates the subject of cells and cell theory using the supplied materials. He distinguishes plant and animal cell using their differences and similarities.

Phase 2: Student Practice

Activity 1

Guided practice stage: The lecturer divides learners in groups, there are eight (8) in a group, he further gives each group the instructional worksheets, and asks them to provide the required answers from the lecture while observing, and giving appropriate corrections as when needed, and informs the groups that did well that they got it right. The students used the microscope to view plant and animal cells. Here, proper handling of the microscope and proper view with one or two eyes is key to observing the specimen properly. Then they differentiate between the plant and animal cell by taking into account the features and sizes of the organelles.

Activity 2

Continuous practice

Here, less influence from the lecturer is allowed for each student to practise longer.

Activity 3

At the conclusion, the student receives feedback if they did it correctly, and if not, the lecturer helps them with the correct answer.

Phase 3: Monitoring and Assessment

The lecturer reviews the lesson's goals with the class to make sure they were achieved; if not, the lecturer goes over the material once again.

LESSON: TWO

TOPIC: PROTOPLASM AND ITS PROPERTIES PART A

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Onion cell, cheek cell.

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. List the different cell organelles

2. State the meaning of each cell organelles

3. State the functions of each organelles

Entry knowledge: Learners were taught the concept of

1. Protoplasm and its properties

Phase 1: Presentation

Activity l:

Review: Review previous knowledge and the day's lesson objective is stated. The lecturer analyses the concept of protoplasm and its properties (cytoplasm, cell wall, cell membrane (plasma membrane), endoplasmic reticulum, ribosomes and mitochondria) stating the functions of each organelles. Then the instructor outlines the lesson objectives on the board.

Activity 2:

Overview: The lecturer presents the concept of protoplasm and its properties as the parts of the cell that has different function that sustains the whole cell as the basic structural and functional unit of life. The teacher mentions examples of different cells to include plant cell, animal cell and outlines this concepts on the board. The instructor goes ahead to outline some of the cell organelles (cytoplasm, cell wall, cell membrane (plasma membrane), endoplasmic reticulum, ribosomes and mitochondria) by listing them on the board and stating at list one function for each of the mentioned cell organelle. The lecturer uses the plant cell to view the endoplasmic reticulum of the cell and goes on the demonstrate using the animal cell. He distinguish the difference between the smooth endoplasmic reticulum and the rough endoplasmic reticulum.

Phase 2 Practice

Activity 1

Guided practice stage: The lecturer divides the learners into various groups, there are eight (8) in a group, he further gives each group the instructional worksheets, and asks them to provide the required answers from the lecture while observing, and giving appropriate corrections as when needed, and informs the groups that did well that they got it right. The students used the microscope to view plant and animal cells. Here, proper handling of the microscope and proper view with one or two eyes is key to observing the specimen properly. Then they differentiate between the different cell organelle (cytoplasm, cell wall, cell membrane (plasma membrane), endoplasmic reticulum, ribosomes and mitochondria) by taking into account the features and sizes of the organelles. Some of the functions of the organelles will be stated to differentiate them from each other.

Activity 2

Continuous practice

Here, less influence from the lecturer is allowed for each student to practise longer.

Activity 3

At the conclusion, the student receives feedback if they did it correctly, and if not, the lecturer helps them with the correct answer.

Phase 3: Monitoring and Assessment

The lecturer reviews the lesson's goals with the class to make sure they were achieved; if not, the lecturer goes over the material once again.

LESSON: THREE

TOPIC: PROTOPLASM AND ITS PROPERTIES PART B

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Onion cell, cheek cell.

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. List the different cell organelles

2. State the meaning of each cell organelles

3. State the functions of each organelles

Entry behaviour: The learners were taught the concept of

1. Protoplasm and its properties

Phase 1: Presentation

Activity l:

Review: Review previous knowledge and the day's lesson objective is stated. The lecturer analyses the concept of protoplasm and its properties (lysosome, golgi apparatus (bodies), centrioles (centromeres), plastids in plants eg chloroplasts, leucoplasts, and chromoplasts, vacuoles and nucleus) stating the functions of each organelles. Then the instructor outlines the lesson objectives on the board.

Activity 2

Overview: The lecturer presents the concept of protoplasm and its properties as the parts of the cell that has different function that sustains the whole cell as the basic structural and functional unit of life. The teacher mentions examples of different cells to include plant cell, animal cell and outlines on the board. The lecturer highlights some of the cell organelles (lysosome, golgi apparatus (bodies), centrioles (centromeres), plastids in plants eg chloroplasts, leucoplasts, and chromoplasts, vacuoles and nucleus) by listing them on the board and stating at list one function for each of the mentioned cell organelle. The lecturer uses the plant cell to view the nucleus of the cell and goes on the demonstrate using the animal cell. He distinguishes between the plant and animal nucleus by stating the sizes of each. He goes further to

state the animal cells contains centrioles while plant cells doesn’t and that vacuoles are using absent in plant cell but if present are small and temporary.

Phase 2 Practice

Activity 1

Guided practice stage: The lecturer divides the learners into various groups, there are eight (8) in a group, he further gives each group the instructional worksheets, and asks them to provide the required answers from the lecture while observing, and giving appropriate corrections as when needed, and informs the groups that did well that they got it right. The students used the microscope to view plant and animal cells. Here, proper handling of the microscope, and proper view with one or two eyes is key to observing the specimen properly. Then they differentiate between the different cell organelle (lysosome, golgi apparatus (bodies), centrioles (centromeres), plastids in plants eg chloroplasts, leucoplasts, and chromoplasts, vacuoles and nucleus) by taking into account the features and sizes of the organelles. Some of the functions of the organelles will be stated to differentiate them from each other.

Activity 2

Continuous practice

Here, less influence from the lecturer is allowed for each student to practise longer.

Activity 3

At the conclusion, the student receives feedback if they did it correctly, and if not, the lecturer helps them with the correct answer.

Phase 3: Monitoring and Assessment

The lecturer reviews the lesson's goals with the class to make sure they were achieved; if not, the lecturer goes over the material once again.

LESSON: FOUR

TOPIC: PHYSICAL PROCESSES OF CELL

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Onion cell, cheek cell, pawpaw fruit, beaker, water, salt and ink.

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. Define osmosis, diffusion, plasmolysis, turgor, pinocytosis and phagocytosis.

2. State the functions of the different processes

3. State the importance of the different processes

4. States the conditions necessary for each of the processes to take place

Entry behaviour: The students have been taught the concept of

1. Osmosis
2. Diffusion
3. Plasmolysis

Phase 1: Presentation

Activity l:

Review: Review previous knowledge and the day's lesson objective is stated. The lecturer analyses the concept of osmosis, diffusion, turgor, pinocytosis and phagocytosis and stating the functions, importance and settings required for each processes to happen. Then the instructor outlines the lesson objectives on the board.

Activity 2

Overview: The lecturer presents the concept of osmosis, diffusion, turgor, pinocytosis and phagocytosis as the process that plant and animal cell uses to convey materials in and out of different cells or tissues or organ or system. He continues by explaining how the osmosis experiment can be carried out to observe the passage of water molecules through a semi-permeable membrane from a point of lower concentration to a region of higher concentration. Diffusion, according to him, is the transfer of molecules from gaseous, liquid, and solid states from one area of upper concentration

to another of lower concentration. He continues, "When a plant cell is placed in a more concentrated salt solution, plasmolysis is the shrinking of the vacuole and pulling away of the cytoplasmic lining from the cell wall." He puts them on the board, he then informs them the materials that will be used for osmosis as pawpaw, water, salt, ink and beaker while for diffusion he states that ink, water and beaker will be used.

Phase 2 Practice

Activity 1

Guided practice stage: The lecturer divides the learners into various groups, there are eight (8) in a group, he further gives each group the instructional worksheets, and asks them to provide the required answers from the lecture while observing, and giving appropriate corrections as when needed, and informs the groups that did well that they got it right. Here the pre-service teachers are to utilize pawpaw, water, salt, ink and beaker for osmosis while ink, water and beaker for diffusion. They are expected to differentiate the different processes they are working on to state which concentration moves to the other. They state the functions of osmosis and diffusion and states how there are important to both plant and animal functioning.

Activity 2

Continuous practice

Here, less influence from the lecturer is allowed for each student to practise longer.

Activity 3

At the conclusion, the student receives feedback if they did it correctly, and if not, the lecturer helps them with the correct answer.

Phase 3: Monitoring and Assessment

The lecturer reviews the lesson's goals with the class to make sure they were achieved; if not, the lecturer goes over the material once again.

LESSON: FIVE

TOPIC: CELL DIVISION (MITOSIS)

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Slides showing Mitosis.

Specific objectives: Students should be able to do the following by the end of the lesson:

1. Define the term mitosis.

2. State the functions of each stage of mitosis

3. Outline the importance of mitosis

Entry behaviour: The students have learnt the concept of

1. Mitosis

Phase 1: Presentation

Activity l:

Review Review previous knowledge and the day's lesson objective is stated. The lecturer analyses the concept of mitosis by that it is a division of a cell to produce two identical cells with the same number of chromosomes and characteristics as those of the parent cell. He states the phases in mitosis to include: Interphase, Prophase (Early and Late Prophase), Metaphase, Anaphase and Telophase. Then the instructor outlines the lesson objectives on the board.

Activity 2:

Overview: The concept of mitosis as a division of a cell to produce two identical cells with the same number of chromosomes and characteristics as those of the parent cell is presented by the lecturer. He state that mitosis occurs in somatic (body) cells such as skin, bone marrow, lymph nodes and injured place and meristematic tissues in plants. He goes further to state what happens at every stage of mitosis as chromosomes become elongated and form a network of fine threads called chromatids in interphase, chromosomes become visible as chromatin threads condense in early prophase, chromosomes become short, thicker and very visible in late prophase, chromosomes (now paired chromatids) arrange themselves along the equator of the spindle in

metaphase, chromatids of each chromosome separate and migrate to the poles by elongation of the spindle axis in anaphase, chromosomes now lose their thick appearance and two daughter cell (diploid number) in produced in telophase. He puts them on the board, he then informs them the materials that will be used to study the process in mitosis.

Phase 2 Practice

Activity 1

Guided practice stage: The lecturer divides the learners into various groups, there are eight (8) in a group, he further gives each group the instructional worksheets, and asks them to provide the required answers from the lecture while observing, and giving appropriate corrections as when needed, and informs the groups that did well that they got it right. Here the pre-service teachers are to use the material shared to study the process of mitosis. They are expected to differentiate the difference in each phase by studying it. They state the functions of each phase of mitosis and the end product.

Activity 2

Continuous practice

Here, less influence from the lecturer is allowed for each student to practise longer.

Activity 3

At the conclusion, the student receives feedback if they did it correctly, and if not, the lecturer helps them with the correct answer.

Phase 3: Monitoring and Assessment

The lecturer reviews the lesson's goals with the class to make sure they were achieved; if not, the lecturer goes over the material once again.

LESSON: SIX

TOPIC: CELL DIVISION (MEIOSIS)

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Slides on cell division **(**meiosis)

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. Define the term meiosis.

2. State the functions of each stage of meiosis

3. State the importance of meiosis

4. State the life processes that involve Meiosis

Entry behaviour: The students have been taught the concept of

1. Meiosis

Phase 1: Presentation

Activity l:

Review: Review Review previous knowledge and the day's lesson objective is stated. The lecturer analyses the concept of meiosis by that it is a division of a cell that produces four daughter identical cells with half (haploid) the original number of chromosomes of the parent cell. He states the phases in meiosis to include: first meiotic division – Prophase (Early, middle and Late Prophase), Metaphase 1, Anaphase 1 and Telophase 1; second meiotic division – Prophase II, Metaphase II, Anaphase II and Telophase II. Then the instructor outlines the lesson objectives on the board.

Activity 2:

Overview: The concept of meiosis as a division of a cell that produces four daughter identical cells with half (haploid) the original number of chromosomes of the parent cell is highlighted by the lecturer. He states that meiosis is a type of cell division during spermatogenesis (sperm formation) and oogenesis (egg formation) in which there is a reduction of chromosomes to half of the original number of chromosomes. During spermatogenesis or oogenesis in human, the 46 chromosome are reduced to 23.

Therefore each sperm or egg now has 23 chromosomes. The fusion of the sperm and egg gives 46 chromosomes which every human being has. He goes further to state what happens at every stage of meiosis as chromosomes become visible as long threads in early prophase, homologous (marching) chromosomes become thicker, shorter and clearly visible in middle prophase, each chromosome reproduces replica of itself (double-stranded) in late prophase, bivalent chromosomes are arranged at the equator and attached to the spindle by their centromeres in metaphase I, each member of the bivalent chromosomes moves apart and moves towards the poles of the cell by the shortening of the spindle in anaphase I, bivalent chromosomes arrive at the poles of the cells in telophase I, chromosomes become distinct in the nuclei in prophase II, the two chromatids of the chromosomes become more distinct in metaphase II, chromosomes get attached at the centromeres and separate and moves to the poles in anaphase II and the chromatids arrive the poles of the cells and nuclear membrane forms and it produces four daughter cells in telophase II. He puts them on the board, he then informs them the materials that will be used to study the process in mitosis.

Phase 2 Practice

Activity 1

Guided practice stage: The lecturer divides the learners into various groups, there are eight (8) in a group, he further gives each group the instructional worksheets, and asks them to provide the required answers from the lecture while observing, and giving appropriate corrections as when needed, and informs the groups that did well that they got it right. Here the pre-service teachers uses the material shared to study the process of meiosis. They are expected to differentiate the difference in each phase by studying it. They state the functions of each phase of meiosis and the end product.

Activity 2

Continuous practice

Here, less influence from the lecturer is allowed for each student to practise longer.

Activity 3

At the conclusion, the student receives feedback if they did it correctly, and if not, the lecturer helps them with the correct answer.

Phase 3: Monitoring and Assessment

The lecturer reviews the lesson's goals with the class to make sure they were achieved; if not, the lecturer goes over the material once again.

LESSON: SEVEN

TOPIC: REVISION 1

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Materials from Lesson 1 - 3

Specific objectives: Students should be able to do the following by the end of the lesson:

1. Revise Lessons 1 to 3:

Entry behaviour: As application to Lessons 1 to 3

Phase 1: Presentation

Activity l:

Review: Review previous knowledge and the day's lesson objective is stated.

Activity 2:

Overview: Highlights of the topics taught from lessons 1 to 3 are discussed by the lecturer.

Phase 2: Student Practice

Activity 1

Guided practice stage: The lecturer divides the learners into various groups, there are eight (8) in a group, he further gives each group the instructional worksheets, and asks them to provide the required answers from lesson 1 to 3.

Activity 2

Continuous practice

Here, less influence from the lecturer is allowed for each student to practise longer.

Activity 3

At the conclusion, the student receives feedback if they did it correctly, and if not, the lecturer helps them with the correct answer.

Phase 3: Monitoring and Assessment

The lecturer reviews the lesson's goals with the class to make sure they were achieved; if not, the lecturer goes over the material once again.

LESSON: EIGHT

TOPIC: REVISION 2

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Materials from Lesson 4 - 6

Specific objectives: Students should be able to do the following by the end of the lesson:

1. Revise Lessons 4 to 6:

Entry behaviour: As applicable to lessons 4 to 6.

Phase 1: Presentation

Activity l:

Review: Highlights of the topics taught from lessons 4 to 6 are discussed by the lecturer.

Activity 2:

Overview: The lecturer presents the concepts from lessons 4 to 6.

Phase 2 Practice

Activity 1

Guided practice stage: The lecturer divides the learners into various groups, there are eight (8) in a group, he further gives each group the instructional worksheets, and asks them to provide the required answers from lesson 4 to 6.

Activity 2

Continuous practice

Here, less influence from the lecturer is allowed for each student to practise longer.

Activity 3

At the conclusion, the student receives feedback if they did it correctly, and if not, the lecturer helps them with the correct answer.

Phase 3: Monitoring and Assessment

The lecturer reviews the lesson's goals with the class to make sure they were achieved; if not, the lecturer goes over the material once again.

APPENDIX II (B)

WORKSHEETS FOR INTERACTIVE INVENTION INSTRUCTIONAL STRATEGY

Name of College_____

Matric_____

LESSON 1

TOPIC: Cell and Cell theory

Phase 1: Presentation

Activity I: Distribution of worksheets/Introduction by the lecturer

Activity II: Lecturer's Overview of the new lesson

Phase 2: Practice

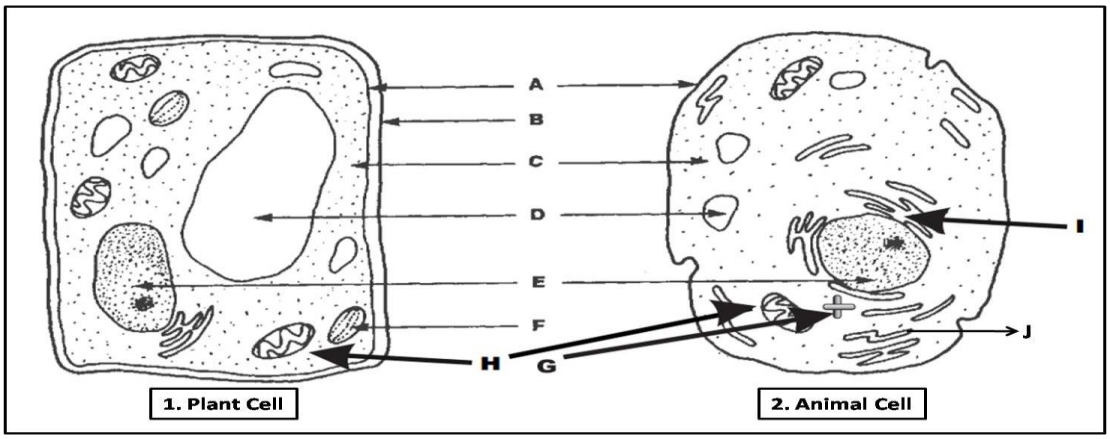
Activity I: Students guided practice in groups of 8. Use a microscope to view the plant and animal cell and use the knowledge to respond to the following

1. Define cell

   ……
   ……
   ……
2. State two cell theories that you can think of.

   ……
   ……
   ……
   ……
3. Mention 2 scientist and their discoveries.

   ……
   ……
   ……
4. Use the diagram below to label the cell organelles



i.	**A**	
ii.	**B**	
iii.	**C**	
iv.	**D**	
v.	**E**	
vi.	**F**	
vii.	**G**	
viii.	**H**	
ix.	**I**	
x.	**J**	

Activity II: Students Continuous practice

The lecturer allows the students to practice independently on the guided content in Phase 2, activity I.

Use a microscope to view the plant and animal cell and use the knowledge to respond to the following

1. Define cell

   ……

   ……

   ……

2. State two cell theories that you can think of.

   ……

   ……

   ……

   ……

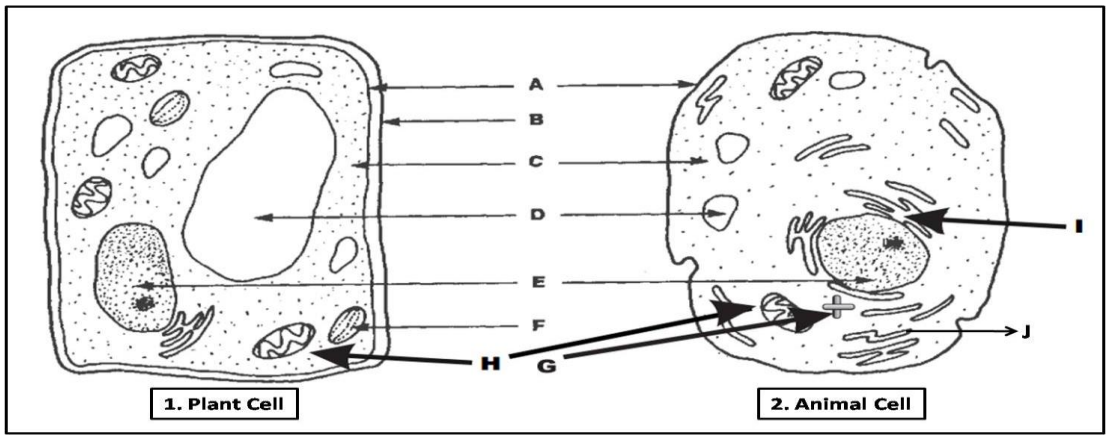
3. Mention 2 scientist and their discoveries.

