INTERACTIVE-LECTURE-DEMONSTRATIONS AND GUIDED-REVERSE JIGSAW INSTRUCTIONAL STRATEGIES, AND SECONDARY SCHOOL STUDENTS' LEARNING OUTCOMES IN CONCEPTS OF LIGHT IN PHYSICS IN OYO STATE, NIGERIA

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A Thesis Submitted to the Department of Science and Technology Education,
Faculty of Education
in Partial Fulfillment of the Requirements for the Degree of
(Ph.D. Physics Education)

DOCTOR OF PHILOSOPHY

of the

UNIVERSITY OF IBADAN

JULY, 2023

CERTIFICATION

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DEDICATION

This study is dedicated to Allah, the great, the unlimited, the most beneficent; the most merciful who made everything regarding this work possible and beautiful.

ACKNOWLEDGEMENTS

Undertaking this programme has been a truly life-changing experience for me and it wouldn't have been possible if not for God, the Almighty and the support I received from many people who to varying degrees provided assistance, encouragement and guidance. I am grateful to all these heroes who gave me so much of their time, love and energy in producing this thesis to acquire Ph.D.

I am grateful to the Almighty Allah who is obviously the one who has always guided me to walk on the right path of life. Without His grace, this project write-up would not become a reality. I would especially like to thank my supervisor, Prof. M. K. Akinsola, who has not only been a supervisor but a guide, a mentor and a father indeed. I thank you for your tolerance, leadership, profitable criticisms, support as well as provision of useful materials that helped to shape this work. Thank you for your supervisory roles. May Almighty God guide and protect him and his family.

Special mention must be made of my indefatigable and amiable Head of the Department in person of Dr. Adedeji Tella for his unquantifiable assistance, timely support, useful words of encouragement, prayers and great support in the course of this programme. May God in His infinite mercy bless you abundantly and grant him all his heart desires. I also appreciate the efforts, support and helpful directives gotten from my distinguished lecturer Dr. Nathaniel A. Omilani. I thank him for his leadership roles. The good Lord would be there for him at his points of need.

I am grateful to Prof. Modupe M. Osokoya, my indefatigable internal/External supervisor from the Institute of Education as well as the academic staff in the Department of Science and Technology Education for their immense contribution to the realization of this project. They are Prof. Alice M. Olagunju, Prof. Ayotola Aremu, Dr. Edidiong U. Ukoh, Dr. Israel Olasunkanmi, Dr. A. Akinyemi, Dr. Mabel I. Idika and Dr. Tope Ojo. I thank them all for their painstaking corrections and critical reviews throughout the departmental assessments and seminars. May God almighty bless them all richly, Amen.

I acknowledge the entire facilitators and participants from the various schools used in this study for their love, cooperation and support throughout the field work of the programme. May they all continue to shine from glory to glory, Amen. My special appreciation also goes to my Ph.D friends and colleagues Mesrrs. Edidiong Akpan, Nathaniel Bello, Solomon Sangoleye, Azeez Morufah, Hamzat L. Folake, Ganiyu Wasiu and Itsapere for their love, support and prayers throughout. They will all bountifully blessed in the mighty name of God, Amen.

My sincere gratitude also goes to my colleagues (both senior and junior) Dr. M. A. O. Sotayo, Dr. M. F. Aderanti, Dr. I.A. Dan-Ologe, Alh. Abubakar Maikudi, Mr. T. H. Adeniji, Dr. S. Agholor, Dr. I. A. Mofikayo, Mr. Sunday Akinyele, Mrs. M.T. Yunus, Mrs. L. A. Adeosun, Mrs. Y. F. Ogungbesan and all staff of the School of Science, FCE, Osiele, Abeokuta for their understanding, prayers and encouragement for the time the programme lasted. May they all remain blessed.

I am also indebted to my family without whom; I would not have had the courage to embark on this journey in the first place. I am grateful to you all Mesrrs. Sukurat .F. Busari, Kehinde O. Busari, Mariam Temitayo, Taiwo Azeezat, Kehinde Zainab, Ibrahim Ogooluwa and Aishat Oluwasemiloore for always believing in me and encouraging me to follow my dreams.

I appreciate my mother Mrs. W. Nihinlola Busari for her love, understanding, endurance and prayers since the beginning of my life. May the Almighty Allah endow her with long life, good health and sound mind. Efforts of my late father Imam Daud Ajani Busari in seeing me becoming great and successful in life would also not go unnoticed. May he continue to rest in perfect peace, Amen.

I say thank you to everyone who has contributed in one way or the other to the success of this programme. God bless you all.

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ABSTRACT

Physics, a unifying subject for most science-related disciplines is important for technological advancement. Reports have shown that academic achievement in and attitude to physics particularly in concepts of light among senior secondary students in Oyo State are poor. Previous studies have focused largely on student-related factors that influence learning outcomes in physics, with little attention paid to student-centred strategies such as Interactive-lecture-demonstrations Strategy (IldsS) and Guided-reverse Jigsaw Strategy (GrJS). This study therefore, was carried out to determine the effects of (IldsS) and (GrJS) on students' learning outcomes (achievement in and attitude to) in concepts of light in physics. It also examined the moderating effects of gender and students' commitments to physics.