   ……

   ……

   ……

4. Use the diagram below to label the cell organelles



i.	**A**	
ii.	**B**	
iii.	**C**	
iv.	**D**	
v.	**E**	
vi.	**F**	
vii.	**G**	
viii.	**H**	
ix.	**I**	
x.	**J**	

Activity III: A Review

The lecturer gives a review on the learnt concept.

Phase 3: Monitoring and Evaluation

Activity I: Here the lecturer asks questions to get the formative evaluation of the content

Activity II: the lecturer gives the students feedback on the activity.

LESSON 2

TOPIC: Protoplasm and its properties Part A

Phase 1: Presentation

Activity I: The lecturer distributes the worksheets/introduction

Activity II: Lecturers' overview of the new lesson

Phase 2: Practice

Activity I: Students guided practice in groups of 8: Use a microscope to view the plant and animal cell and use the knowledge to respond to the following

Use the table below to write down the cell part on the right hand column to match the structure/function on the left hand column. The cell parts **MAY BE** used more than once.

S/N	Structure/Function	Cell Part
1.	A semi-fluid that contains all the other cell organelles.	
2.	A non-living outer boundary of the cell made up of cellulose/gives rigidity to cells and allows free passage of materials	
3.	It protects the cytoplasm/regulates the movement of substance in and out of the cell/delimits the content of the cytoplasm	
4.	It helps in the formation of enzymes and protein/transports metabolic products within cytoplasm or between the cytoplasm and nucleus/interconnects cell organelles/provides surface for the attachment of ribosome	
5.	They contain roughly equal amount of RNA/makes proteins by joining amino acids together/sites for protein synthesis.	
6.	These are tiny rod-shaped bodies in the cytoplasm/concentrated on very active cells such as the liver cells/centre of cellular respiration in which food substances are oxidized to release energy/contains enzymes and DNA/the DNA helps to code the synthesis of protein in mitochondria membranes	

Activity II: Students Continuous practice

The lecturer allows the students to continue to practice on the guided content in Phase 2, activity I.

Use a microscope to view the plant and animal cell and use the knowledge to respond to the following

Use the table below to write down the cell part on the right hand column to match the structure/function on the left hand column. The cell parts **MAY BE** used more than once.

S/N	Structure/Function	Cell Part
1.	A semi-fluid that contains all the other cell organelles.	
2.	A non-living outer boundary of the cell made up of cellulose/gives rigidity to cells and allows free passage of materials	
3.	It protects the cytoplasm/regulates the movement of substance in and out of the cell/delimits the content of the cytoplasm	
4.	It helps in the formation of enzymes and protein/transports metabolic products within cytoplasm or between the cytoplasm and nucleus/interconnects cell organelles/provides surface for the attachment of ribosome	
5.	They contain roughly equal amount of RNA/makes proteins by joining amino acids together/sites for protein synthesis.	
6.	These are tiny rod-shaped bodies in the cytoplasm/concentrated on very active cells such as the liver cells/centre of cellular respiration in which food substances are oxidized to release energy/contains enzymes and DNA/the DNA helps to code the synthesis of protein in mitochondria membranes	

Activity III: A review.

The lecturer gives a review on the learnt concept.

Phase 3: Monitoring and Evaluation

Activity I: Here the lecturer asks questions to get the formative evaluation of the content

Activity II: the lecturer gives the students feedback on the activity.

LESSON 3

TOPIC: Protoplasm and its properties Part A

Phase 1: Presentation

Activity I: The lecturer distributes the worksheets/introduction

Activity II: Lecturers' overview of the new lesson

Phase 2: Practice

Activity I: Students guided practice in groups of 8. Use a microscope to view the plant and animal cell and use the knowledge to respond to the following

Use the table below to write down the cell part on the right hand column to match the structure/function on the left hand column. The cell parts **MAY BE** used more than once.

S/N	Structure/Function	Cell Part
1.	Minute and rounded bodies containing enzymes/destroys worn out parts of cells by discharging enzymes into them to clear the area for a new healthy cell growth/discharges enzymes to degenerate tissues causing the breakdown of the cells/releases enzymes to destroy bacteria and cells	
2.	May help to distribute proteins made by the cell/may help in the manufacture of lysosomes/may help in the formation of membranes of endoplasmic reticulum and production of cellulose of cells in plants	
3.	They provide spindle fibres to which chromosomes are attached during cell division	
4.	The help in the formation of cilia and flagella	
5.	It is the seat of photosynthesis where organic foods are synthesized	
6.	Stores nutrients and waste products	
7.	It controls directly or indirectly most of the activities of a living cell/carries chromosomes on which hereditary materials (genes) are coded	

Activity II: Students Continuous practice

The lecturer allows the students to continue to practice on the guided content in Phase 2, activity I.

Use a microscope to view the plant and animal cell and use the knowledge to respond to the following

Use the table below to write down the cell part on the right hand column to match the structure/function on the left hand column. The cell parts **MAY BE** used more than once.

S/N	Structure/Function	Cell Part
1.	Minute and rounded bodies containing enzymes/destroys worn out parts of cells by discharging enzymes into them to clear the area for a new healthy cell growth/discharges enzymes to degenerate tissues causing the breakdown of the cells/releases enzymes to destroy bacteria and cells	
2.	May help to distribute proteins made by the cell/may help in the manufacture of lysosomes/may help in the formation of membranes of endoplasmic reticulum and production of cellulose of cells in plants	
3.	They provide spindle fibres to which chromosomes are attached during cell division	
4.	The help in the formation of cilia and flagella	
5.	It is the seat of photosynthesis where organic foods are synthesized	
6.	Stores nutrients and waste products	
7.	It controls directly or indirectly most of the activities of a living cell/carries chromosomes on which hereditary materials (genes) are coded	

Activity III: A review.

The lecturer gives a review on the learnt concept.

Phase 3: Monitoring and Evaluation

Activity 6: Here the lecturer asks questions to get the formative evaluation of the content

Activity 7: the lecturer gives the students feedback on the activity.

LESSON 4

TOPIC: Physical Processes of cell

Phase 1: Presentation

Activity I: The lecturer distributes the worksheets/introduction

Activity II: Lecturers' overview of the new lesson

Phase 2: Practice

Activity I: Students guided practice in groups of 8. Use the following items to carry out a diffusion and osmosis experiment. Ink, water, yam tuber, salt, pin, beaker. Thereafter respond to the following questions.

1. With the aid of a diagram discuss diffusion using ink and water.
2. With the aid of a diagram discuss osmosis using a yam tuber, salt, pin, beaker and water

3. When is a cell said to be turgid?

……

……

……

……

4. Discuss pinocytosis and phagocytosis

……

……

……

……

……

……

……

……

Activity II: Students Continuous practice

The lecturer allows the students to continue to practice on the guided content in Phase 2, activity I.

Use the following items to carry out a diffusion and osmosis experiment. Ink, water, yam tuber, salt, pin, beaker. Thereafter respond to the following questions.

1. With the aid of a diagram discuss diffusion using ink and water.
2. With the aid of a diagram discuss osmosis using a yam tuber, salt, pin, beaker and water

3. When is a cell said to be turgid?

……

……

……

……

Discuss pinocytosis and phagocytosis

……

……

……

……

……

……

Activity III: A review

The lecturer gives a review on the learnt concept.

Phase 3: Monitoring and Evaluation

Activity I: Here the lecturer asks questions to get the formative evaluation of the content

Activity II: the lecturer gives the students feedback on the activity.

LESSON 5

TOPIC: Cell Division (Mitosis)

Phase 1: Presentation

Activity I: The lecturer distributes the worksheets/introduction

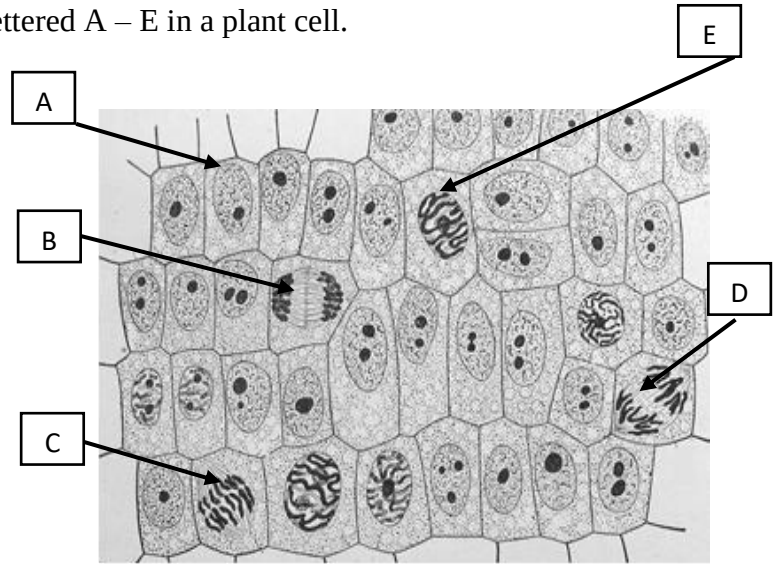
Activity II: Lecturers' overview of the new lesson

Phase 2: Practice

Activity I: Students guided practice in groups of 8. View the provided cell division slide using a microscope and identify the different stages.

Identify the stages of mitosis each lettered A – E in a plant cell.

1	**A**	
2	**B**	
3	**C**	
4	**D**	
5	**E**	



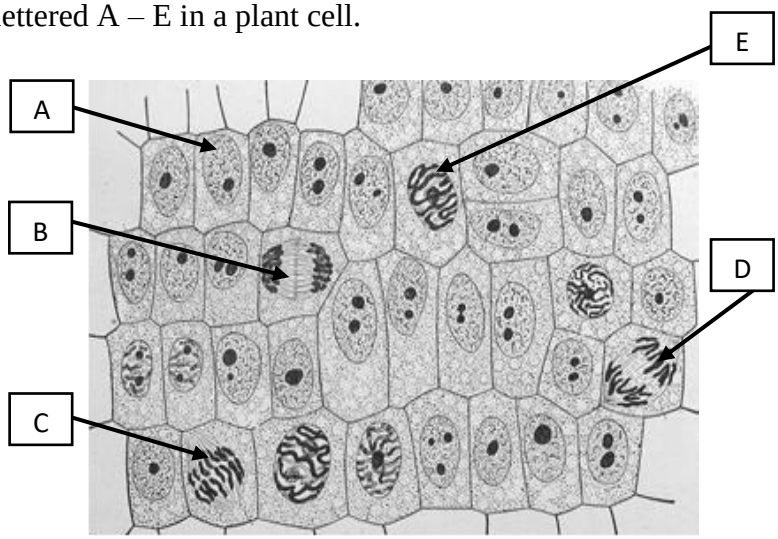
Activity II: Students Continuous practice

The lecturer allows the students to continue to practice on the guided content in Phase 2, activity I.

View the provided cell division slide using a microscope and identify the different stages.

Identify the stages of mitosis each lettered A – E in a plant cell.

1	**A**	
2	**B**	
3	**C**	
4	**D**	
5	**E**	



Activity III: A review

The lecturer gives a review on the learnt concept.

Phase 3: Monitoring and Evaluation

Activity I: Here the lecturer asks questions to get the formative evaluation of the content

Activity II: the lecturer gives the students feedback on the activity.

LESSON 6

TOPIC: Cell Division (Meiosis)

Phase 1: Presentation

Activity I: The lecturer distributes the worksheets/introduction

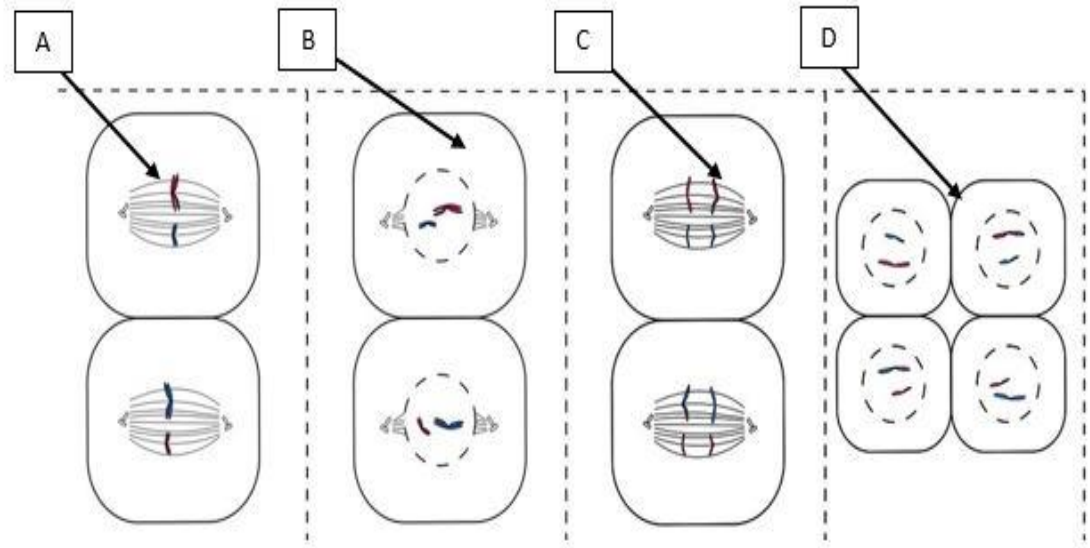
Activity II: Lecturers' overview of the new lesson

Phase 2: Practice

Activity I: Students guided practice in groups of 8. View the provided cell division slide using a microscope and identify the different stages.

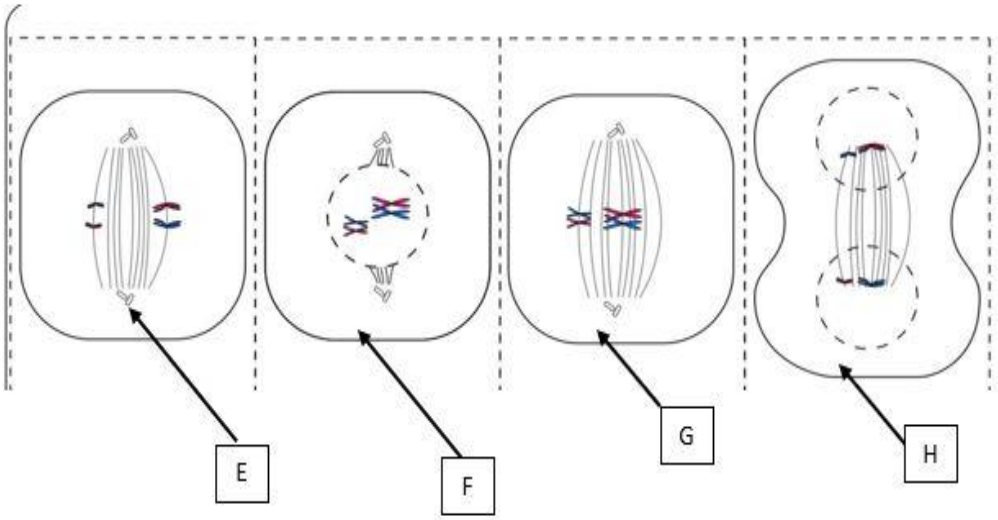
Identify the stages of meiosis from first meiotic division to second meiotic division each lettered A – H in an animal cell.

Identify the division ……



Identify the division

……..……



1	**A**	
2	**B**	
3	**C**	
4	**D**	
5	**E**	
6	**F**	
7	**G**	
8	**H**	

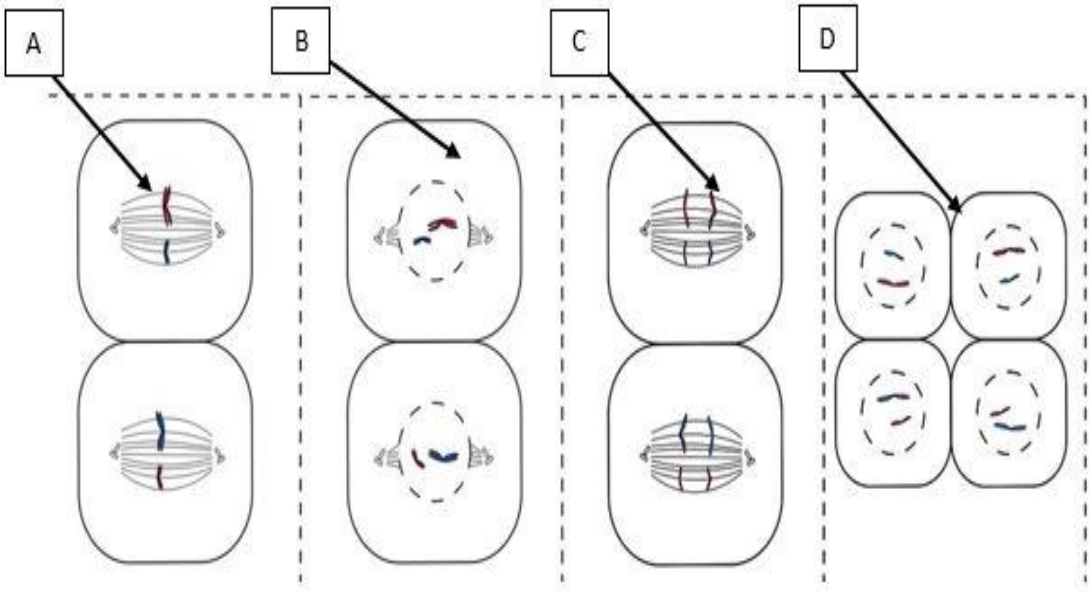
Activity II: Students Continuous practice

The lecturer allows the students to continue to practice on the guided content in Phase 2, activity I.

View the provided cell division slide using a microscope and identify the different stages.

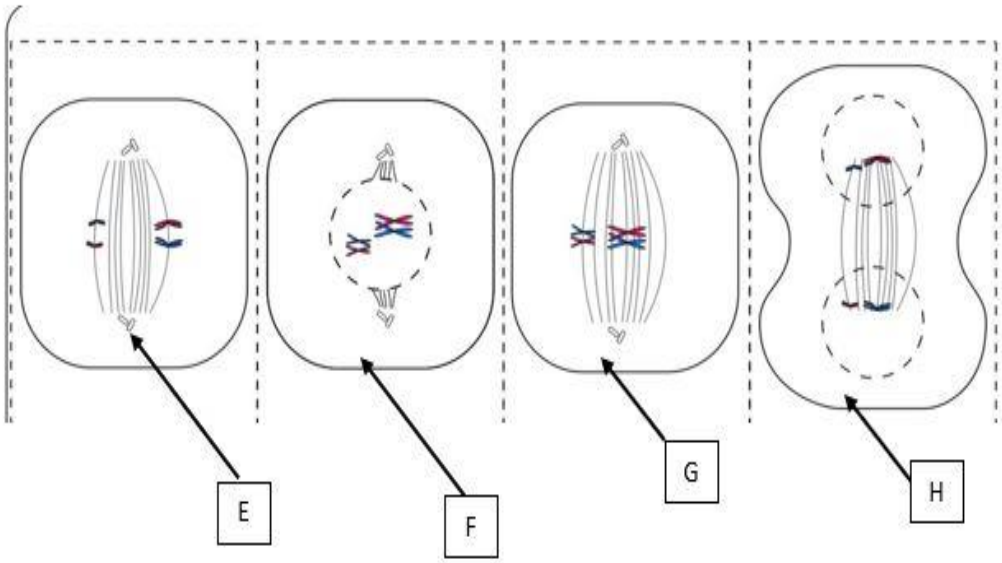
Identify the stages of meiosis from first meiotic division to second meiotic division each lettered A – H in an animal cell.

Identify the division ……



Identify the division

……



1	**A**	
2	**B**	
3	**C**	
4	**D**	
5	**E**	
6	**F**	
7	**G**	
8	**H**	

Activity III: A review

The lecturer gives a review on the learnt concept.

Phase 3: Monitoring and Evaluation

Activity I: Here the lecturer asks questions to get the formative evaluation of the content

Activity II: the lecturer gives the students feedback on the activity.

Appendix III (A)

INSTRUCTIONAL GUIDE FOR PUZZLE-BASED INSTRUCTIONAL STRATEGY (OGPBIS)

LESSON: ONE

TOPIC: CELL AND CELL THEORY

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Puzzle on cell biology

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. 1. Define the term cell theory

2. State the cell theory

3. List the different cell theorist and their discoveries

4. State the similarities and differences between flora and fauna cell

5. Draw and label a typical flora and fauna cell

Entry behaviour: The students have learnt the concept of

1. Cell

Introduction:

Step I: The following questions are asked based on students' previous knowledge:

What is cell?

State the cell theory.

What were the contributions of the different scientists?

Differentiate between plant and animal cell.

Students' intuition is used to determine the answers to the questions. The instructor explains the idea to the class by pointing out and outlining its main elements using the cell biology puzzle as a guide.