John Dewey's Constructivist Theory of Interaction and Albert Bandura's Social Cognitive Theory underpinned the study. The pretest-posttest control group quasi-experimental design with a 3x2x2 factorial matrix was adopted. One Local Government Area (LGA) was randomly selected from each of the three existing senatorial districts in Oyo State. Three schools were purposively selected from each LGA based on availability of qualified physics teachers and functional laboratory. Intact classes of Senior School II students from each school were randomly assigned to IldsS (83), GrJS (126) and control (105) groups. The instruments used were Physics Achievement Test (r=0.78), Students' Commitment to Physics Scale (r=0.80), Students' Attitude Questionnaire (r=0.87) and instructional guides. The treatment lasted 10 weeks. The data were analysed using descriptive statistics, Analysis of covariance and Bonferroni Post-hoc test at 0.05 level of significance.

The participants' age was 15.30±2.50 years and 52.9% were female. The participants' commitment to physics (45.2%) was low. Treatment had a significant main effect on students' achievement in concepts of light in physics ($F_{(2,\ 312)}$ = 53.95; partial η^2 = 0.26). The participants in IldsS had the highest post-achievement mean score (11.89), followed by those in GrJS (11.82) and the control (8.55) groups. There was a significant main effect of treatment on students' attitude to physics ($F_{(2,\ 312)}$ = 44.28; partial η^2 = 0.23). The participants in IldsS had the highest post-attitude mean score (50.70), followed by those in GrJS (45.12) and control (42.30) groups. There was a significant main effect of students' commitment to physics on achievement ($F_{(1,\ 313)}$ = 6.54; partial η^2 = 0.02), but not on attitude to concepts of light. The participants in high commitment group obtained a higher post mean score (11.13) than their counterparts with low (10.38) commitment group. The main effects of gender were not significant on students' achievement in and attitude to concepts of light. The two-way and three-way interaction effects on achievement in and attitude to concepts of light were not significant.

Interactive-lecture-demonstrations and guided-reverse jigsaw instructional strategies improved students' achievement in and attitude to concepts of light in physics in Oyo State, Nigeria with emphasis on students' commitment to physics. Both strategies should be adopted by physics teachers.

Keywords: Interactive-lecture-demonstrations strategy, Guided-reverse jigsaw strategy, Students' commitment to physics, Achievement in concepts of light in Physics, Attitude to Physics

Word count: 471

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Science plays a very important role in this modern era such that it has become an indispensable tool in the hands of man to unveil the many secrets in the universe. It is such a potent tool that any nation desiring to advance in the socio-economic sphere cannot afford to downgrade its learning in educational institutions. Among all fundamental sciences, physics is the most utilised subject in most science and technology–related professions (Josiah, 2013) which is a clear indication that the enormous role that physics plays in the industrial and scientific growth of any nation must not be undermined.

Physics is a science subject that deals with all aspects of nature thereby enabling man to understand how the universe behaves. Physics at microscopic level deals with small and/or subatomic distances, while at macroscopic level, it deals with human in different areas such as in aeronautics, astronomy, geophysics among others. This description stems from its concern for nature, energy and properties of matter, and the interaction among them. It is one of the disciplines among sciences and described as the heart of scientific and technological advancement worldwide perhaps, because of its role in the provision of the much-needed trained personnel such as engineers, astronauts and specialists in the other physical and biomedical sciences. Many reasons have been advanced to justify its inclusion in the school curriculum such as its role in helping students to comprehend the world around them and in preparing them to improve on it.

Specifically, the study of physics according to American Institute of Physics (2003) helps students among others to control and exploit the forces of nature (proves a sense of empowerment); satisfy human curiosity; understand the body of knowledge so that we can choose between good and bad applications; become aware of nature and its limitations; avoid alienation from the technological world; distinguish between facts and fiction; live healthier and safer lives; promote a scientific attitude; provide a competent workforce to maintain economic growth; build problem-solving skills; generate openness to new ideas, and understand the greatest of human accomplishment (AIP, 2003). Equally worthy of note is the fact that physics as a subject is a prerequisite for admission into several courses in the field of science, engineering, medical sciences and technology. Without a credit pass in physics, students who wished to be admitted into the above listed disciplines will not be able to do so. This is to say that physics is a unifying factor for almost all disciplines in life, a submission that was attested to by Mbamara and Eya, (2015).

In view of the gains that a society will amass for admiring and admitting physics as a basic element of the human culture, efforts are now being made all over the world not only to study physics, but also to find ways of providing scientific literacy and teaching of attitudes and skills to physics students. As Khisfe and Lederman, in Okoroncha and Adeoye, (2011) put it, not only should we teach science knowledge but also how science works with appropriate tools. They contend that the kind of insight, imaginative processes and intuition used by scientists like Galileo and Einstein should be emphasised in order to break even. Achieving these goals is however difficult within Nigeria context due to some challenges. Some of such challenges are the high failure rate of students in physics (Owolabi, 2004 and Ogunleye and Babajide, 2011), declining enrolment of students in physics (Adolphus, 2016) and unsatisfactory attitude of students due to the wrong perception that the subject is difficult to assimilate (Project Clue, 2021). These challenges according to Xavier and Croix, (2016) are alarming at both secondary schools and universities. Pointer to this assertion is exemplified in the Table 1.1

Table 1.1: Summary of SSCE WAEC Physics Performance from 2007 – 2019

Year	Candidates that sat for the Exam	A1–C6	% of A1-C6	D7–E8	% of D7-E8	F9	% of F9
2007	418,593	180,797	43.19	140,172	33.49	97,624	23.32
2008	415,113	200,345	48.26	91,116	21.95	123,652	29.79
2009	465,636	222,722	47.83	149,595	32.13	93,319	20.04
2010	463,755	192,180	41.44	125,770	27.12	141.805	30.57
2011	563,161	247,171	43.89	143,009	25.39	172,981	30.71
2012	624,658	279,472	44.74	182,837	29.27	151,167	24.20
2013	637,037	297,189	46.65	175,987	27.63	163,861	25.72
2014	639,311	273,689	42.81	161,937	25.33	195,246	30.54
2015	658,442	298,867	45.39	213,467	32.42	134,190	20.38
2016	658,393	319,188	48.48	212,792	32.32	126,411	19.20
2017	704,504	307,586	43.66	208,462	29.59	188,456	26.75
2018	727,733	570,542	78.40	101,518	13.95	55,673	7.65
2019	742,394	571,272	76.95	109,058	14.69	62,064	8.35

Source: *Research and Statistics unit WAEC Yaba, Lagos, Nigeria*

A closer look at Table 1.1 shows fluctuations in performance of students across the years. Although, there were some improvements in the performances of students in some years, the observed improvement notwithstanding, the percentage of students with minimum of credit pass in physics is less than 50% for most of the years under review. Equally worthy of note is that poor passes of D7 and E8 in Table 1.1 are outright failure as students found in the category are not accepted for admission into higher institutions of learning in Nigeria for science and technology-related courses. This evidence is enough to conclude that students do not pass physics as expected. Thus, it could be asserted that students find it difficult to understand most of the physics concepts; an assertion which was corroborated by West African Examination Council Chief Examiner's report (WAEC, 2011 and Nkwo, Akinbobola and Edinyang, 2008). The students' performance in physics for the years under review was further processed in the Table 1.2.

Table 1.2: Summary of SSCE WAEC Physics (Theory) Results from 2007 – 2019

Year	Candidature	R.M.S/60	SD
2007	418,593	25	11.14
2008	415,113	25	10.25
2009	465,636	13	8.83
2010	463,755	18	10.17
2011	563,161	19	10.39
2012	624,658	16	8.83
2013	637,037	13	8.77
2014	639,311	16	8.77
2015	658,442	19	9.90
2016	658,393	19	8.83
2017	704,504	15	8.43
2018	728,924	26	9.80
2019	762,340	26	9.59

Source: *Research and Statistics unit WAEC Yaba, Lagos, Nigeria 2021*

Key: R.M.S= Raw Mean Score; **SD** = Standard Deviation

This is a further validation of the abysmal performance of students in physics theory (essay) paper with clear fluctuations in the raw mean scores of the candidates in those years. The students' performance could be said to be fairly better in the early years 2007 and 2008 with a score of 25 out of 60. Similar results were obtained in the latter years of 2018 and 2019 with a raw means score of 26. For the years in between, it dropped to 19 over 60. The situation was unsatisfactory in the year 2017 with a raw mean score of 15 as there were very few students who were able to gain admission to pursue physics-related courses in institutions of higher learning.

The same WAEC reported that lack of understanding or better still, students' inadequate knowledge of basic concepts in physics accounted for their abysmal performance in physics examinations. Obafemi and Onwioduokit, (2013), while comparing the students' responses with those of the teachers, found out that some concepts which were considered difficult by students to understand were also considered difficult for the teachers to teach. Such topics include light, (mirrors and images), simple harmonic motion, projectile motion and measurement of heat energy. The submission was corroborated in the Chief examiners' report (2017) that light (optics)-related questions were in most cases attempted by many candidates, but many of those who did at times stop at the definition level without any additional information or were unable to write the formula and substitute the data correctly. Students lack the knowledge of the functionality of the object and image when they are real or virtual. The report went further to say that a good number of candidates after plotting light-related graphs were unable to give the correct interpretation of the slope of the graph.

In analysing the situation, it suffices to ask a question: What then is responsible for this state of the subject? Paramount among the factors is the confusing and hard-to explain nature of theoretical junk in physics text books (Akanbi, 2003; Okoth, Ogeta, Otieno and John, 2019); students' lack of interest due to preconceived notion that physics is a difficult subject (Bamidele, 2004). Olarinmoye, (2000), submitted that most laboratories are not well equipped as schools rely more on alternative to practical where funds are not enough to procure laboratory apparatuses.