Presentation:

Step II: Students are given a quiz which is the cell biology puzzle with clues/keys which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single puzzle from their individual puzzles for presentation. The instructor provides a list of how many hints each student must supply.
The following hints are provided for the cell biology puzzle;

Hint 1 – Hint 11

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.
Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.
Step VII: Students take notes of the corrections and ask questions for more clarification.
Step VIII: The lecturer ends the lecture and to assess the skills developed an assignment is given.
Evaluations: The students' knowledge are assessed by the lecturer on the concept by asking the following questions:

What is cell?

State the cell theory.

What were the contributions of the different scientists?

Differentiate between plant and animal cell.

Assignment: The pre-service teachers are asked to read on protoplasm and its properties against next lesson.

LESSON: TWO

TOPIC: PROTOPLASM AND ITS PROPERTIES PART A

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Puzzle on cell biology

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. List the different cell organelles

2. State the meaning of each cell organelles

3. State the functions of each organelles

Previous Knowledge: The students learnt the concept of

1. Protoplasm and its properties

Introduction:

Step I: The lecturer asks the pre-service teachers questions based on their previous knowledge:

List the different cell organelles

State the meaning of each cell organelles and its properties (cytoplasm, cell wall, cell membrane (plasma membrane), endoplasmic reticulum, ribosomes and mitochondria)

State the functions of each organelles

Students' intuition is used to determine the answers to the questions. The instructor explains the idea to the class by pointing out and outlining its main elements using the cell biology puzzle as a guide.

Presentation:

Step II: Students are given a quiz which is the cell biology puzzle with clues/keys which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single

puzzle from their individual puzzles for presentation. The instructor provides a list of how many hints each student must supply.

The following hints are provided for the cell biology puzzle;

Hint 1 – Hint 12

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

Step VIII: The lecturer ends the lecture and to assess the skills developed an assignment is given.

Evaluations: The students' knowledge are assessed by the lecturer on the concept by asking the following questions:

List the different cell organelles

State the meaning of each cell organelles

State the functions of each organelles

Assignment: The pre-service teachers are asked to study protoplasm and its properties against next lesson.

LESSON: THREE

TOPIC: PROTOPLASM AND ITS PROPERTIES PART B

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Puzzle on cell biology

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. List the different cell organelles

2. State the meaning of each cell organelles

3. State the functions of each organelles

Previous Knowledge: The students have learnt the concept of

1. Protoplasm and its properties

Introduction:

Step I: The lecturer asks the pre-service teachers questions based on their previous knowledge:

List the different cell organelles

State the meaning of each cell organelles and its properties (lysosome, golgi apparatus (bodies), centrioles (centromeres), plastids in plants eg chloroplasts, leucoplasts, and chromoplasts, vacuoles and nucleus)

State the functions of each organelles

Students' intuition is used to determine the answers to the questions. The instructor explains the idea to the class by pointing out and outlining its main elements using the cell biology puzzle as a guide.

Presentation:

Step II: Students are given a quiz which is the cell biology puzzle with clues/keys which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single puzzle from their individual puzzles for presentation. The instructor provides a list of how many hints each student must supply.
The following hints are provided for the cell biology puzzle;

Hint 1 – Hint 21

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

Step VIII: The lecturer ends the lecture and to assess the skills developed an assignment is given.

Evaluations: The students' knowledge are assessed by the lecturer on the concept by asking the following questions:

List the different cell organelles

State the meaning of each cell organelles

State the functions of each organelles

Assignment: The pre-service teachers are informed to read on physical processes of cell against next lesson.

LESSON: FOUR

TOPIC: PHYSICAL PROCESSES OF CELL

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Puzzle on cell biology

Behavioural objectives: Students should be able to do the following by the end of the lesson:

1. Define osmosis, diffusion, plasmolysis, turgor, pinocytosis and phagocytosis.

2. State the functions of the different processes

3. State the importance of the different processes

4. States the conditions necessary for each of the processes to take place

Entry behaviour: The students have been taught the concept of

1. Osmosis
2. Diffusion
3. Plasmolysis

Introduction:

Step I: The lecturer asks the pre-service teachers questions based on their previous knowledge:

Define osmosis, diffusion, plasmolysis, turgor, pinocytosis and phagocytosis.

State the functions of the different processes

State the importance of the different processes

States the conditions necessary for each of the processes to take place

Students' intuition is used to determine the answers to the questions. The instructor explains the idea to the class by pointing out and outlining its main elements using the cell biology puzzle as a guide.

Presentation:

Step II: Students are given a quiz which is the cell biology puzzle with clues/keys which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single puzzle from their individual puzzles for presentation. The instructor provides a list of how many hints each student must supply.
The following hints are provided for the cell biology puzzle;

Hint 1 – Hint 21

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

Step VIII: The lecturer ends the lecture and to assess the skills developed an assignment is given.

Evaluations: The students' knowledge are assessed by the lecturer on the concept by asking the following questions:

Define osmosis, diffusion, plasmolysis, turgor, pinocytosis and phagocytosis.

State the functions of the different processes

State the importance of the different processes

States the conditions necessary for each of the processes to take place

Assignment: The pre-service teachers are informed to read on cell division (mitosis) against next lesson.

LESSON: FIVE

TOPIC: CELL DIVISION (MITOSIS)

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Puzzle on cell biology

Specific objectives: Students should be able to do the following by the end of the lesson:

1. Define the term mitosis.

2. State the functions of each stage of mitosis

3. State the importance of mitosis

Entry behaviour: The students have learnt the concept of

1. Mitosis

Introduction:

Step I: The lecturer asks the pre-service teachers questions relying on what there have learnt before:

Define the term mitosis.

State the functions of each stage of mitosis

State the importance of mitosis

Students' intuition is used to determine the answers to the questions. The instructor explains the idea to the class by pointing out and outlining its main elements using the cell biology puzzle as a guide.

Presentation:

Step II: Students are given a quiz which is the cell biology puzzle with clues/keys which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single

puzzle from their individual puzzles for presentation. The instructor provides a list of how many hints each student must supply.
The following hints are provided for the cell biology puzzle;

Hint 1 – Hint 10

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

Step VIII: The lecturer ends the lecture and to assess the skills developed an assignment is given.

Evaluations: The students' knowledge are assessed by the lecturer on the concept by posing some questions thus:

Define the term mitosis.

State the functions of each stage of mitosis

State the importance of mitosis

Assignment: Read on the protoplasm and its properties against next lesson.

LESSON: SIX

TOPIC: CELL DIVISION (MEIOSIS)

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Puzzle on cell biology

Specific objectives: Students should be able to do the following by the end of the lesson:

1. Define the term meiosis.

2. State the functions of each stage of meiosis

3. State the importance of meiosis

4. State the life processes that involve Meiosis

Entry behaviour: The learners have learnt the concept of

1. Meiosis

Introduction:

Step I: The lecturer asks the pre-service teachers questions relying on what there have learnt before:

Define the term meiosis.

State the functions of each stage of meiosis

State the importance of meiosis

State the life processes that involve Meiosis

Students' intuition is used to determine the answers to the questions. The instructor explains the idea to the class by pointing out and outlining its main elements using the cell biology puzzle as a guide.

Presentation:

Step II: Students are given a quiz which is the cell biology puzzle with clues/keys which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single puzzle from their individual puzzles for presentation. The instructor provides a list of how many hints each student must supply.
The following hints are provided for the cell biology puzzle;

Hint 1 – Hint 12

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

Step VIII: The lecturer ends the lecture and to assess the skills developed an assignment is given.

Evaluations: The students' knowledge are assessed by the lecturer on the concept by posing some questions thus:

What is meiosis?

State the functions of each stage of meiosis

State the importance of meiosis

State the life processes that involve Meiosis

Assignment: The pre-service teachers are to revise what has been taught in weeks 1 to 3 against next lesson.

LESSON: SEVEN

TOPIC: REVISION 1

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Puzzle on cell biology from lesson 1 - 3

Specific objectives: Students should be able to do the following by the end of the lesson:

1. Revise lessons 1 to 3

Entry behaviour: The students should revise lesson 1 to 3.

Step 1:

Introduction:

Step I: The lecturer asks the pre-service teachers questions relying on what there have learnt in lesson 1 – 3.

Students' intuition is used to determine the answers to the questions. The instructor explains the idea to the class by pointing out and outlining its main elements using the cell biology puzzle from lesson 1 to 3 as a guide.

Presentation:

Step II: Students are given a quiz which is the cell biology puzzle with clues/keys which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single puzzle from their individual puzzles for presentation. The lecturer also includes the number of hints that the students are expected to offer.

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

Step VIII: The lecturer ends the lecture and to assess the skills developed an assignment is given.

Evaluations: The students' knowledge are assessed by the lecturer on the concept by asking the following questions:

Assignment: The pre-service teachers are instructed to revise lessons 4 to 6 against next lesson.

LESSON: EIGHT

TOPIC: REVISION II

TIME: 2 HOURS

INSTRUCTIONAL MATERIALS: Puzzle on cell biology from lesson 4 - 6

Specific objectives: Students should be able to do the following by the end of the lesson:

1. Revise lessons 4 to 6

Entry behaviour: The students should revise lesson 4 to 6.

Step 1:

Introduction:

Step I: The lecturer asks the pre-service teachers questions relying on what there have learnt in lesson 4 – 6:

Students' intuition is used to determine the answers to the questions. The instructor explains the idea to the class by pointing out and outlining its main elements using the cell biology puzzle from lesson 4 to 6 as a guide.

Presentation:

Step II: Students are given a quiz which is the cell biology puzzle with clues/keys which leads them to the concept and objective of the lesson.

ii. Students work individually with the cell biology puzzle.

Step III: Students are placed in groups of 8 to brainstorm on the questions the lecturer asked at the beginning and individual puzzles. They are expected to work out a single puzzle from their individual puzzles for presentation. The lecturer also includes the number of hints that the students are expected to offer.

Step IV: Students' group representative present their ideas on the concepts with the aid of the group-cell biology puzzle.

Step V: Lecturer clarifies group submissions and discussions are made on the ones they disagree using the cell biology puzzle.

Step VI: The lecturer does further elaboration on the content to ensure better understanding and improved thinking abilities.

Step VII: Students take notes of the corrections and ask questions for more clarification.

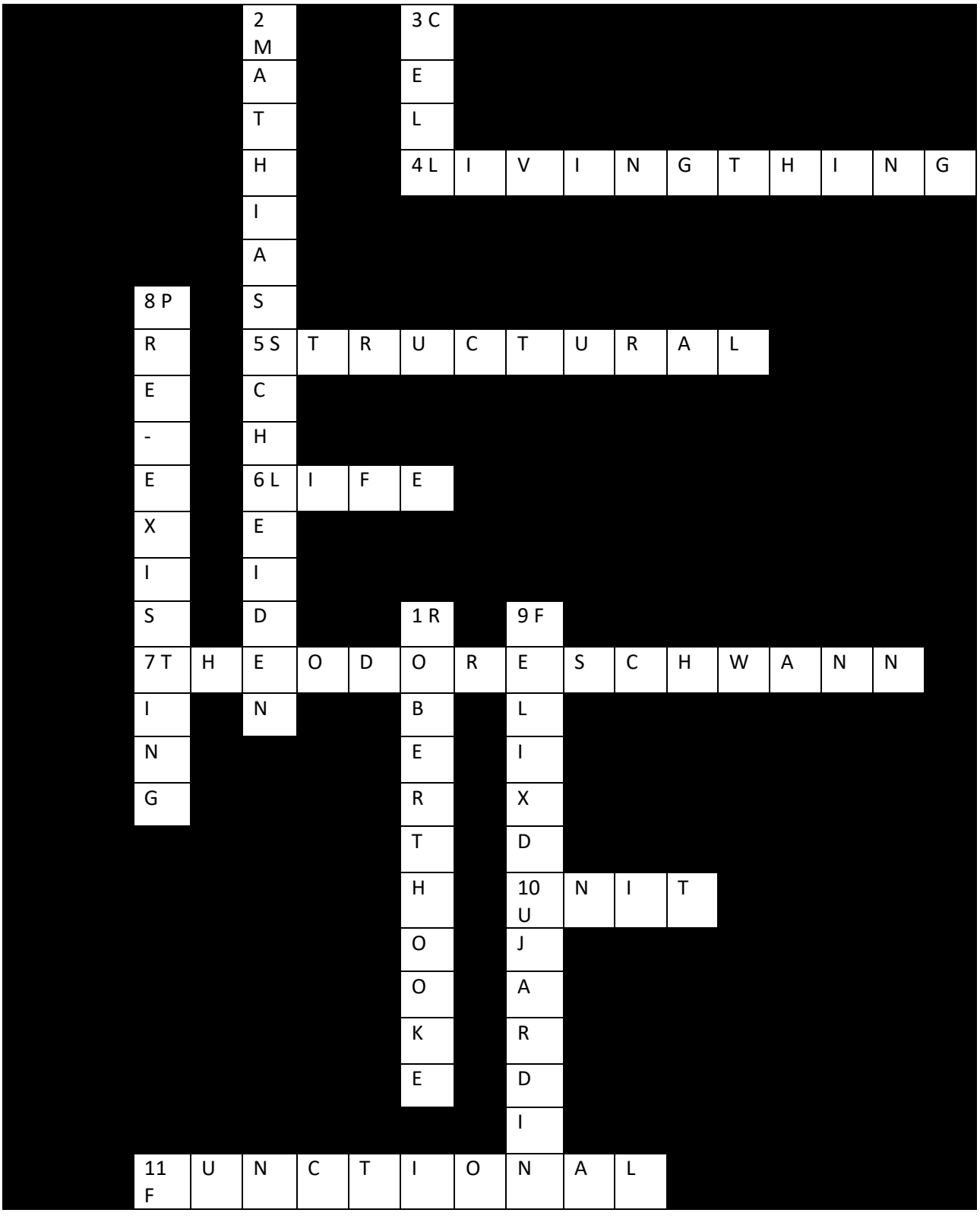
Step VIII: The lecturer ends the lecture and to assess the skills developed an assignment is given.

Evaluations: The students' knowledge are assessed by the lecturer on the concept by asking the following questions:

Assignment: The pre-service teachers are asked to read up all that has been taught.

Appendix III (Bi)

CELL BIOLOGY PUZZLE KEY A (Cell and Cell Theory)

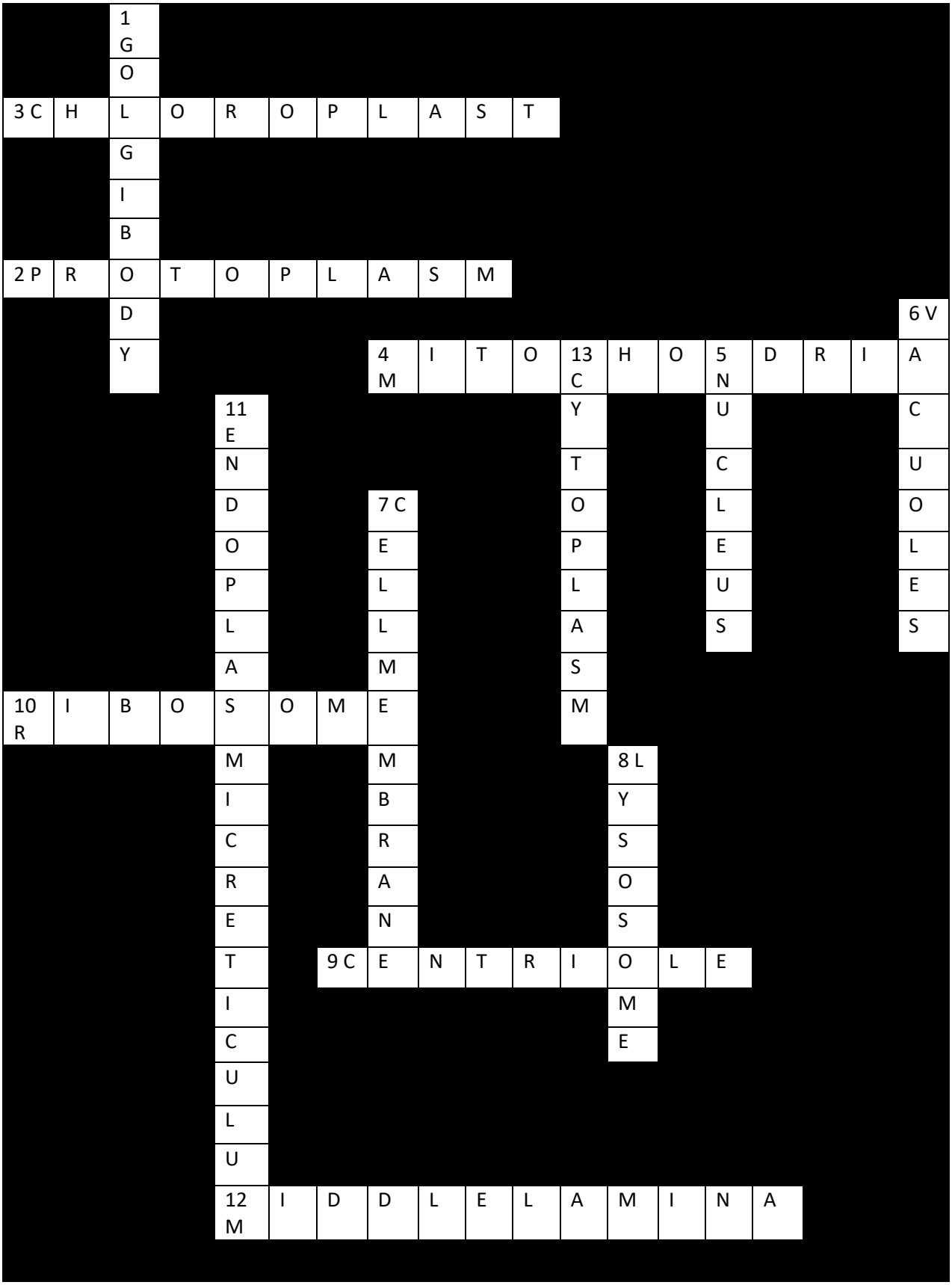


CLUES TO PUZZLE A – Cell and Cell Theory

1. A British scientist who examined thin slices of cork tissue under a compound microscope and found it has chambers. He is regarded as the father of cell (11) Robert Hooke
2. A German Botanist who studied the structures of the plants and concluded that plants were composed of cells (16) Mathias Schleiden
3. The Basic structural and functional unit of life (4) Cell
4. Part of the cell theory 2 that has to do with being with life (12) Living thing
5. Part of the definition of cell that has to do with the build-up (10) Structural
6. Part of the definition of cell that has to do with existence (4) Life
7. A German Zoologist who examined bits of animals under a microscope and found out it contained cells (15) Theodore Schwann
8. Part of the cell theory 3 that has to do with what has been there before (12) Pre-existing
9. A French biologist who examined thin slice of living plants under an improved microscope and found that the cells has content , he called it Sarcode (13) Felix Dujardin
10. Part of the definition of cell that has to do with a piece out from a large content (4) Unit
11. Part of the definition of cell that has to do with the workability of the cell (10) functional

Appendix III (Bii)

CELL BIOLOGY PUZZLE KEY B (Cell Organelles)

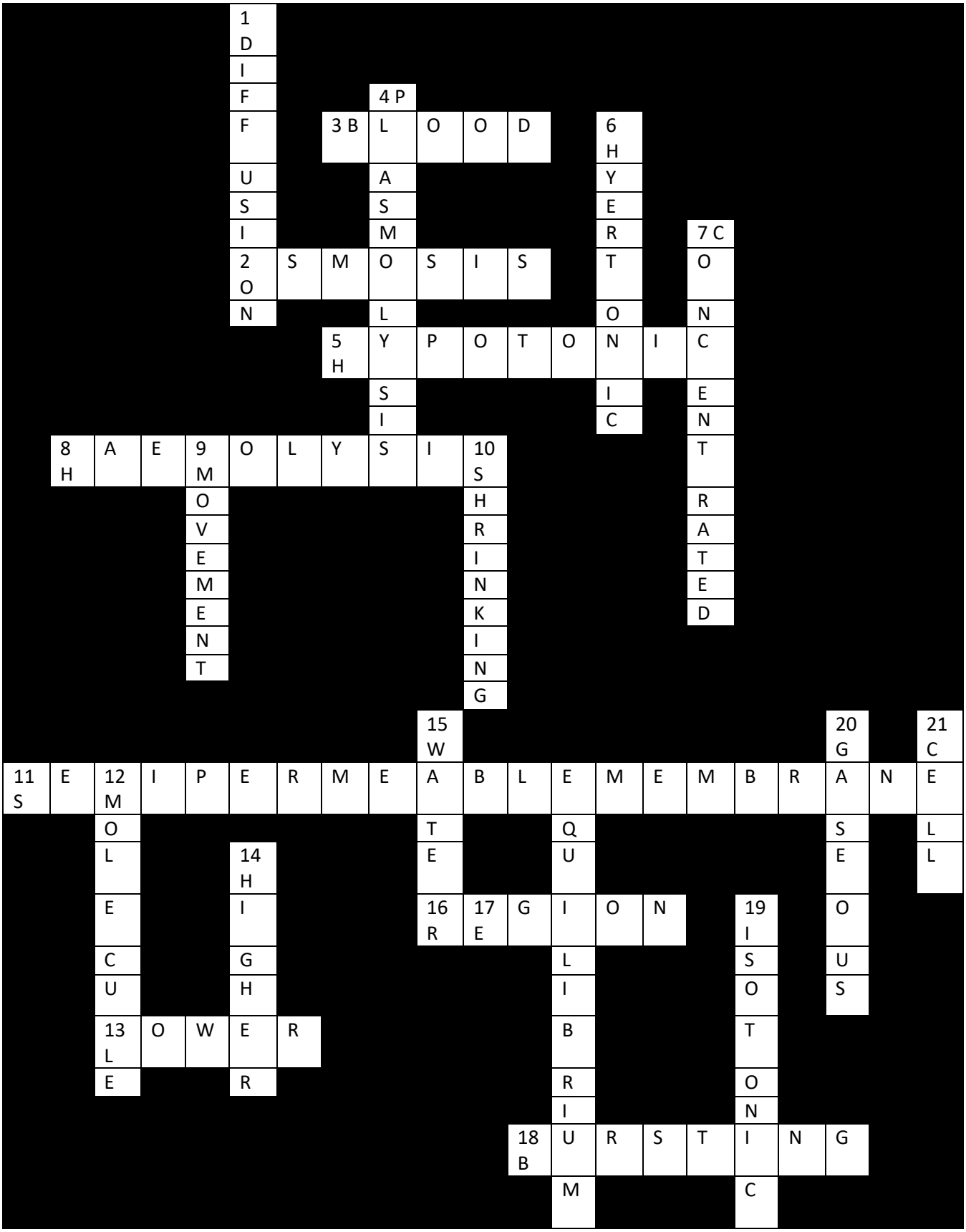


Clues for puzzle B – Cell Organelles

1. It function may help to distribute proteins made by the cell (9) Golgi Body
2. The colourless material comprising the living part of a cell, including the cytoplasm, nucleus and other organelles (10) Protoplasm
3. It functions as the seat of photosynthesis where organic foods are synthesized (11) Chloroplast
4. Functions as the power house of the cell (12) Mitochondria
5. It controls directly or indirectly most of the activities of the living cell (7) Nucleus
6. It is found only in plant cell but if found in animal cell it is small and it stores nutrients and waste products (8) Vacuoles
7. It is the thin and flexible living layer that surrounds the entire cytoplasm and seperates the cell from neighbouring cells (12) Cell Membrane
8. It destroys worn out parts of cells by discharging enzymes into them and thereby clearing the area for a new healthy cell to grow (8) Lysosome
9. They provide the spindle fibres to which chromosomes are attached during cell division (9) Centriole
10. They are the sites for protein synthesis (8) Ribosome
11. It helps in the formation of enzyme and protein, together with making lipids (20) Endoplasmic reticulum
12. Its an organelle that is found in between cell wall and cell membrane in plant cell (13) Middle lamina
13. All the living materials outside the nucleus (9) Cytoplasm

Appendix III (Biii)

CELL BIOLOGY PUZZLE KEY C (PROCESSES OF CELL)

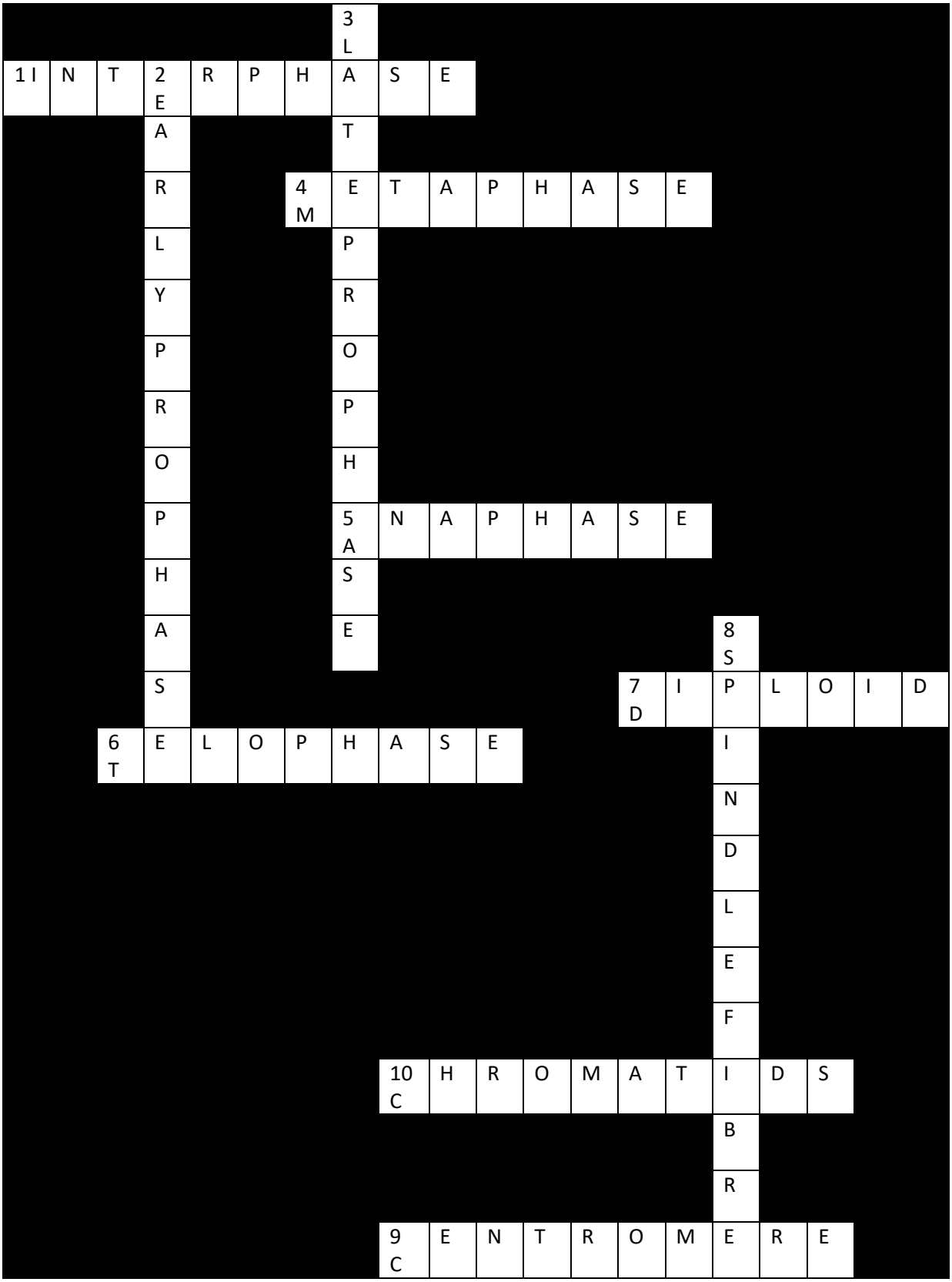


Clues for Puzzle C – Processes of Cell

1. The movement of gaseous or liquid molecules from a region of higher concentration to a region of lower concentration through the medium of air or liquid (9) Diffusion
2. The movement of water molecules from a region of lower concentration to a region of higher concentration through a semi-permeable membrane (7) Osmosis
3. A part of the haemolysis definition that has to do with a red liquid (5) Blood
4. The shrinkage of the vacuole and pulling away of the cytoplasmic lining from the cell wall when a plant cell is placed in more concentrated solution (11) Plamolysis
5. The bursting of an over stretched cell when dropped in a dilute solution (9) Hypotonic
6. The shrinking of a cell when dropped in a concentrated solution (10) Hypertonic
7. A solution that contains a large quantity of salt (13) Concentrated
8. The bursting of red blood cells in the plasma (10) Haemolysis
9. The act of leaving point A to point B (8) Movement
10. The act of reducing in size (9) Shrinking
11. The medium that allows lower concentrated liquid to pass and vis versa (20) Semi permeable membrane
12. The smallest particle of a specific compound e.g water, gas and solid (9) Molecule
13. The less concentrated solution in Osmosis or diffusion (5) Lower
14. The more concentrated solution in Osmosis or diffusion (6) Higher
15. The solute in a solution (5) Water
16. The area where which each solution is located (6) Region
17. When the lower solution is no more moving to the concentrated solution (10) Equilibrium
18. The opening of the cell when in hypertonic solution (8) Bursting
19. When there is zero osmosis in a cell (8) Isotonic
20. It is the molecule referred to as air (7) Gaseous
21. The basic structural and functional unit of Life (4) Cell

Appendix III (Biv)

CELL BIOLOGY PUZZLE KEY D (CELL DIVISION-MITOSIS)

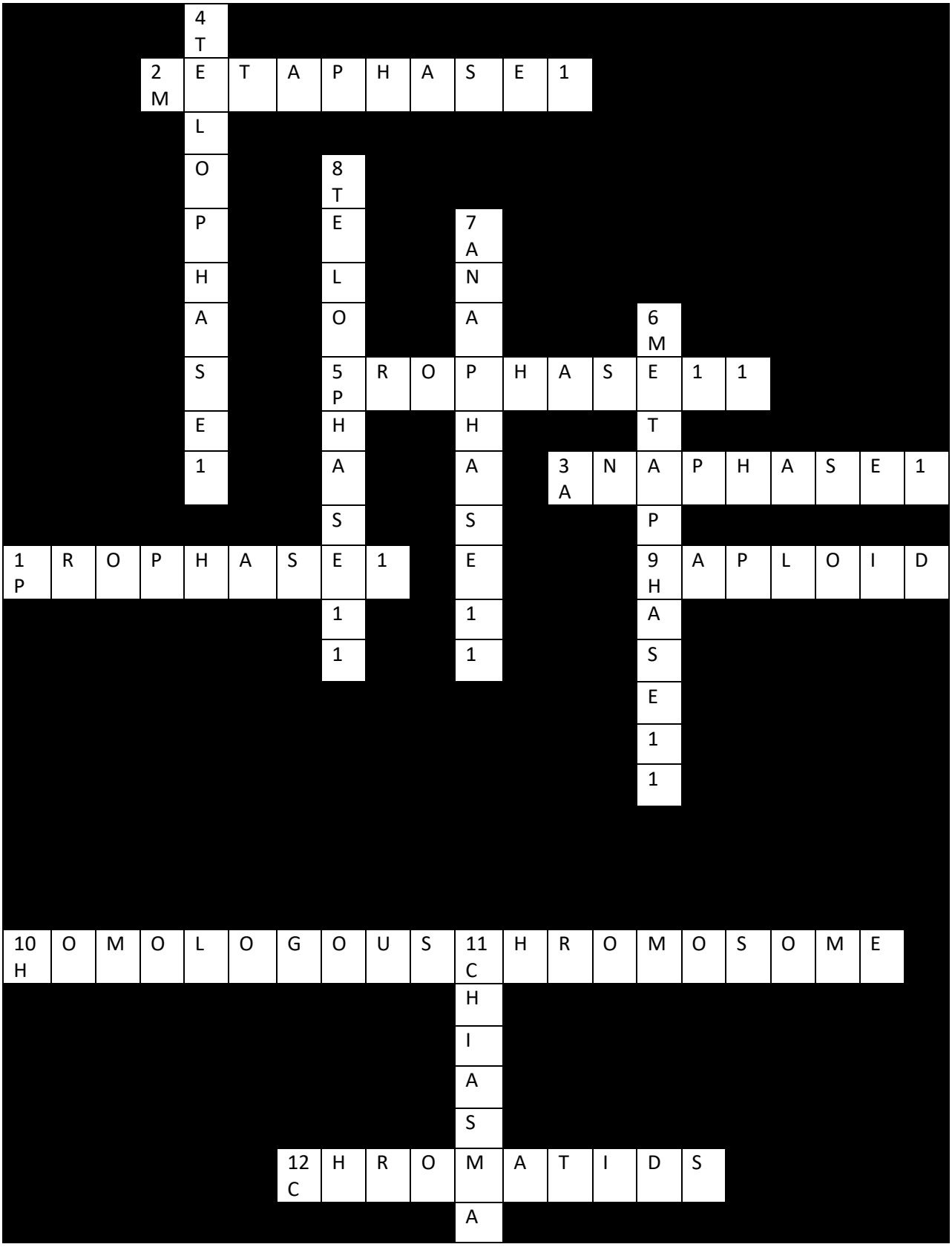


Clues for Puzzle D – Mitosis

1. The first phase of mitosis where chromosomes becomes elongated (10) Interphase
2. The first stage of the second phase of mitosis where chromosomes becomes visible as chromatin thread condense (13) Early Prophase
3. The second stage of the second phase of mitosis where chromosome becomes shorter, thicker and very visible (12) Late prophase
4. The third phase of mitosis where chromosome are now paired chromatids and align along the equator of the spindle (9) metaphase
5. The fourth phase of mitosis where chromatids of each chromosomes separate (8) Anaphase
6. The last phase of mitosis where chromosomes now lose their thick appearance and two daughter cell form (9) Telophase
7. The end result of mitosis producing two daughter cell (7) diploid
8. The thread where the chromosome gets attached using the centromere (12) Spindle fibre
9. The chromatids are attached to the spindle using it (10) Centromere
10. They are attached to the spindle by the centromeres (10) Chromatids

Appendix III (Bv)

CELL BIOLOGY PUZZLE KEY E (CELL DIVISION-MEIOSIS)



Clues for Puzzle E – Meiosis

1. The first phase of first meiotic division where homologous chromosome become thicker, shorter and clearly visible and held by chiasma (9) Prophase I
2. The second phase of first meiotic division where bivalent chromosomes are arranged at the equator and attached at the spindle by their centromeres (10) Metaphase I
3. The third phase of first meiotic division where each bivalent chromosome moves apart and move to the poles shortening the spindle (9) anaphase I
4. The last phase of first meiotic division where each bivalent chromosome arrive at the poles of the cell (10) Telophase I
5. The first phase of second meiotic division where chromosome becomes distinct in the two nuclei (10) Prophase II
6. The second phase of second meiotic division where chromosomes are attached to the spindle by their centromeres (10) Metaphase II
7. The third phase of second meiotic division where chromosomes get attached to the centromeres, separate and move to the poles (10) Anaphase II
8. The last phase of second meiotic division where chromatids arrive the pole of the cell, forms nuclear membrane (11) Telophase II
9. The end result of meiosis producing 4 daughter cells (7) Haploid
10. Chromosomes having the same structural features (20) Homologous chromosome
11. The point at which paired homologous chromosomes remain in contact as they begin to separate during the first prophase of meiosis forming across shape (7) Chiasma
12. There are attached to the spindle by the centromere (10) Chromatids

Appendix IV

INSTRUCTIONAL GUIDE FOR CONVENTIONAL INSTRUCTIONAL STRATEGY (OGCIS)

The lectures were based on the usual ways of writing lecture notes. The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

LESSON ONE: CELL AND CELL THEORY

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

LESSON TWO: PROTOPLASM AND ITS PROPERTIES PART A

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

LESSON THREE: PROTOPLASM AND ITS PROPERTIES PART B

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

LESSON FOUR: PHYSICAL PROCESSES OF CELL

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

LESSON FIVE: CELL DIVISION (MITOSIS)

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

LESSON SIX: CELL DIVISION (MEIOSIS)

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

LESSON SEVEN: REVISION I

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

LESSON EIGHT: REVISION II

The steps involved include:

1. The lecturer introduces the lecture
2. The lecturer goes through the content of the lesson
3. Lecturer gives examples and uses of the concept
4. Students write down the lecture note
5. The lecturer gives a window for questions from the class
6. Lecturer gives classwork
7. The lecturer assign marks to the students work.
8. The lecturer gives an assignment.

Appendix V (A)

PRE-SERVICE TEACHERS CELL BIOLOGY ACHIEVEMENT TEST (PTCBAT)

Part I – Demographic Information

Please fill accordingly

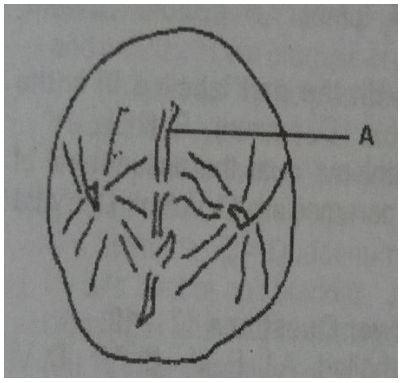
Name of College ……..……

Part II

Instruction – Please shade the appropriate right responses from the options lettered A – D.

1. Which of the following is not correct about the living cells.
   a. The basic unit of a living organism is the cell.
   b. All living organisms are either single or groups of cell(s)
   c. All the cells in the organisms are the same
   d. Life does not exist apart from the life in the cells.

The diagram below illustrates a stage in mitosis. Use it to answer questions 2



2. What is the name given to the structure labelled A at this stage of cell division?
   a. chromatin
   b. chromosome
   c. chromatid
   d. daughter-chromosome
3. Which of this organelles is common to both plants and animals cells?
   a. Chlorophyll
   b. Pyrenoid
   c. Centriole
   d. Mitochondrion
4. The activities of the living cell is controlled by which of the following structures?

a. Nucleus

b. Centrosome

c. Golgi body

d. Mitochondrion

5. Which of the following substances pass through the root cell membrane by osmosis?

   a. Cell sap

   b. Carbon dioxide

   c. Oxygen

   d. Water

6. The energy used by the cell is produced in the

   a. mitochondrion

   b. lysosome

   c. golgi apparatus

   d. cytoplasm

7. The structure in the cell that controls the movement of substances in and out of the cell is the

   a. cell membrane

   b. nuclear membrane

   c. cytoplasm

   d. endoplasm

8. At the end of mitosis the number of cells produced from a parent cell is

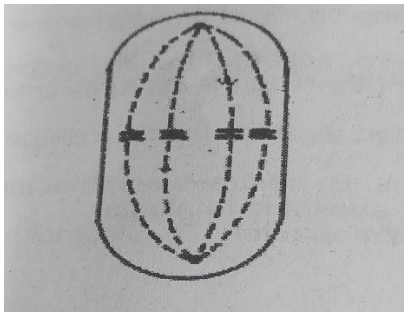
   a. Four

   b. Six

   c. Three

   d. Two

Below is a drawing of a stage in mitosis. Use it to answer questions 9



9. The stage of mitosis represented in the diagram is known as the
    a. Telophase
    b. metaphase
    c. anaphase
    d. interphase
10. The protozoans eliminates water from their body through which of the following organelles
    a. Plasma membrane
    b. contractile vacuole
    c. cell wall
    d. protoplasm
11. The essential mechanism of gaseous exchange in living organisms is through
    a. Osmosis
    b. inhalation
    c. diffusion
    d. exhalation
12. Which of the following statements is correct about diffusion?
    a. It involves the movement of water molecules only
    b. molecules move from a region of higher concentration to a region of lower concentration
    c. differentially permeable membrane must be present for diffusion to occur
    d. it involves the movement of only solute molecules into the bowman's capsule
13. Who formulated the theory of natural selection in evolution?
    a. Robert Hooke
    b. Jean Lamarck
    c. Mathias Schleiden
    d. Charles Darwin
14. Which of the following is not true of the nucleus of a living cell? It contains
    a. Chromosome
    b. nucleolus
    c. nucleolus
    d. chromatids
15. The cell membrane consists of
    a. Carbohydrates and lipids

b. vitamins and proteins

c. lipids and proteins

d. water and sugar

16. The theory of use and disuse of organs was propounded by

a. Gregor Mendel

b. Charles Darwin

c. Jean Lamarck

d. Louis Pasteur

17. Which of the following is a similarity between a typical animal cell and a typical plant cell? Presence of

a. Cellulose cell wall

b. centrally-placed nucleus

c. cell membrane

d. large vacuole

18. The first scientist to describe the cell was

a. Theodor Schwann

b. Robert Hooke

c. Charles Darwin

d. Mattias Schleiden

19. In which of the following parts of a cell is the chromosome found?

a. Nucleus

b. Golgi body

c. Cytoplasm

d. Cell membrane

20. Spermatogenesis and Oogenesis are both terms used to describe

a. mitosis

b. meiosis

c. mating

d. implantation

21. The cell membrane of a cell is said to be semi-permeable because

a. It allows only large molecular substances to pass through it into the cell

b. it is actively involved in energy-production in the cell

c. it actively allows all substances to pass through it by diffusion

d. it is actively selective in allowing substances pass through it

22. Which of the following is not a cell organelle?

a. Golgi body

b. fat droplets

c. ribosome

d. endoplasmic reticulum

23. Movement of water across a semi-permeable membrane from a weaker solution to a stronger solution is known as

a. Transpiration

b. diffusion

c. active transport

d. osmosis

24. Which of the following statement is not true about chromosomes?

a. Each chromosome is made up of two chromatids

b. body cells have diploid numbers of chromosomes

c. homologous chromosomes do not occur in pairs naturally

d. the sex cells have haploid number of chromosomes

25. One major difference between osmosis and diffusion is that diffusion

a. Does not need a semi-permeable membrane

b. does not take place in living tissues

c. takes place only in a liquid medium

d. takes place only in a gaseous medium

26. The presence of a large member of mitochondria in a cell indicates that

a. it has little cytoplasmic content

b. the cell is very active

c. the cell is dormant

d. the respiration is poor

27. Which of the following substances pass through the root cell membrane by osmosis?

a. Cell sap

b. water

c. carbon dioxide

d. oxygen

28. The nucleus controls the activities of the cell because it

a. Synthesis hormones

b. is like a brain in the cell

c. uses DNA to synthesize enzymes which are used in cell metabolism

d. sends out nervous impulses to ensure the functioning of the cytoplasm

29. The basis of growth involves the following processes **except**

a. cell division

b. cell differentiation

c. cell enlargement

d. cell reduction

30. In a living cell, factors which are responsible for inheritance are located

a. On the nuclear membrane

b. on the nucleolus

c. on the chromosomes

d. on the nucleoplasm

Appendix V (B)

ANSWER SHEET

PRE-SERVICE TEACHERS CELL BIOLOGY ACHIEVEMENT TEST (PTCBAT)

1. Name of School……..…….....

2. Matric Number……..

S/N	a	b	c	d
i.				
ii.				
iii.				
iv.				
v.				
vi.				
vii.				
viii.				
ix.				
x.				
xi.				
xii.				
xiii.				
xiv.				
xv.				
xvi.				
xvii.				
xviii.				
xix.				
xx.				
xxi.				
xxii.				
xxiii.				
xxiv.				
xxv.				
xxvi.				
xxvii.				
xxviii.				
xxix.				
xxx.				