Among the various efforts made towards making physics simple and easy for students is the unification of all the topics of physics into five major concepts using the principle of conceptual approach as suggested and agreed upon at the National Critique Workshop of December 1984 (Adeyemo, 2010). These concepts include the concept of space, time and motion, conservation principle, waves, fields and quanta. The curtailment of topics has an advantage of bringing topics together under broad generalisation to show relevance and connectedness. As if this was not good enough, the West African Examinations Council (WAEC) felt the need to revise the physics syllabus due to consistent students' failure in the subject hence, STAN was invited and saddled with the responsibility of revising physics curriculum as well as other science subjects. This effort later resulted to revised WAEC syllabus. The revised syllabus or better still, the new physics curriculum in Nigeria though, has some similarities to the earlier one; it however has six themes instead of five in the old curriculum and it's loaded with teachers' and students' activities (Daramola and Omosewo, 2012). It thus puts more emphasis on the utilisation of practical work as against the rote learning of the former one. This modernisation has not only consistently and sufficiently influenced the content area of what is to be learned in schools, it has always been reflected in the mode and type of examination questions set by public examination bodies.

The West African Examination Board also recommended the establishment of Science Equipment Centres for the local production and servicing of laboratory equipment. Perhaps, this explains the establishment of Science Laboratory Manufacturing Industries like Project Development Institute popularly known as PRODA by the Nigerian government in Enugu (Olayiwola, 2014). Though, PRODA was created by the defunct East Central State government in 1971, with the splitting of East Central State into Imo and Anambra, the Federal Government took it over in 1977. In the nearby Ghana, the government in 1995, through the Ministry of Education (MoE) and Ghana Education Service (GES) established Science Resource Centres (SRCs) in Senior High Schools (SHSs) all over the country (Buabeng, Ossei-Anto and Ampiah, 2014). This project was initiated to bridge the gap between schools with well-resourced science laboratories (both human and material resources) and those with little or no resources hence, ensuring equity in students' learning across rural-urban divide. The SRCs were equipped with basic science equipment including modern electronic devices and computers to use in teaching and learning of sciences including physics for improved students' performance.

After so many endeavours, performance of students in physics in Nigeria was still regarded as not satisfactory enough. Studies such as Owolabi (2004), Bello (2011), Adunola (2011); Akinbobola (2015), and Isiaka and Mudasiru (2015) in their quest for the causes of students' underachievement as well as dwindling performance in physics identified a teacher-related factor and specifically their failure to adopt new, innovative and student-oriented strategies such as guided-discovery method as recommended by the New Physics Curriculum, Adeyemo (2010); enriched demonstration and enriched lecture as suggested by Lawrence, (2018); cooperative learning recommended by Azmin (2016), interactive lecture demonstrations by Milner-Bolotin, Kotlicki and Reiger, (2007); jig-saw instructional strategy by Adejoh, (2015) among others which were recommended in the revised physics curriculum.

One of the consistent goals in science education is the building and sustaining of students' attitudes towards science, bearing in mind that attitude is germane for learners of sciences in order for them to excel. This was corroborated by Fulmer, Ma and Liang, (2019) and Tytler and Osborne, (2012) when they described attitude as an important aspect of students' persistence in school science and interest in pursuing science careers. Unfortunately, students' attitude towards physics is generally on the decline (Norezan, Mohd and Siti, 2019). Numerous studies such as Xavier and Croix, (2016); Adesoji, (2008); Gonen and Basaran, (2008); Cracker, (2006) have also been conducted to determine the effects of teaching strategies and students' attitudes towards sciences (physics inclusive). Erdimer, (2009) reported that conventional and traditional teaching methods have negative effects on the attitude of majority of students towards learning of physics. In a similar study on the impacts of directive and non-directive problem-solving on attitudes as well as learners performance, students' attitude was observed to have been enhanced afterwards (Gok and Sılay, 2008) on the A closely related observation was made when Erdimer, (2009) explored the effects of teacher-directed and self-directed problem-solving strategies on students' attitudes toward physics. Participants in the treatment class (problem-solving) had positive improvement in terms of attitude to physics than those in control group. The long and short of these observations is that positive attitudes stimulate students to put in more effort.

Attitude refers to someone's "favourable or unfavourable feelings" about something, a person, an event or a school subject (Sitotaw and Tadele, 2016). The same term was comprehensively implied by Guido as a favourable or unfavourable reaction concerning things, happenings and programmes as shown in a person's philosophies, state of mind, passions or anticipated actions. Taking cue from these definitions and those of George (2006), students' attitude to physics can be described as students' level of likes and dislikes for learning of physics. Thus, it connotes students' tendency or predisposition to respond either positively or negatively towards the learning of physics. It therefore becomes very clear that students' attitude towards physics may be incredibly important especially when one considers the fact that physics appears to be the most challenging and abstract subject in the realm of science. This assertion was corroborated by Saleh (2014), who submitted that physics requires the students to deal with different types of illustrations, such as formulas, calculations, graphics representations, and also a theoretical understanding at an abstract level. The implication of the submission is that attitude of a person may influence his/her choice of action, and responses to challenges, incentives, and rewards.