Appendix V (C)

ANSWERS

PRE-SERVICE TEACHERS CELL BIOLOGY ACHIEVEMENT TEST (PTCBAT)

1	C
2	B
3	D
4	A
5	D
6	A
7	A
8	D
9	B
10	A
11	C
12	B
13	D
14	D
15	C
16	C
17	C
18	B
19	A
20	B
21	D
22	B
23	D
24	C
25	A
26	B
27	B
28	D
29	D
30	C

Appendix V (D)

NCE BIOLOGY COURSE OUTLINE FOR BIO 112 (CELL BIOLOGY)

BIO 112: CELL BIOLOGY 1 Credit Compulsory

Objectives:

Students should be able to highlight the following by the end of the course:

i. Discuss the cell theory
ii. Enumerate the cell constituents
iii. Differentiate between mitosis and meiosis.

a) A brief history of the concept of cell and cell theory. The structure of a generalized plant cell and a generalized animal cell, and their comparison

- Protoplasm and its properties. Cytoplasmic Organelles: Definition and functions of nucleus, endoplasmic reticulum, cell membrane, mitochondria, ribosomes, Golgi complex, plastids, lysosomes and other cell organelles

b) Chemical constituents of cell – salts, carbohydrates, proteins, fats and oils, nucleic acid.

c) Physical processes of cell: particle size, molecules and ions, suspensions, colloids and true solutions, properties of aqueous system; diffusion, osmosis plasmolysis, turgor, pinocytosis, phagocytosis.

d) Cell Division:

- Mitosis and meiosis
- Major stages of mitosis and meiosis
- Comparison of the two divisions
- Significance of mitosis and meiosis

Appendix VI

PRE-SERVICE TEACHERS CELL BIOLOGY INTEREST QUESTIONNAIRE (PTCBIQ)

The purpose of this questionnaire is to obtain your views on your interest in cell biology. Be assured that your responses are solicited exclusively for this study and your responses will be confidential. Thanks for your Cooperation.

SECTION A – Demographic Information

Please fill accordingly

Name of College ……..……..

Matric number/Level ……..…….

SECTION B

Tick the appropriate response for each of the following questions below. The acronyms used represent the following: SA – Strongly Agree, A – Agree, D – Disagree, SD – Strongly Disagree

S/N	ITEMS	SA	A	D	SD
1.	When the concept of cell is taught, I am always ready to learn.				
2.	I always want to partake in any hands-on activities in cell biology.				
3	I do not like to learn cell biology.				
4.	I dislike cell biology because I cannot relate it to life.				
5.	I like participating in the entire learning process of cell biology				
6.	I dislike studying cell biology because I used to have diverted attention in the class.				
7.	I do not pay attention when I am being taught cell biology.				
8.	I dislike carrying out practical in cell biology because it waste time.				
9.	Activities in cell biology lessons are not interesting.				
10.	I enjoy cell biology because it is full of hands-on activities.				
11.	I prefer carrying out practical in cell biology than class activities.				
12.	I dislike being given class work or assignments.				
13.	I do not enjoy learning cell biology concepts.				

14.	I enjoy writing down notes from practical sessions in cell biology.				
15.	I like chalkboard summary when the lecturer is teaching.				
16.	I dislike when the lecturer summarizes the lecture.				
17.	I understand cell biology better when hand-on activities are used.				
18.	I feel practical is a waste of time.				
19.	I do not understand the concept of cell biology no matter the teaching strategy.				
20.	I understand cell biology concepts when I see what is being taught.				
21.	I like being taught cell biology when visuals aids are incorporated.				
22.	I intend to pursue a career related to cell biology.				
23.	I dislike cell biology because it tends to be voluminous				
24.	Cell biology concept helps me understand the importance of cell in living organisms				

Appendix VII (A)

PRE-SERVICE TEACHERS CELL BIOLOGY PROBLEM-SOLVING ABILITY SCALE (PTCBPAS)

Instruction: the aim of the problem-solving ability test is to get your logical and accurate ways you think when issues are presented. To see how you are able to solve problems based on the narration given.

It is important that you put down your answers to each of the spaces given in the problem-solving ability test. This steps below will guide you in writing down your answers.

1. Carefully study the scenario/narration given.
2. Critical analysis your answers before writing it down.
3. Put down the answers on the spaces given to each of the questions.
4. Do this for each of the scenarios.
5. Record your matric number/name on the booklet
   You are free to study the questions and provide the appropriate answers.
   Try to answer all problems.

Section A

Name of College: ……..……

Matric number: ……..……..

Section B

PROBLEM-SOLVING ABILITY TEST – CELL BIOLOGY

SCENARIO 1

You have a garden with a limited space that can only accommodate a single tree in your compound. However, there is a need for you to plant an orange and a tangerine in the garden. A friend suggested grafting when you discussed it with him. To graft in agriculture, you will need a cutlass, nylon and rope. Figure I – III is a diagrammatic representation of the progress of the grafted tree showing the progression at 1 month, 3 months, and 6 months.

Grafting: at 1 month

Based on the scenario 1, answer question 1 to 4.

Defining the problem

Question 1. In your view, discuss the situation of your garden

_____

_____

_____

_____

Selecting the pieces of information

Questions 2. From your view in question 1, state the various farm tools you will use

_____

_____

_____

_____

Combining the pieces of information

Question 3. Device a plan with the items stated in question 2 on how to graft the two plants

_____

_____

_____

_____

Evaluation

Question 4. Will your plan have any effect on the plant? What aspect of cell does this deal with? In a short sentence explain how grafting will work in this scenario.

_____

_____

_____

_____

SCENARIO 2

Being the only eyewitness in an accident between a motorbike rider and a car. You observed that the rider sustained a wound, and what seems to be a broken femur. With your knowledge of first aid and a diagrammatic representation of the accident scene below, provide the answers the questions.

Defining the problem

Question 1. Identify and Mention the injuries in the scenario in the order in which you will attend to them.

_____

_____

_____

_____

Selecting the pieces of information

Questions 2. From your view in question 1, state the various equipment that you will use if you are provided with a first aid box

_____

_____

_____

_____

Combining the pieces of information

Question 3. Device a plan you will use to deal with the situation (s) you identified in question 1

_____

_____

_____

_____

Evaluation

Question 4. Will your plan have any effect on the affected area? What area of cell is this related to?

_____

_____

_____

_____

SCENARIO 3

Assuming you bought five oranges and were peeling them. While peeling the fourth orange you cut yourself with the knife. The following are available in your first aid box at home methylated spirit, cotton wool, and Gentian Violet (GV) etc. With the diagrammatic representation of the injured finger, provide answers to the questions below.

Defining the problem

Question 1. Identify and Mention the injury in scenario 1

_____

_____

_____

_____

Selecting the pieces of information

Questions 2. From your view in question 1, state the things in the box that you will require?

_____

_____

_____

_____

Combining the pieces of information

Question 3. Device a plan you will use to deal with the situation you identified in question 1

_____

_____

_____

_____

Evaluation

Question 4. Will your plan have any effect on the wound. Mention three blood cells in relation to the wound and healing.

_____

_____

_____

_____

SCENARIO 4

There is a mango tree in your garden. Children in the compound have the habit of pushing nails into the tree trunk as they play about. You noticed that the tree has begun to wilt. Use the diagrammatic representation of the tree below to respond to the questions provided below.

Defining the problem

Question 1. Identify and Mention the situation in your garden

_____

_____

_____

_____

Selecting the pieces of information

Questions 2. From your view in question 1, state what the item needed in other to solve the problem

_____

_____

_____

_____

Combining the pieces of information

Question 3. Device a plan you will use to deal with the situation you identified in question 1

_____

_____

_____

_____

Evaluation

Question 4. Will your plan have any effect on the affected area? What area of cell is this related to?

_____

_____

_____

_____

Appendix VII (B)

PRE-SERVICE TEACHERS CELL BIOLOGY PROBLEM-SOLVING ABILITY SCALE (PTCBPAS) ANSWERS

Section A

Name of College: ……..……

Matric Number: ……..

Section B

Scenario 1

Question 1:

The garden has limited space

Problem of getting two trees to be planted on the same spot

Using grafting to solve the problem

Question2:

Cutlass, orange tree or branch, nylon, tangerine tree or branch, rope

Question 3:

The orange tree will be planted first then the branch will be cut off with cutlass and the branch from the tangerine will be grafted.

It will be held together by the nylon and a rope so that budding can occur and a single citrus tree with orange and tangerine fruits will spring up.

Question 4:

The tangerine will bud with the orange.

There will be no effect on the orange tree

Cell growth

The grafting works by fusing the two stem cell together

Scenario 2

Question 1:

An accident between a motorbike and a car

A passenger breaks his femur bone and fractures his tibia

Making use the first aid kit to arrest the situation and stop the bleeding

Question 2:

Bandage, methylated spirit, cotton wool, Gentian violet (GV), scissors

Question 3:

Making use of the cotton wool and the methylated spirit to clean the wound

Making use of the bandage to try to hold the bone in place

Applying the GV to the wound

Question 4:

Yes it will stop the bleeding

Cell growth and regeneration

Scenario 3

Question 1:

Cutting off your skin while peeling an orange

A Bleeding finger

Making use of methylated spirit, cotton wool etc to stop the bleeding

Question 2:

Methylated spirit, Gentian violet (GV), cotton wool, scissors and plaster

Question 3:

Making use of the scissors to hold the cotton wool and dipping it in the methylated spirit to clean the wound

Making use of the scissors to hold the cotton wool and dipping it in the Gentian violet (GV)

Applying the GV to the wound and covering it with the plaster

Question 4:

Yes the procedure will stop the bleeding and aid healing

Cell growth and regeneration

Scenario 4

Question 1:

A mango tree having with pierced nails on its trunks

The blockage of the phloem and xylem by the pierced nails

The mango tree beginning to wilt

Question 2:

Hammer, nail, nylon, rope

Question 3:

The use of the hammer to remove the nails

Covering the affected are with the nylon to prevent insect infestation

Question 4:

Yes, because when the nails are removed the stem cell can heal and re-joins.

Cell growth and regeneration

Appendix VIII

PRE-SERVICE TEACHERS' COGNITIVE STYLE TEST (PTCST)

Instruction

The students are handed the booklets containing all the cards with pictures and are informed to provide the following.

Matric Number ……

The instrument is explained to the students.

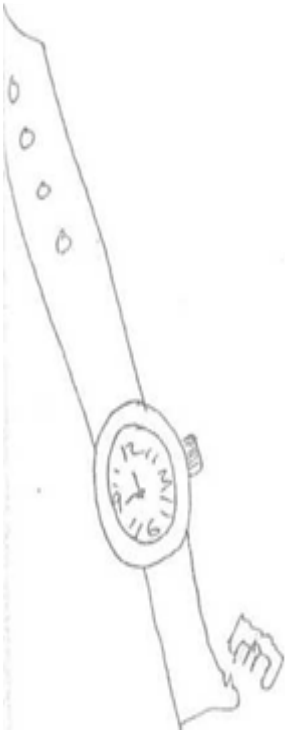
The lecturer gives a brief explanation of what is expected from the students. An example is given by picking the first card with three pictures. The first card has a wristwatch with the letter A written under it. A man with letter B written under it, while letter C is the ruler. The instruction is that you should pick any two pictures out of the three given and indicate how they are together, related or belong together and further indicate why you choose the two pictures by stating as many reasons as you can. When you have exhausted all reasons, you can move to the next set of cards until you answer all 20 cards. Use at least 75 seconds for each card.

Note that we do not have a wrong or right answer, what is important is that we want to see the various ways you see things. People see a single thing whereas others see numerous things, in all you are expected to put in effort in matching these pictures. You are allowed to switch your answers if you so wish, however just write by the side sorry and the old response will not be scored but only the recent one. Your grammar or expression will not be scored.

Test Rule

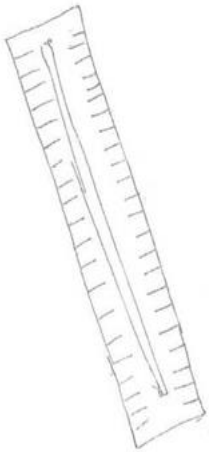
Pre-service teachers that have already taken the test should not be allowed to influence others with their own reasons.

There are not allowed to work as long as there want. It is 75 seconds for each card.