Fulmer, Ma and Liliang, (2019) submitted that attitudes toward science were positively related to cooperative teaching strategies. The import of these submissions is that student's attitude toward science appears to be more related to social interaction or cooperation. Also, if a students' attitude towards physics is positive, performance in the subject will be optimal. Such students usually develop positive attitudes towards their physics teacher, physics curriculum and physics classroom environment. However, attitude in whatever form, towards science (physics) may change especially with exposure to physics lesson and the direction of the observed change may be related to the quality of exposure, the learning environment and the teaching method. In other words, attitudes are acquired through learning and can be changed through persuasion using various techniques (Ibeh, Onah, Umahi, Ugwuonah, Nnachi and Ekpe, 2013). Thus, in order to increase the level of attitude and success in physics education, active teaching strategies need to be implemented into physics classroom.

However, the use of conventional strategy in class appeals more to sense of hearing than others which in the words of Jegede and Awodun, (2015) may lead to forgetfulness. This is to stress the point that student's positive attitude towards learning could be developed; and more effective learning can occur when many senses are involved. Achieving this may however, require combining it with other more effective methods or strategies that are activity-based with the belief that the abstract nature of physics will be reduced to the barest minimum when students are exposed to the practicality of physics.

The traditional method of teaching in the words of Cottel and Millis in Belias, Sdrolias, Kakkos, Koutiva and Koustelios, (2013) is characterised by reading texts and problem; formulate questions; attending lectures; monitor discussions; writing and replying brief or extensive questions/objective types of questions; solving short or lengthy unstructured problems or cases and oral presentation of topics/reply to short questions from the students. It relies heavily on the use of drill and practice for solving numerical problems, requiring routine application of formulae and equations for the solutions. The method appears as the easiest and the cheapest; and can be used to cover the syllabus within a short time and teach large group of students at the same time. However, the approach did not just come without its own attendant weaknesses. It may lead to surface learning as students are often passive and their attention wanes quickly after few minutes (Learning Spark, 2018). The implication of this is that very little of the science of physics can be conveyed to students in this way. Students will only be able to clear the first hurdle – learning the laws – but unable to solve the more complex problems that may follow due to the fact that they experience less practice in problem solving, no opportunity to test conclusions and no satisfaction of accomplishment (Aderibigbe, 2012). In other words, the traditional method of teaching does not only fail to inspire students to indulge themselves in independent thinking and self-exploration processes, it does not also encourage students' active participation in a physics class. Thus, with the method, the objective of getting an all-round development of the students cannot be achieved in any way. In addition, the strategy fails to inculcate scientific attitudes and training in scientific method among the students, as a result of which, an important objective of teaching cannot be fulfilled successfully and all the efforts of teacher will prove to be waste of time.

Meanwhile, for a subject like physics and concepts like optics and light, no meaningful success can be achieved without engaging students in a range of activities that will involve students in doing things and thinking about the things they are doing which according to Eison, (2015) is termed active learning strategies. Thus, in practice, active learning refers to activities such as demonstration, group work, practical work and the likes that are introduced into the classroom in order to supplement the traditional lecture method (Karamustafaoglu, 2015). In supporting this position, studies in physics education such as Ashkenazi and Weaver (2007), submitted that students learn difficult concepts effectively when they are actively engaged with the materials they are studying, and that cooperative activity, such as classroom discussion is an excellent way to engage students effectively. Two of such interactive teaching strategies capable of inculcating such are Interactive Lecture Demonstrations (ILDs) and Guided-Reverse-Jigsaw Instructional Strategy (GRJIS).

Consequent upon the ineffectiveness of traditional approach in teaching concepts of light in physics, it became necessary to use a strategy to make learning in large (and small) lectures more active. Perhaps, this explains why physics education research studies, primarily at the University of Oregon and Tufts University (in the United States), started to explore strategies that will improve conceptual learning in physics. The exploration according to Vasudevan, (2011) started in 1989 and the team was led by David Sokoloff (University of Oregon) and Ron Thornton (Tufts University) amongst others. They thereafter came up with the development of a teaching and learning strategy called interactive lecture demonstrations. The strategy adopts the use of a learning cycle tagged Prediction, Experience and Reflection (PER) with a belief that students would become aware of the differences between their prior beliefs that they bring to the class and the actual physical laws that govern the world. It operates on the conception that the concrete nature of the demonstrations to illustrate difficult concepts to students will help to convince learners who come to the class with misconceptions that physics applies to the real world.

In the strategy, students will observe real physics demonstrations, make predictions about the outcomes on a prediction sheet, are allowed to change their answer if they choose and collaborate with fellow students by discussing their predictions in small groups. Students then examine the results of the demonstration, compare these results with their predictions, and attempt to explain the observed phenomena. The teacher thereafter leads the class in a brief discussion on the real-world application of the theory (Sokoloff and Thornton, 2006). The implication of this account is that though, traditional lecture and conventional demonstration have been criticised, the duo can be improved upon by proper planning and by engaging students in class activities. For example, demonstration can be improved upon or combined with other techniques such as lecture method to make it interactive. This literarily translates into what this study termed Interactive Lecture Demonstrations (ILDs).

Several studies carried out on strategies of teaching especially, in this part of the world, have concentrated on lecture and demonstration methods of teaching at the detriment of interactive-lecture-demonstrations. For instance, Ameh and Dantani (2012) carried out a research study in Nassarawa Local Government area of Kano State on the efficacy of lecture and demonstration methods on students' achievement in chemistry. Similarly, Giridharan and Raju, (2016) carried out a study on the effects of teaching methods with emphasis on demonstration and lecture methods on academic achievement of engineering students, while Bako, (2017) examined the effects of project and demonstration teaching methods on acquisition of brooding skills in poultry among students in colleges of education in Plateau State, Nigeria. From the foregoing, not much has been done on particularly on its effects on students' attitude to and achievement in physics. Studies on this strategy and students' attitude to physics or students' academic achievement were carried out elsewhere other than Nigeria. It thus becomes necessary to address the issue of dearth of researches on the effectiveness of interactive-lecture-demonstrations on students' achievement as well as students' attitude with particular reference to concepts of light in physics in Nigeria

The jigsaw strategy on the other hand and according to Social Psychology Network, (2019) was invented by Elliot Aronson and his graduate students in 70s in Austin, Texas as a matter of absolute necessity to help defuse an explosive situation in the city's schools which had been disunited. The disunity in Austin was as a result of racial discrimination among the white youngsters, African-American youngsters, and Hispanic youngsters who found themselves in the same classrooms for the first time. Their coming together to learn under the same roof led to long-standing suspicion, fear and distrust between groups, and this ultimately culminated in a relentlessly competitive atmosphere of turmoil and hostility with fist-fights erupting in corridors and schoolyards across the city. There is therefore the need to shift to a more cooperative atmosphere.

The strategy organises students into group work in such a way that they have no choice than to collaborate and rely on one another in the task of learning a concept as individual in a group has something unique to contribute to their group's outcome. No one else in the group will be doing the same task, so each student experiences a higher sense of ownership and accountability to the members of their group. The strategy according to Catapano, (2018) is characterised with the steps such as organising students into a group of 4-6 students; dividing the day's lesson into 4-6 parts, and assigning one student in each group to be responsible for a different segment; giving students time to learn and process their assigned segment independently; putting students who completed the same segment together into an "Expert group" to talk about and process the details of their segment; having students return to their original "Jigsaw" groups and take turns, sharing the segments they have become experts on and having students complete a task or a quiz that depends on students having a better understanding of the material from the contributions of all their group members" .

Meanwhile, Maden, (2011) posited that some modifications have been made to the strategy in the practice process due to various studies conducted on the jigsaw strategy with new types of the strategy emerging. The original was tagged jigsaw-I, and it was developed to new types in the form of jigsaw-II-III-IV and reverse-subject jigsaw. Basically, the assembling technique follows same steps in all forms. At present, five types of jigsaw strategies are available for teachers to use in their classroom. These according to Maden, (2011) are the original jigsaw developed by Aronson in 1978, jig-saw II by Slavin which was developed in 1987 and jigsaw III by Stahl which came into existence in 1994. Others are jigsaw IV put forward by Holliday in the year 2000 and reverse jig-saw strategy of 2003 by Hedeen. Jigsaw and Jigsaw II differ only in the fact that team competition is allowed in jigsaw II. Jigsaw IV differs from jigsaw I-II-III because students have quizzes for checking correct learning in expert and actual groups and the practice includes re-teaching missing parts in the subject at the last step.

The reverse jigsaw was purposely designed to cater for higher students and it has its own objectives to fulfill. The type rather than focusing on students' comprehension of the instructor's material, directs its energy on the students' interpretations such as perceptions and judgments through a very active discussion. Besides this, in the reverse jigsaw, students in the expert groups teach the whole class rather than return to their home groups to teach the content. Thus, it differs from the original jigsaw during the teaching portion of the activity. The detail of the reverse jigsaw is better described in three steps. The first step involves forming a mixed group where each student in the group is assigned a unique task and given 10 – 15 minutes to accomplish and discuss it within the mixed group. An expert group is thereafter formed where points and outcomes of the given task are compared and a report is prepared detailing all common and divergent opinions. It is at this stage that somebody is appointed to represent each group as a reporter or representative who would present the findings to the whole class. At the last stage, the whole class gathers to listen to the reporters from the different groups who will report to the whole class by ways of chalkboard, flipcharts or overheads. The instructor thereafter reviews and evaluates the whole process.

In an investigation carried out by Timayi, Bolaji and Kajuru, (2016) to determine the impacts of jigsaw-IV instructional strategy (J4IS) on learning outcomes of senior students in geometry in Kaduna State, Nigeria, a substantial boost in performance which favour students in jigsaw IV approach tagged (J4IS) was obtained. The results also revealed insignificant relationships regarding students' performance and gender when exposed to jigsaw IV strategy. The result further indicated that difference observed in students' interest between those in JAIS and the conventional strategy was significant in favour of students exposed to the jigsaw IV but gender had no significant main effect on their interest.