MAN

B

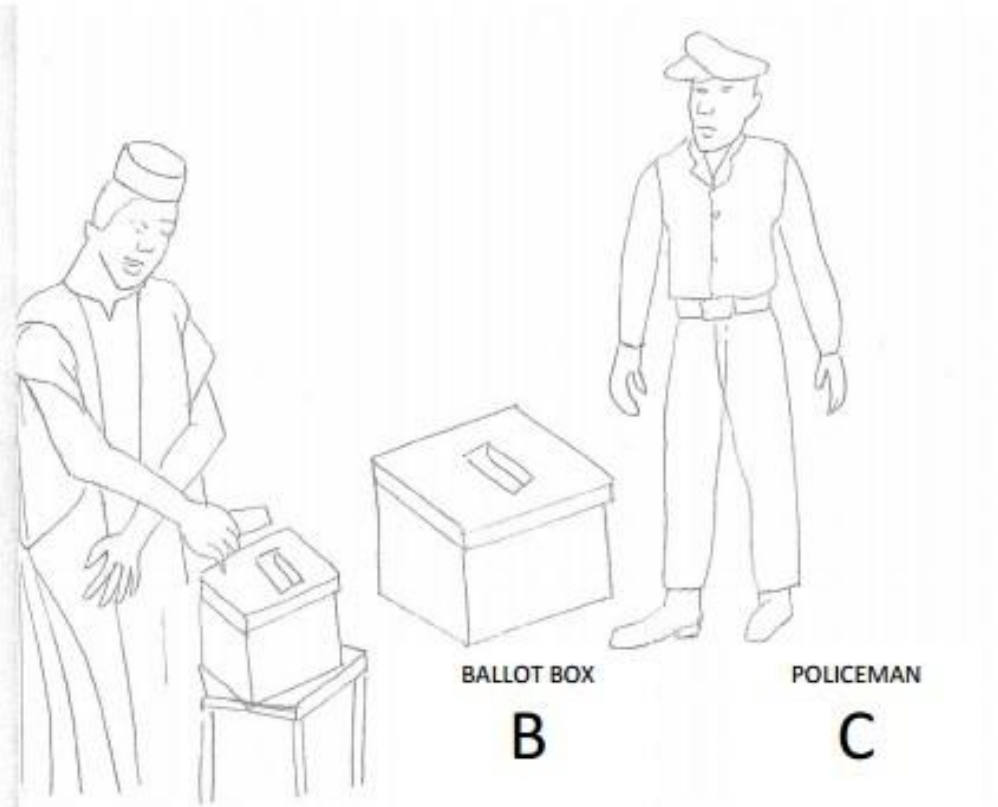


RULER

C

WRISTWATCH

A



VOTER

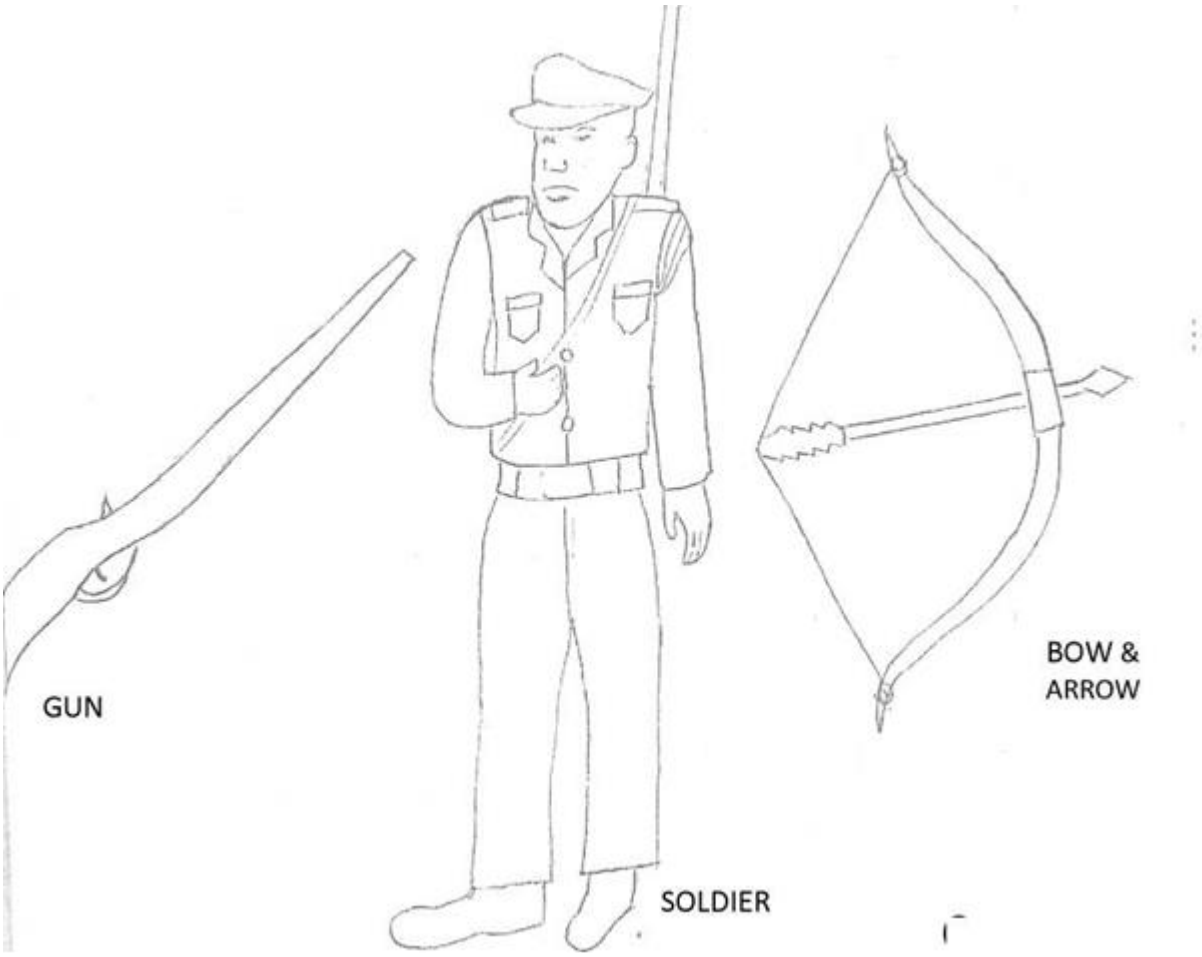
A

BALLOT BOX

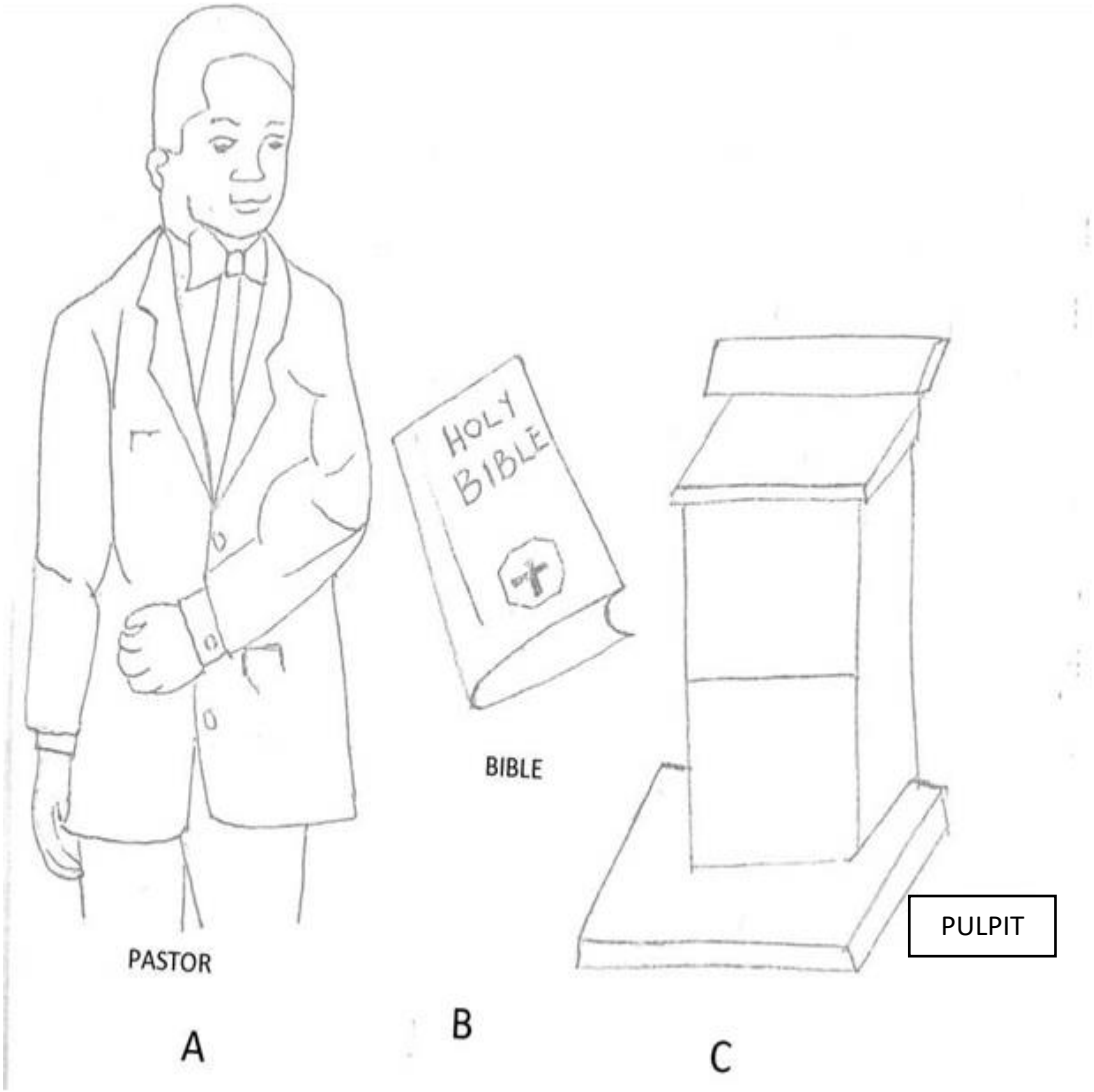
B

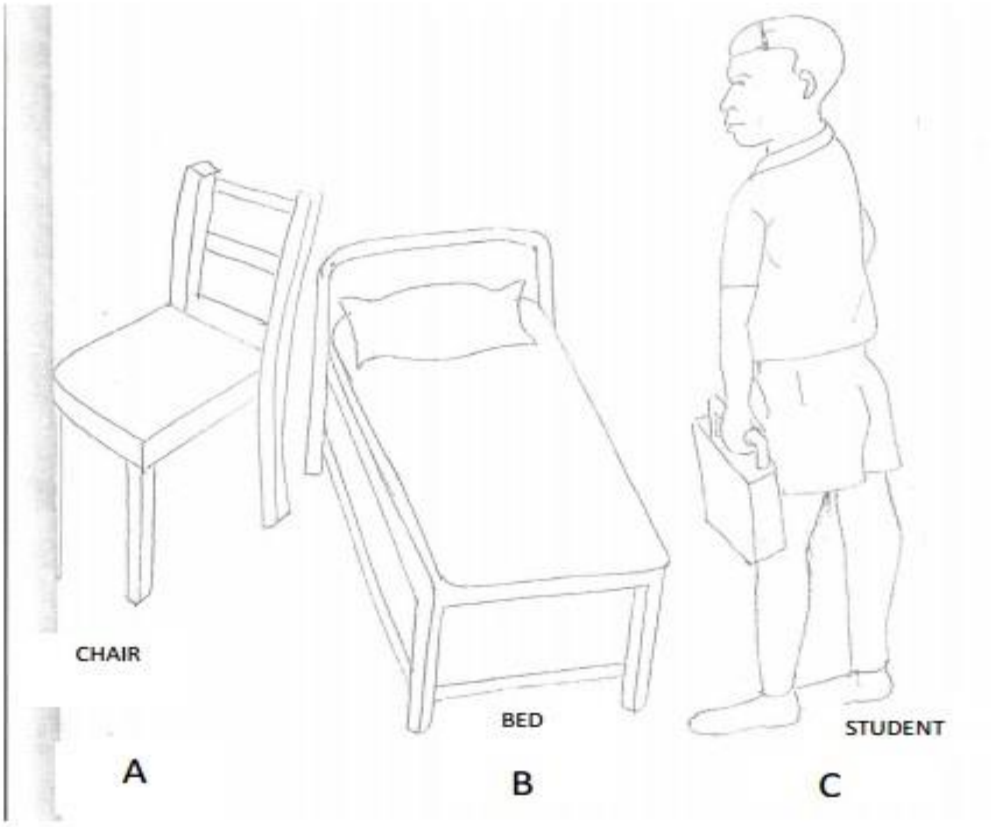
POLICEMAN

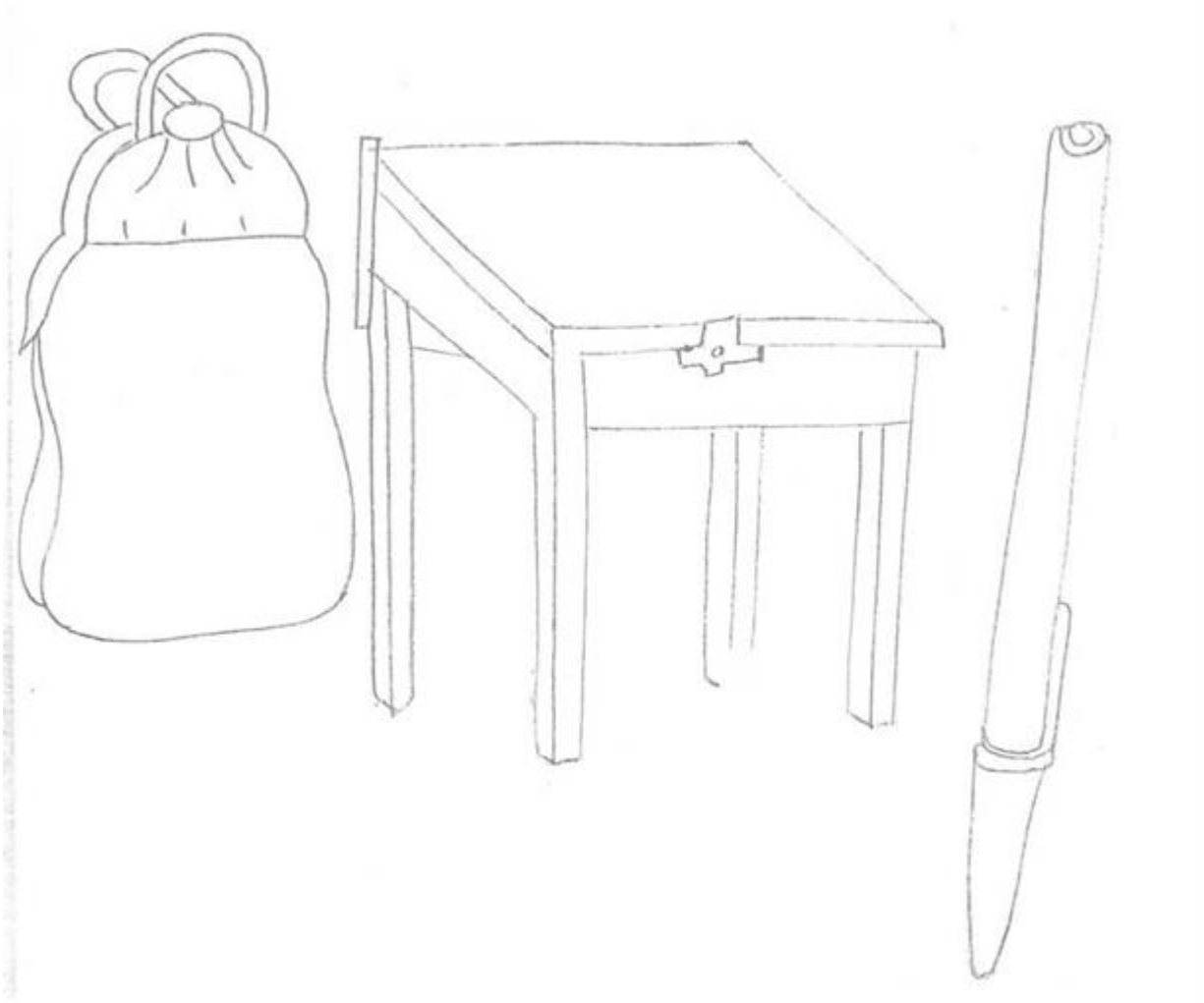
C



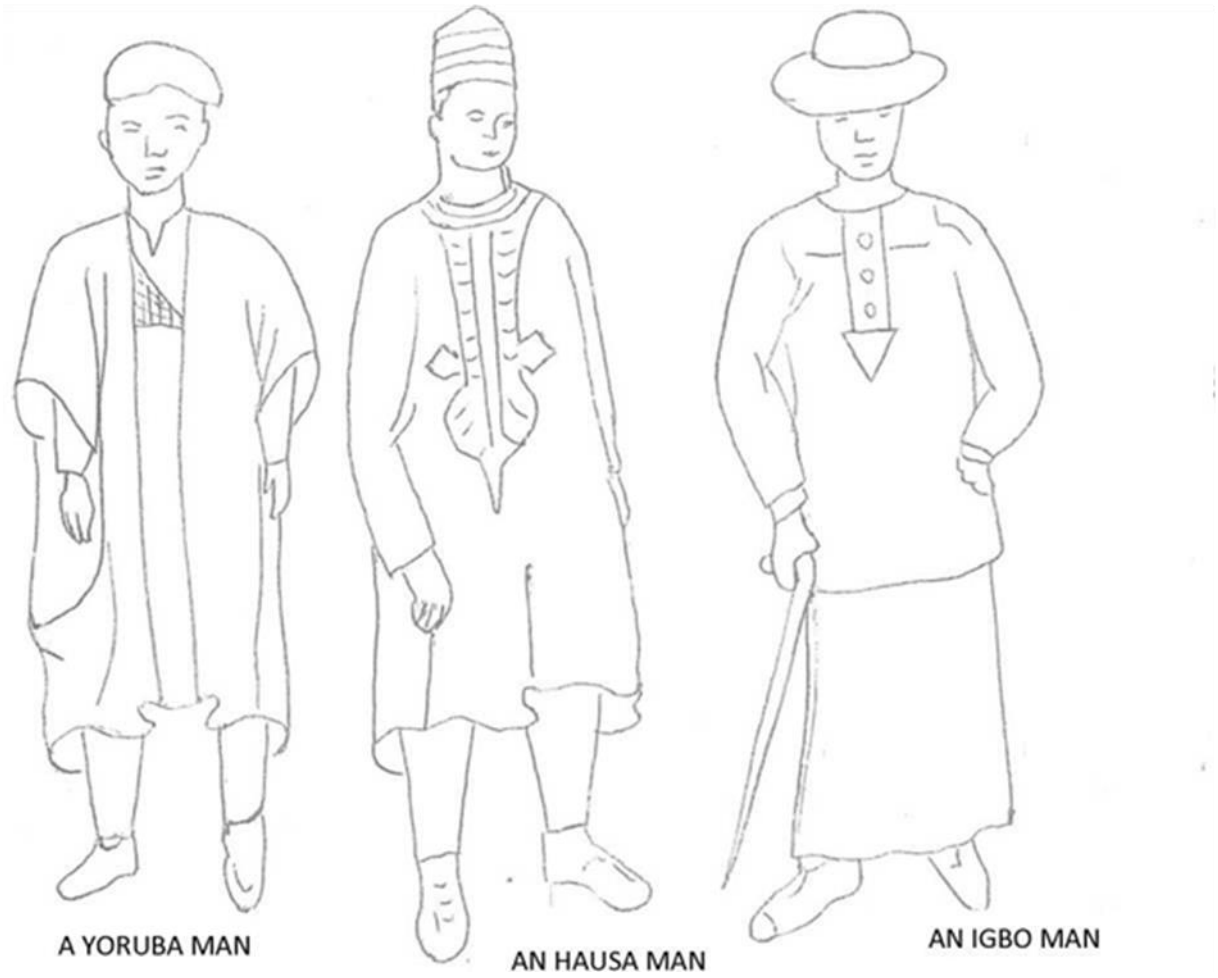
A **B** **C**


HOLY BIBLE
PASTOR
BIBLE
PULPIT
A
B
C

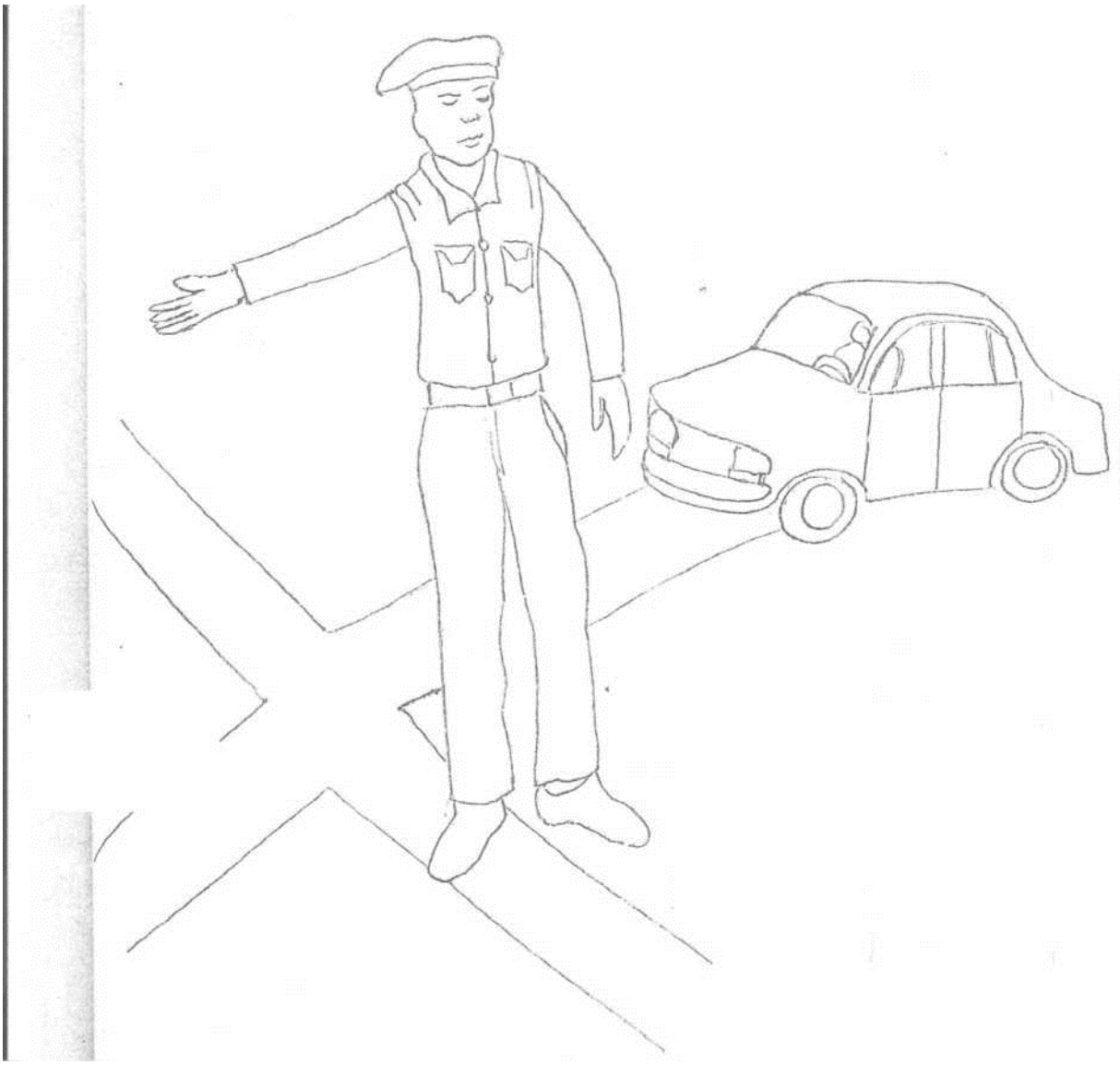

CHAIR
BED
STUDENT
A
B
C



A	**B**	**C**