In a similar study carried out by Areelu and Ladele, (2018) on the adoption of jigsaw and individual personalisation instructional strategies for improving secondary school students' interest in mathematics. A sample size of 250 senior secondary II students from six purposively selected secondary schools in Lagos, Nigeria, It was observed that students taught with jigsaw instructional strategy had the highest post interest score, and that male students were above their female counterparts in all groups. Similar result was obtained by Mbacho and Changeiywo, (2013) in a study conducted in Laikipia East district, Kenya on impact of jigsaw strategy on learners' performance in senior school mathematics. Students taught using jigsaw instructional strategy did better academically than those taught with conventional learning strategy. Pelobillo, (2018) also examined the worth of jigsaw technique in learning physics and problem-solving dimensions of senior high school students in Davao city, Philippines. Findings of the study revealed that students' exposure to jigsaw technique had gained in physics achievement. Similarly, Gambari, Olumorin and Yusuff, (2013) carried out a study on the effectiveness of computer-assisted jigsaw II cooperative learning strategy on the performance of secondary school students in physics. The study reported that students taught using computer-assisted jigsaw II cooperative learning strategy performed better than those who used individualised computer instruction. The same students were observed to have positive attitude to physics than those taught with individualised computer instruction.

Moreover, Amosa and Mudasiru, (2017) investigated the efficiency of computer-based jigsaw II instructional strategies on the achievement of senior school physics students using gender and attitude to physics as moderating variables. Findings indicated among others that students taught physics using Jigsaw II cooperative learning strategy had positive attitude to physics than those taught with ICI. The submission is consistent with that of Ajitoni and Salako, (2014) who assessed the influence of jigsaw method as well as gender on students' attitude to cultural integration that would culminate in a supportable and workable development in Ogun State, Nigeria. This was done to see how the strategy can be used to promote national unity through education. It is revealed that jigsaw technique benefited students who form jigsaw group (experimental group) than the conventional learning group (control group) in terms of promotion of unity and peaceful co-existence among students. This could further translate into better integration and sustainable development in Nigeria. The study interrelates with the ongoing study as it investigated the effect of jigsaw on students' attitude. Though, it was carried out in the area of social studies while the present study has its focus on physics.

It is obvious from the above that few attempts on interventions have made in order to improve secondary schools students' learning mostly on their attitude and achievement in physics using the reverse jigsaw instructional strategy. Based on the premise the research work investigated the effects of reverse jigsaw instructional strategy on students' attitude and achievement in secondary school physics. The reverse jigsaw was used being one of the newest strategies under cooperative learning strategies. Beside this, it is noted that the strategy was originally created to cater for students in higher classes hence, its veracity was tested on senior secondary school physics students. However, in view of the abstract and mathematical nature of physics coupled with perceived difficult concepts, the strategy was accompanied with teacher's guide where necessary hence, the strategy was guided-reverse jigsaw.

Apart from instructional strategy, other factors that may interfere with the activity of teachers in classroom include interest, (Olaf and Baumert, 2001); gender, (Onah and Ugwu, 2010) and commitment, (Vogel and Human-Vogel, 2016). One of such moderating variables that have not been given adequate attention as it relates to achievement in physics is commitment. In other words, the issue of poor achievement of students and negative attitude might not be with the subject as it is being speculated. It could be due to a student's outright lack of commitment or low level of commitment to the learning of physics due to the method of instruction. The term academic commitment (academic commitment to physics) as used here includes interest, values and other affective behaviors of students and it is conceptualised in terms of the percentage of effort and time that an individual (a student) devotes to the learning of physics. Thus ordinarily, commitment is construed to mean engagement though; the two concepts may not be too far from being interconnected as a student's initial commitment results in increased engagement within the academic context (Kahu, 2013 in Viljoen 2015). Alternatively, the more students engage academically and socially, the more they would be committed to their own academic success. In the context of the foregoing, the concept of academic commitment appears multidimensional in nature as it may result from a variety of factors relating to the individual and the context in which they are learning. This explains why at times, commitment or engagement could be regarded as the degree of willingness of student's compliance with organisational and subject rules, values and processes. It can as well focus on students' participation and emotional dedication or engagement to students' learning. The latter definition underpins this study. This is because committed students are hopefully going to find it easy coping with academic stress and feel more satisfied (Muhammad, Bala and Ladu, 2016). The belief not-withstanding, academic commitment is such a variable that is less well researched into; and limited evidence was found regarding a possible relationship between academic commitment and student success. This makes the study of academic commitment a necessity for this study.