SCHOOL BAG	TABLE	BIRO

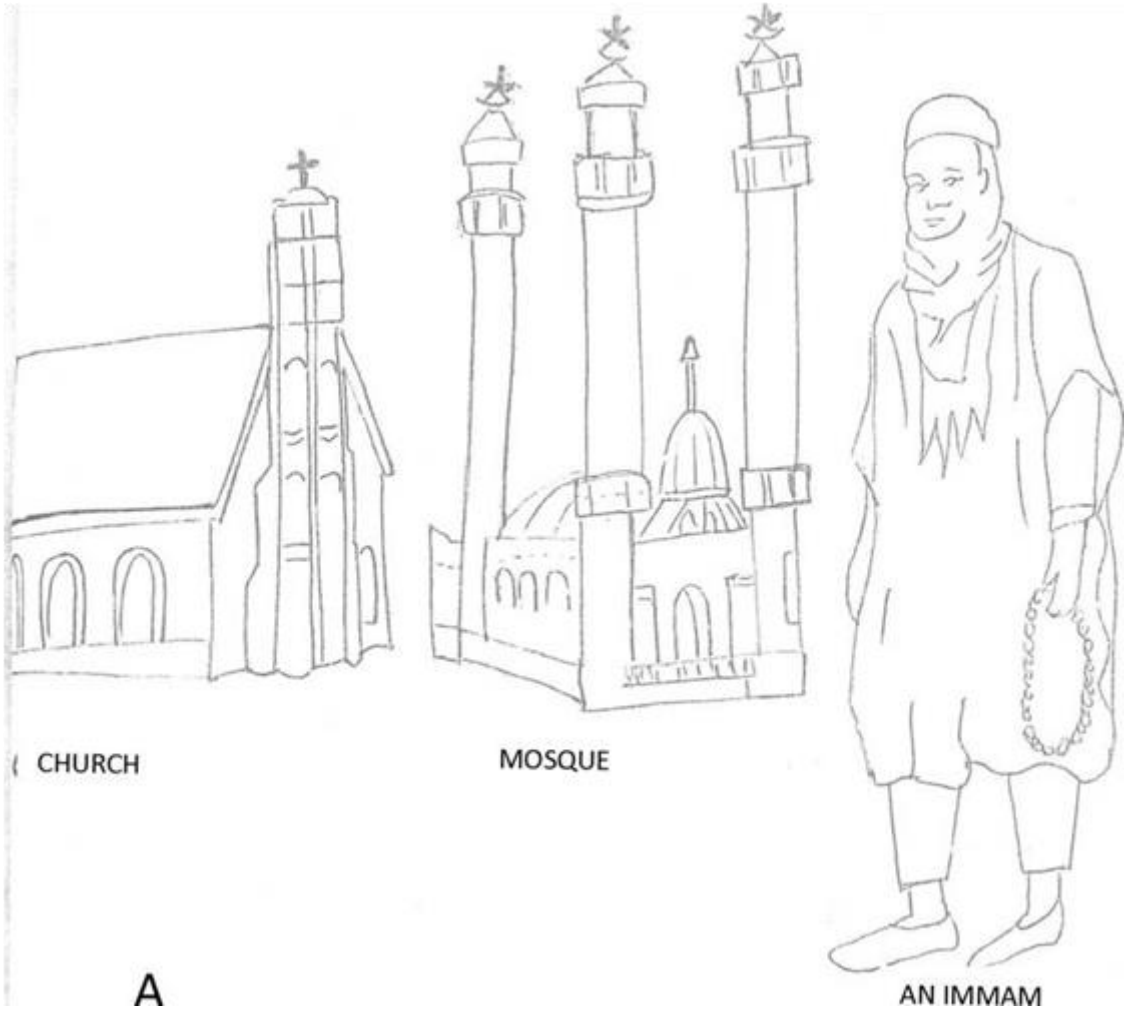


A **B** **C**



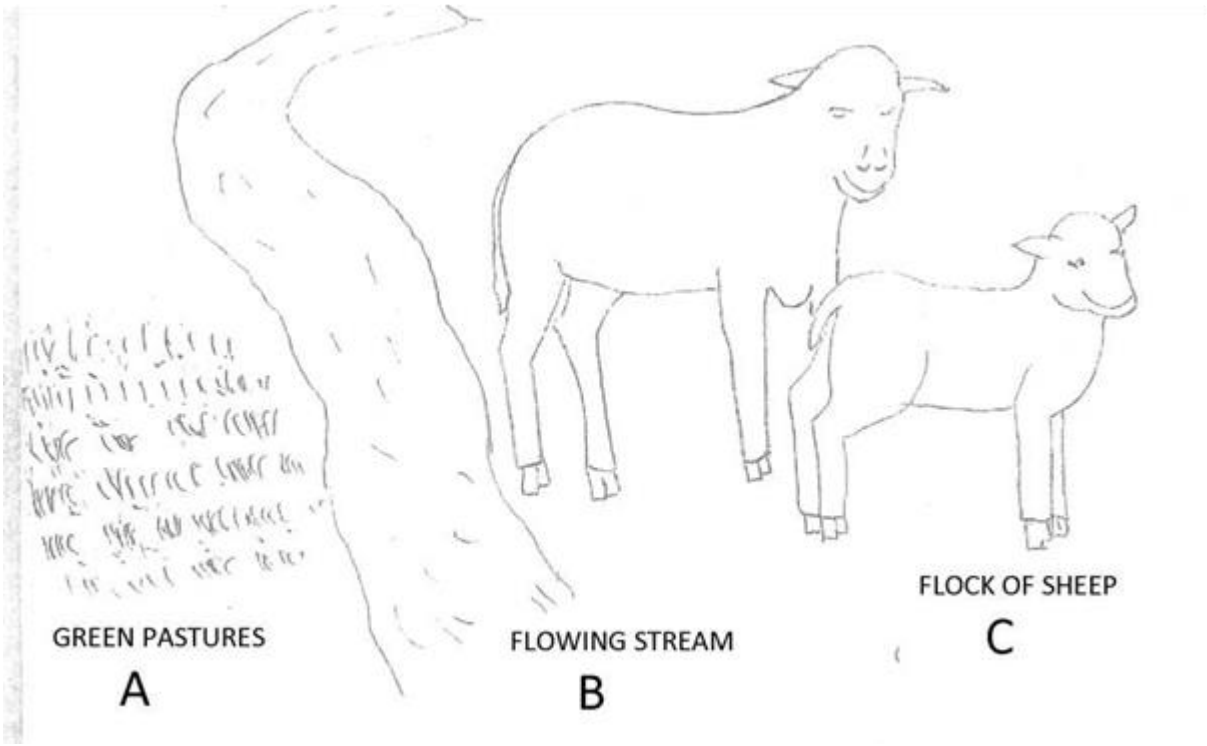
A B C

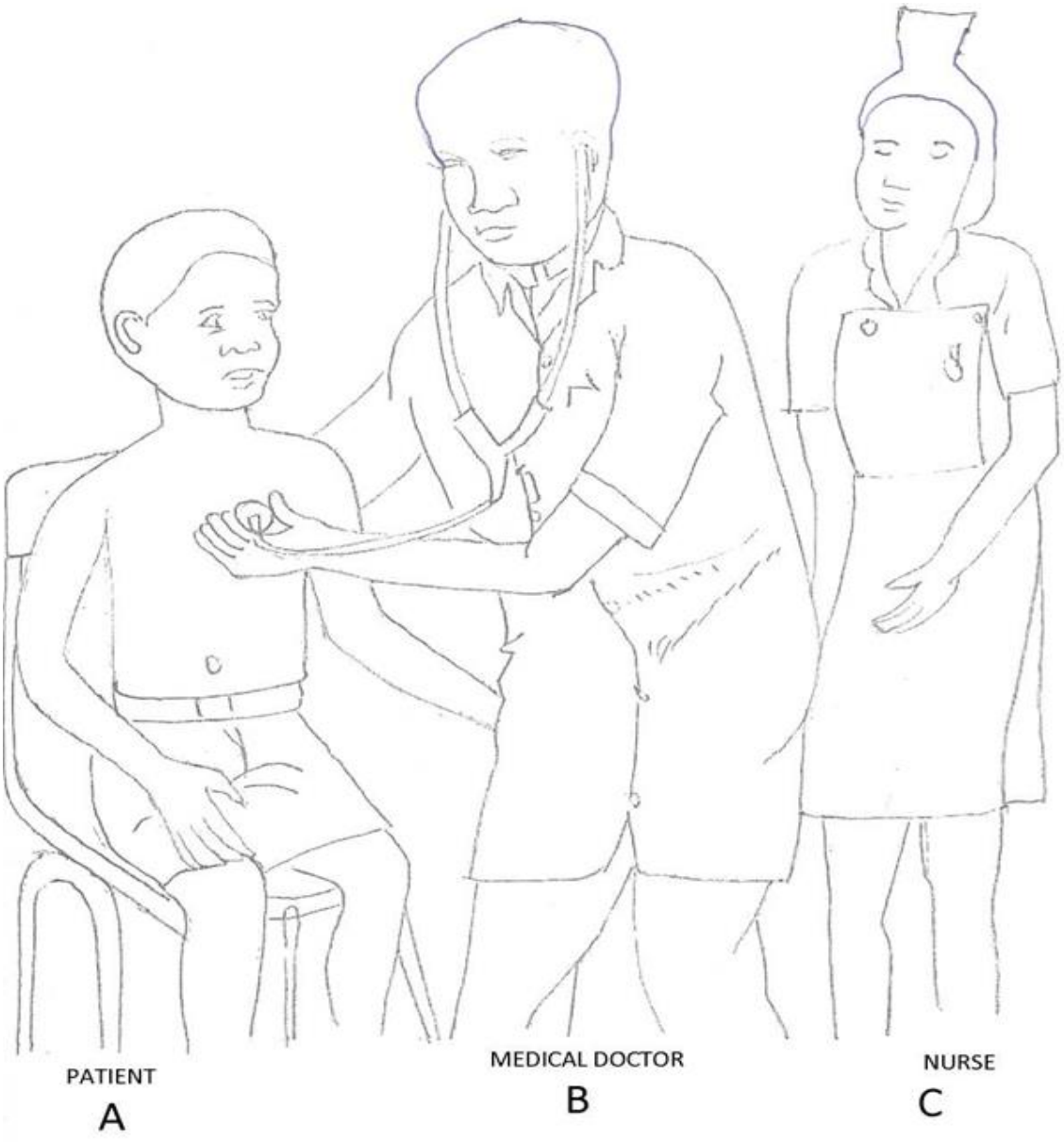
T-JUNCTION TRAFFIC WARDEN CAR

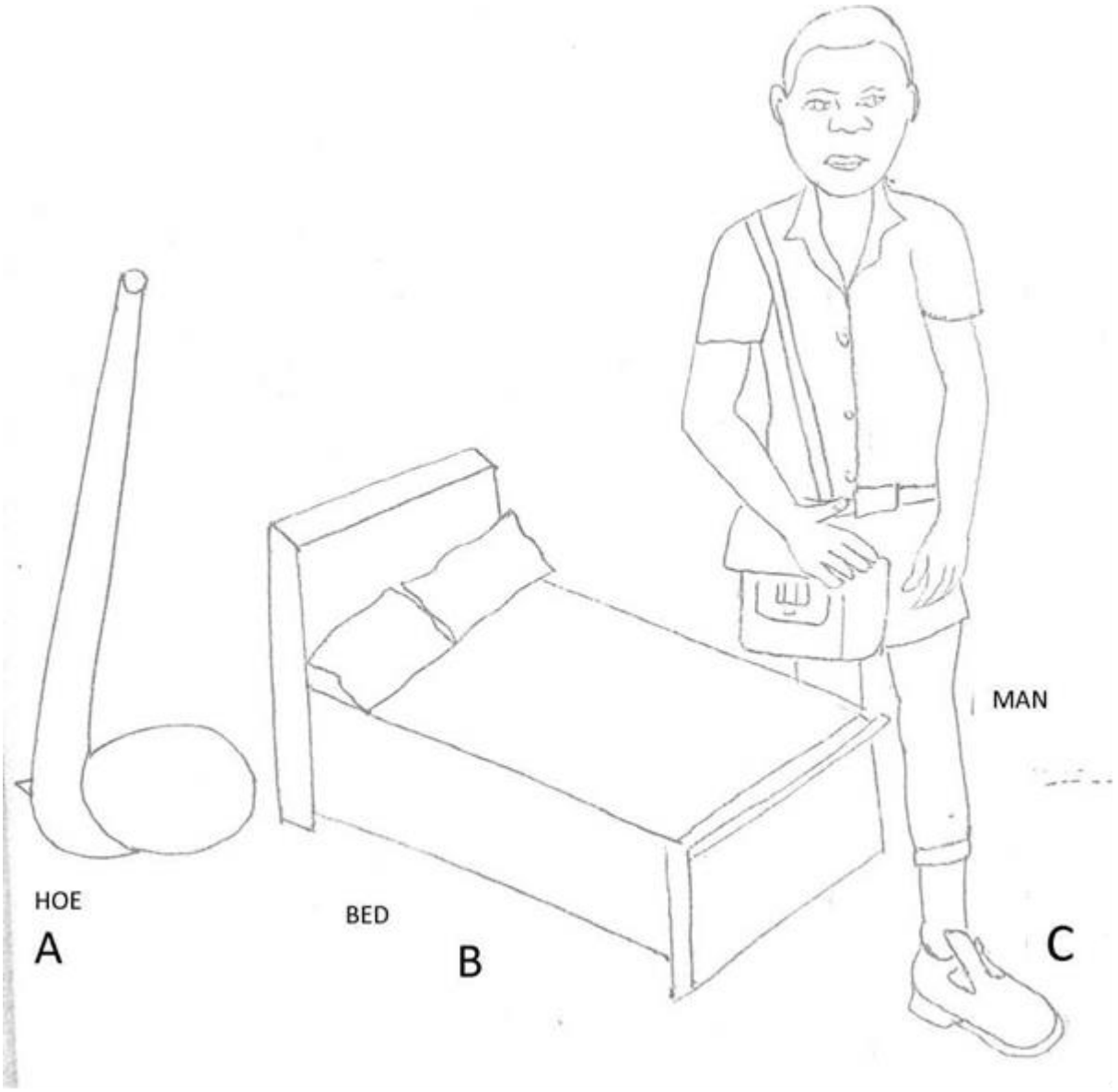


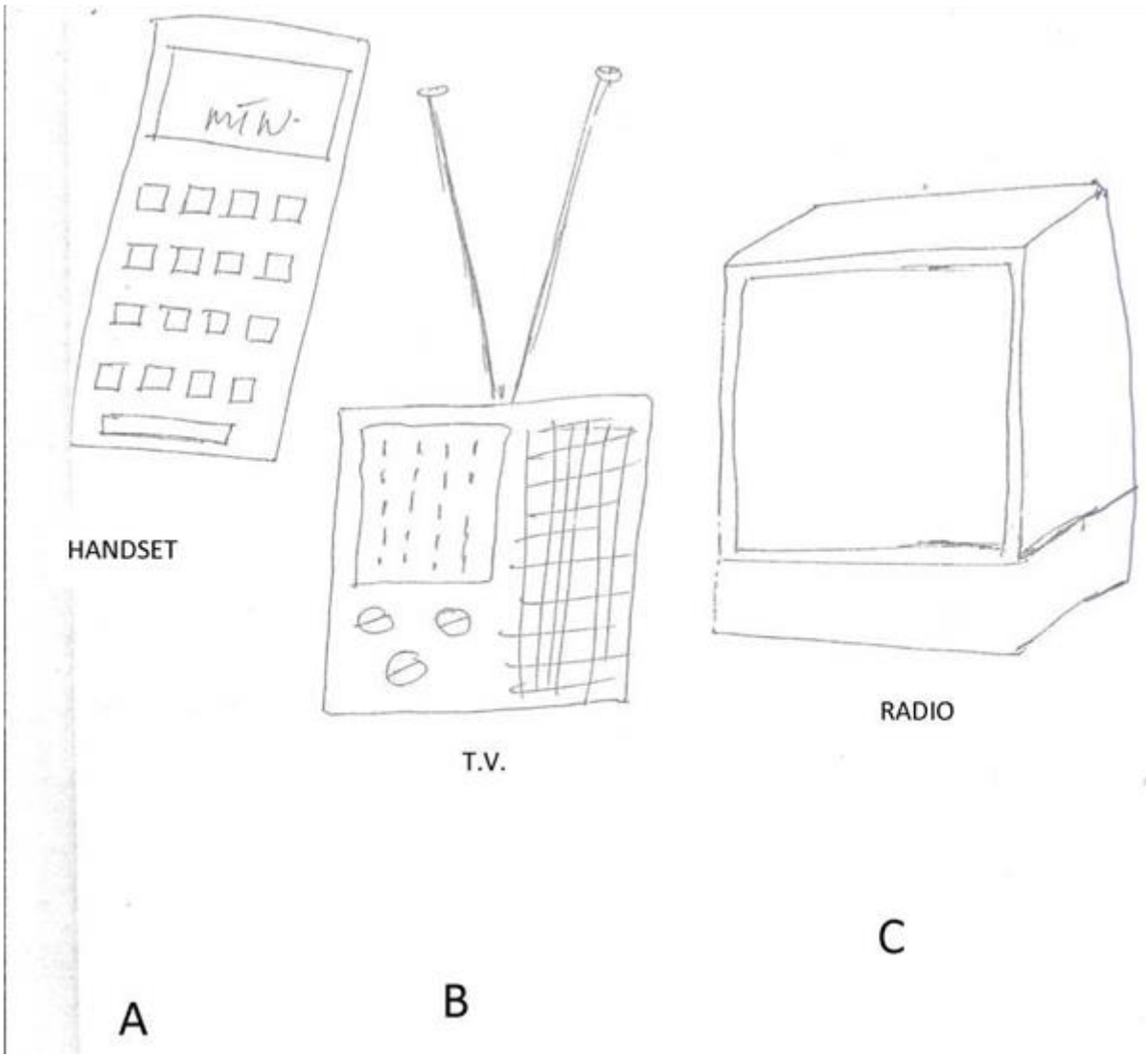
A

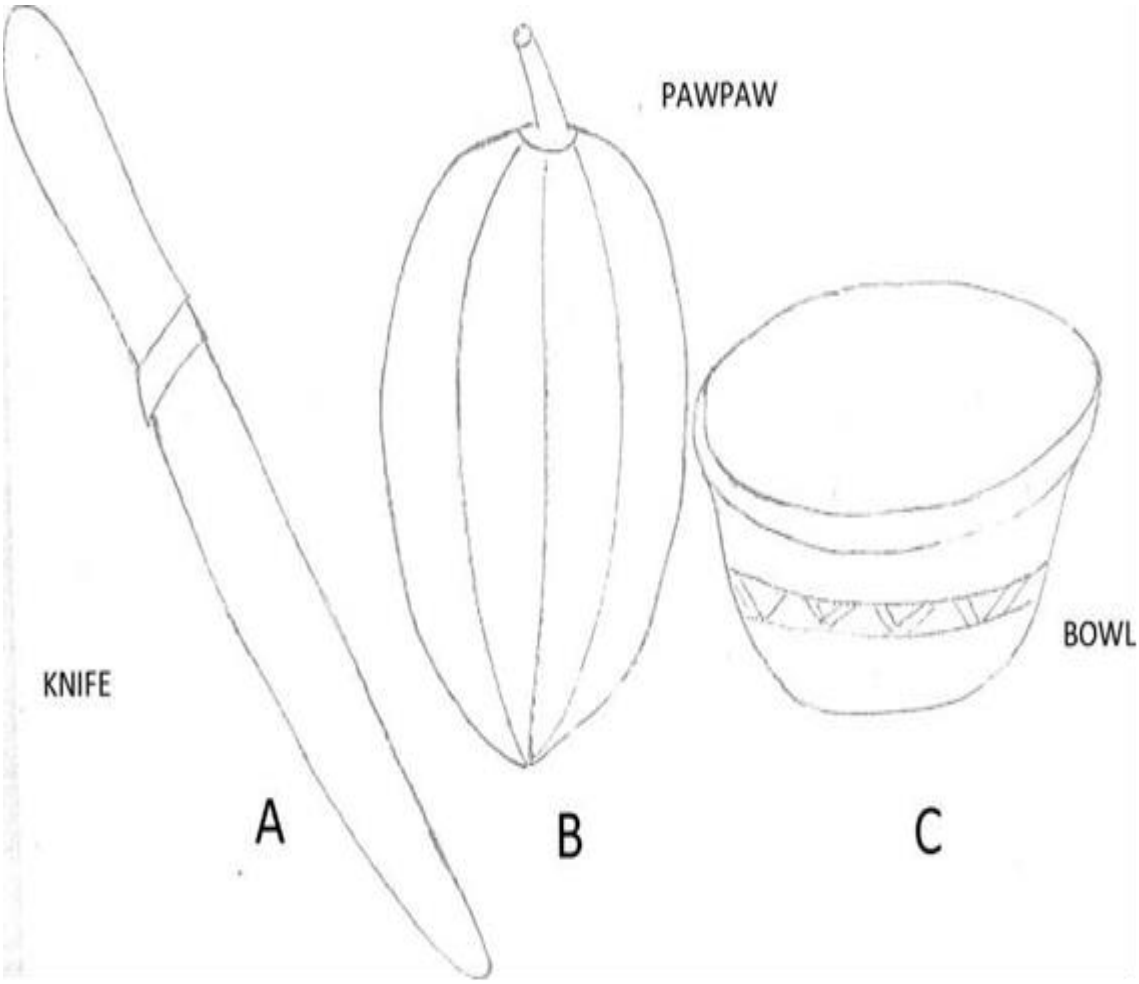
C

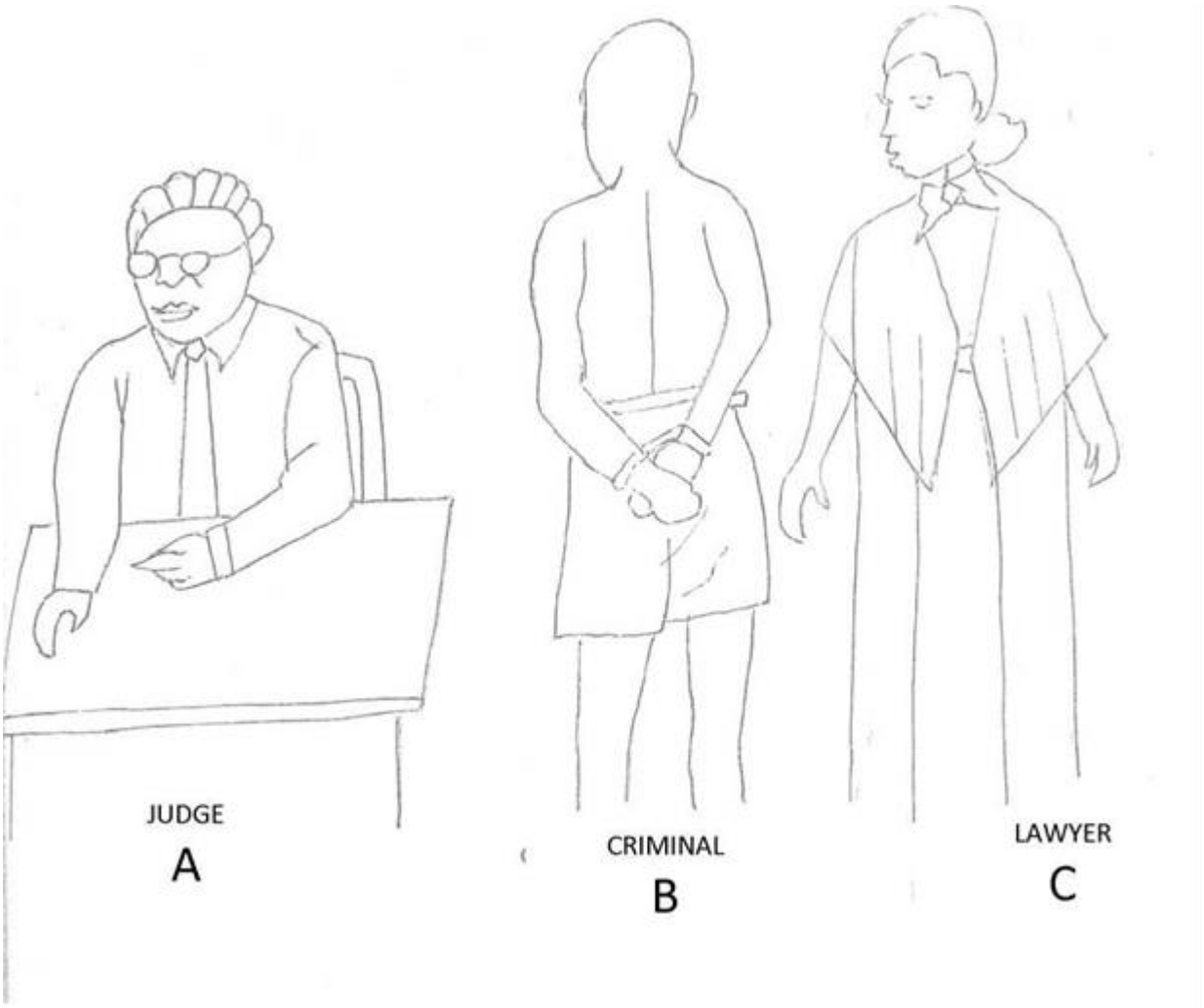

GREEN PASTURES
A
FLOWING STREAM
B
FLOCK OF SHEEP
C

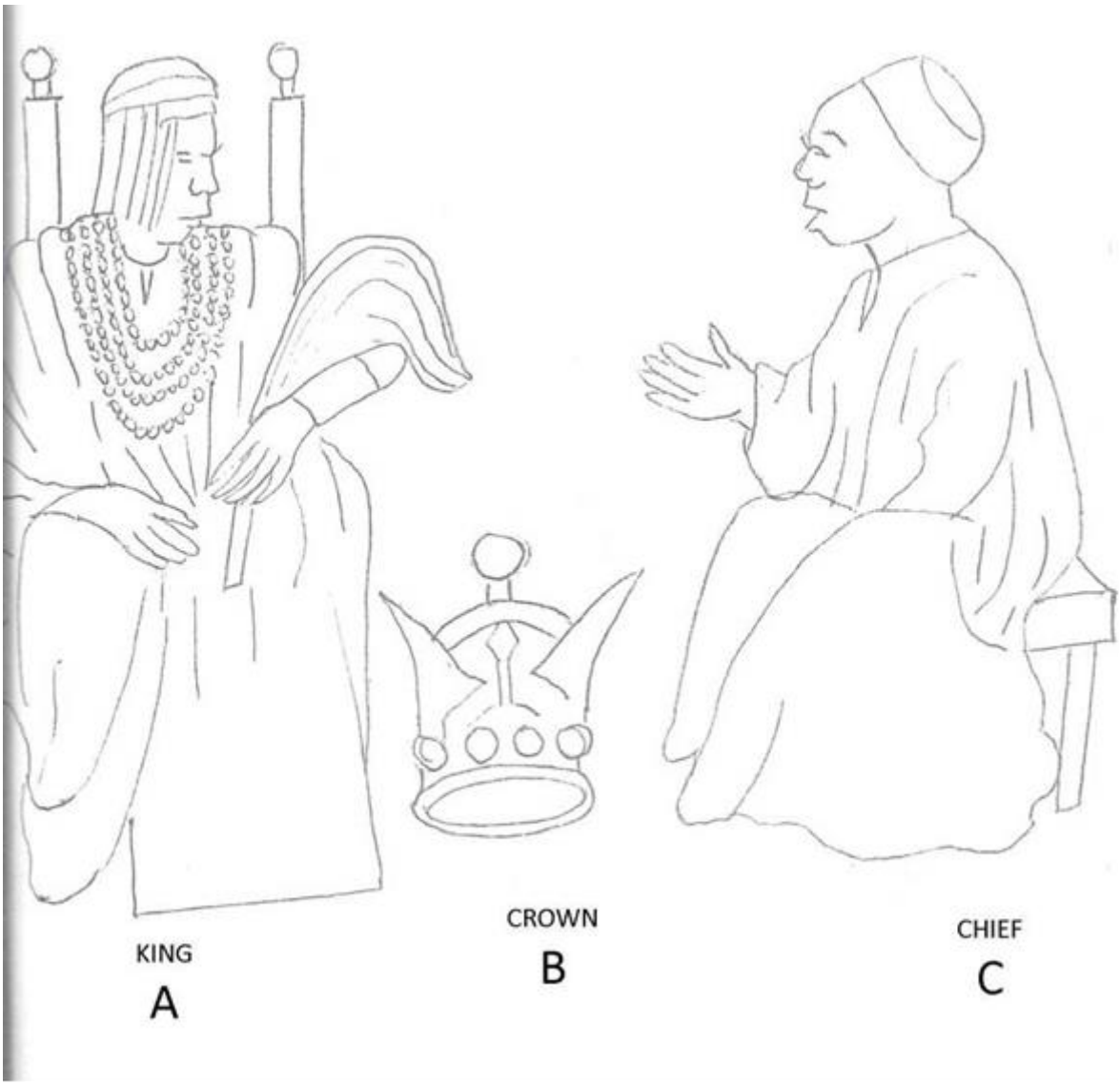

PATIENT
A
MEDICAL DOCTOR
B
NURSE
C

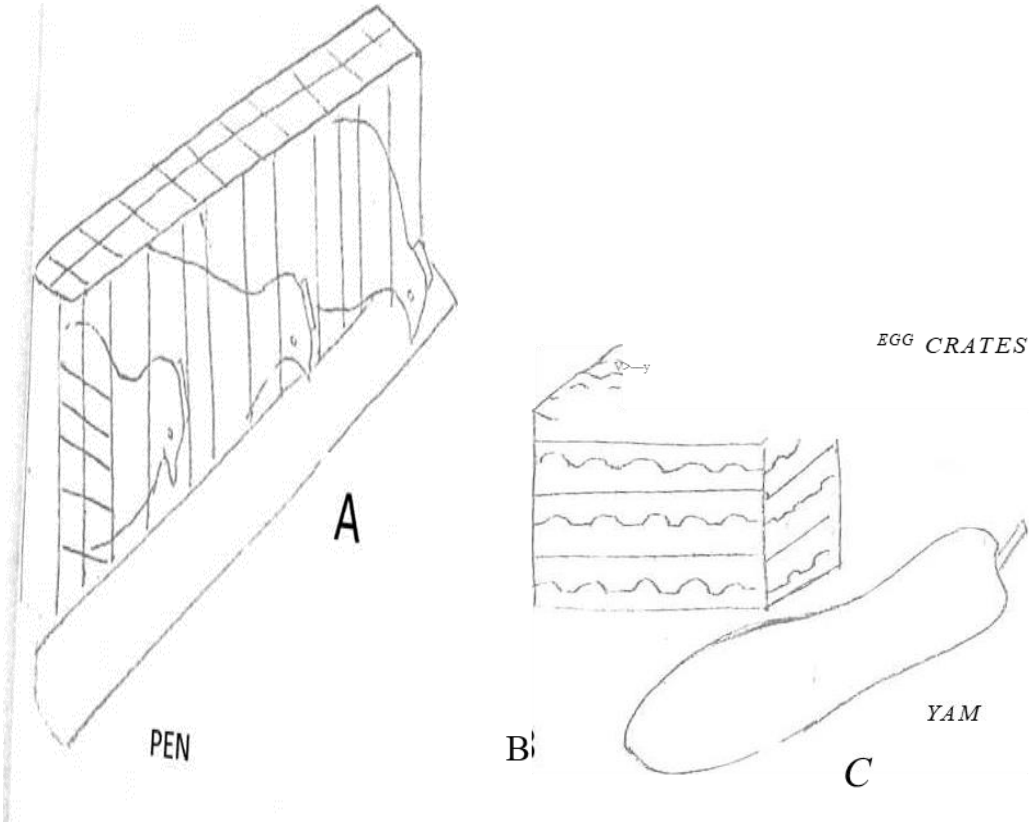

MAN
HOE
A
BED
B
C

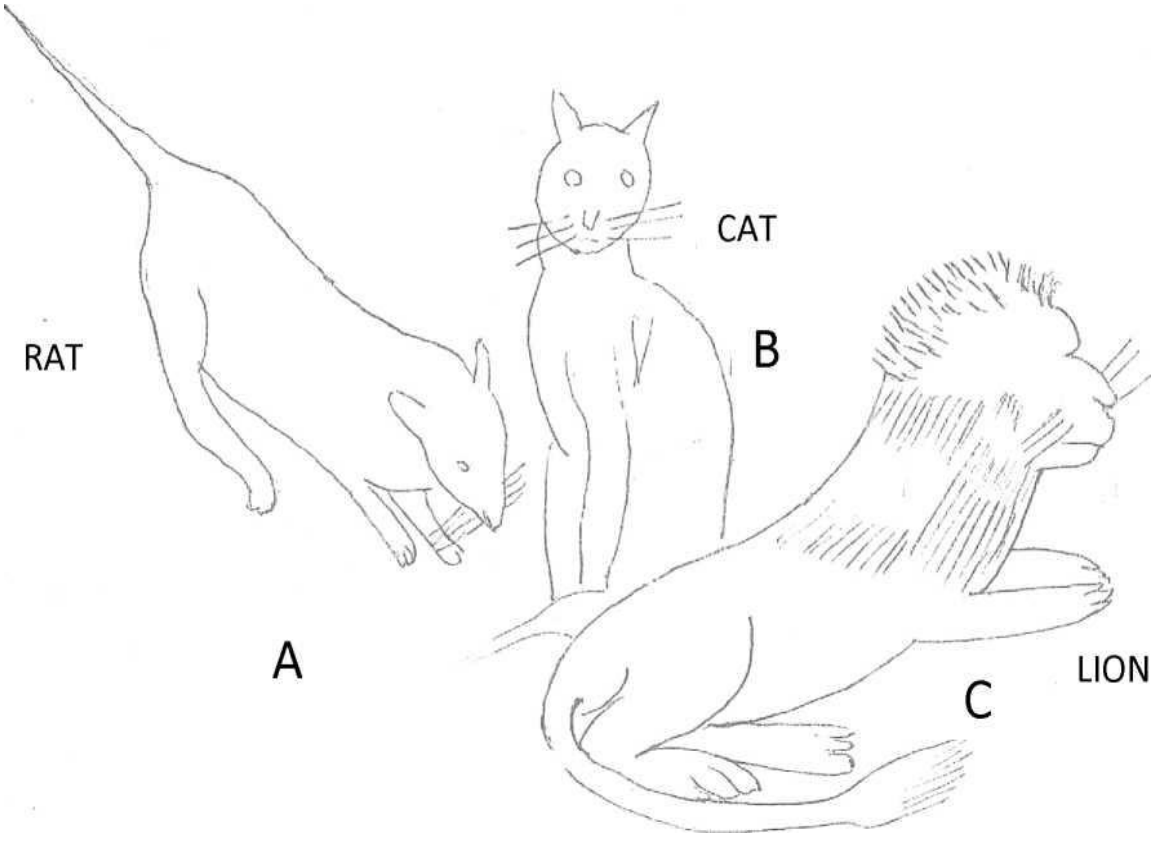

HANDSET
T.V.
RADIO
A
B
C

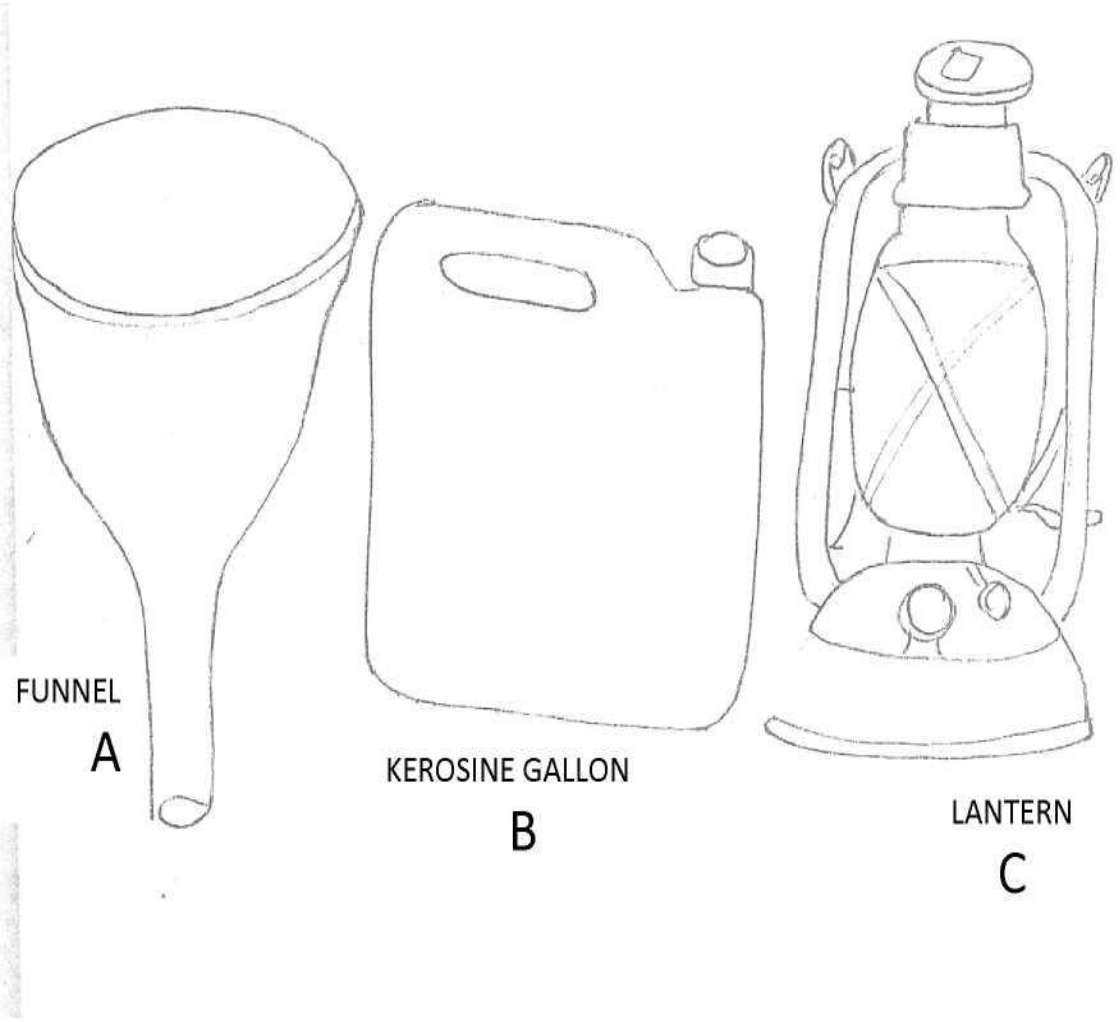

PAWPAW
KNIFE
BOWL
A
B
C

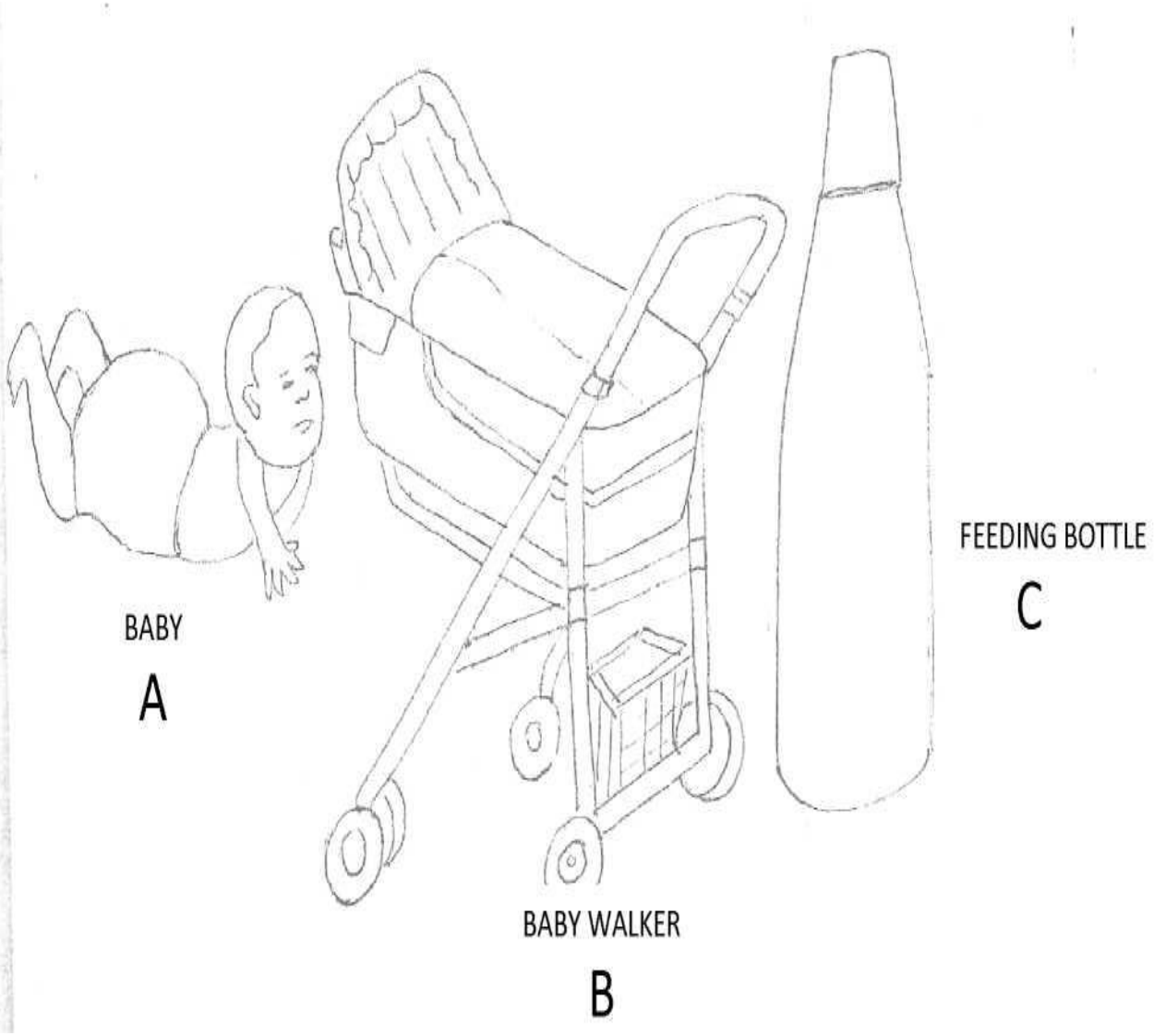

JUDGE
A
CRIMINAL
B
LAWYER
C


KING
A
CROWN
B
CHIEF
C


A
PEN
EGG CRATES
YAM
C


RAT
CAT
B
A
C
LION


FUNNEL
A
KEROSINE GALLON
B
LANTERN
C


BABY
A
BABY WALKER
B
FEEDING BOTTLE
C