As noted by Odagboyi (2015), the role of female in most societies is relegated to the background thereby, preventing them from participating in, and benefitting from many development efforts of both government and private organisations. Similarly, in schools, observations have shown that some subjects such as science and mathematics are branded masculine, while others like home economics, secretarial studies are branded feminine. The observation is in agreement with the view of Nwona and Akogun, (2015) who also noted gender imbalance in science, technology and mathematics. Gender as used here is described as a social concept that refers to masculine and feminine traits. There are however divergent opinions as to the influence of gender on students' achievement and their attitude to physics. In some studies, such as Kolawole, (2007); Afuwape and Oludipe, (2008); and Sayid and Milad, (2011), it is revealed that the female students are not achieving as high as their male counterparts in physics examinations. The finding is consistent with that of Aina and Akintunde, (2013) which submitted that physics is perceived as a subject that is friendlier to male than female. This according to them may be due to the fact that male students had more time for their studies than their female counterparts. Besides, cultural setting does not encourage the girls to learn science like boys; boys go out freely to explore and learn outside but girls are kept at home doing domestic work (Olanrewaju, 2006 in Aina and Akintunde, 2013). While Obafemi, (2015) observed that the benefits of physics have not been the same for males and females as girls are underachieving and under-represented in physics. On the other hand, the likes of scholars such as Arigbabu and Mji, (2004) and Bilesanmi-Awoderu, (2006) reported that there were no longer distinguishing differences in the cognitive, affective and psychomotor skill achievements of students in respect to gender. Similarly, Ingels and Dalton, (2008) asserted that females perform equal to male peers especially in coursework completed. These divergent views about the influence of gender on students' achievement and attitude when they are exposed to physics using different teaching strategies are a pointer to the fact that it worth being investigated. Gender is therefore one of the moderating variables in this study.

Bearing in mind the submission of Ayeni, (2011) that the worth of teaching is reflected by the performance of students; the interplay of instructional strategies, academic performance of students in physics as well as attitudes of students to physics with respect to the concepts of light thus form the crux of this study. Specifically, this research work sought to ascertain the impact of interactive-lecture-demonstrations and guided reverse jigsaw instructional strategies and other variables of students' level of commitment to learning and gender on physics learning outcomes with a focus on the concepts of light.

1.2 Statement of the Problem

Physics is a unifying subject for most disciplines such as engineering, medicine and pharmacy but surprisingly, students' performance in the subject especially the aspect of light concepts, has not been satisfactory over the years as reported by most public examination bodies like the West African Examinations Council. One of the major factors identified for this prevailing problem is the teachers' dominant adoption of teacher-centred teaching strategy like conventional lecture method in physics classes over the active learning strategies recommended for the teaching physics. Efforts have been made by government, schools and other agencies to address this mass failure. Such efforts include curricular reviews, training and retraining of teachers through regular workshops, provision of funds for the purchase of instructional materials and establishment of science resource centres PRODA at Enugu for the local production and maintenance of laboratory facilities among others. These efforts notwithstanding, students' poor performance in concepts of light in physics still persists. The implication of this is that a lot still needs to be done to improve students' achievement in light aspects of physics.

Most of the earlier studies on teaching strategies especially in this part of the world focussed on lecture and demonstration methods at the detriment of interactive-lecture-demonstrations and reverse-jigsaw strategy which was meant to cater for higher students and that have proved efficacious in enhancing other subjects students' performance. Again, considering the importance of light to life as that which awakens nature and generates food for both plants and animals among others; and as a concept on which both the students and teachers are having difficulties to understand and teach respectively, it becomes imperative to adopt strategies that will drastically reduce learners' failure rate in and poor attitude to physics by adopting instructional strategies that will enhance a conceptual change. It is on this premise that this study sought to determine the effects of interactive-lecture-demonstrations and guided-reverse jigsaw strategies on learners' achievement and attitude to physics specifically, optics (light). The moderating effect of students' commitment and gender were also examined.

1.3 Objectives of the Study

The main objective of the study is to ascertain the impact of interactive-lecture-demonstrations and guided-reverse jigsaw instructional strategies on learners' achievement and attitude to physics specifically, optics (light).

The specific objectives are to:

i. Determine the effect of interactive-lecture-demonstrations and guided-reverse jigsaw instructional strategies on learners' achievement and attitude to concept of light in physics.
ii. Ascertain moderating effect of students' commitment and gender on learners' achievement and attitude to concept of light in physics.

1.4 Hypotheses

For this study, the following seven null hypotheses were formulated and tested at 0.05 level of significance:

H_O1: There will be no significant main effect of treatment (interactive-lecture-demonstrations and guided-reverse jigsaw strategies) on students'

(a) achievement in concepts of light in Physics

(b) attitude to concepts of light Physics.

H_O2: There will be no significant main effect of level of commitment on students'

(a) achievement in concepts of light Physics.

(b) attitude to concepts of light in Physics.

H_O3: There will be no significant main effect of gender on students'

(a) achievement in concepts of light in Physics.

(b) attitude to concepts of light in Physics.

H_O4: There will be no significant interaction effect of treatment and level of commitment on students'

(a) achievement in concepts of light in Physics.

(b) attitude to concepts of light in Physics.

H_O5: There will be no significant interaction effect of treatment and gender on students'

(a) achievement in concepts of light in Physics.

(b) attitude to concepts of light in Physics.

H_O6: There will be no significant interaction effect of gender and level of commitment on students'

(a) achievement in concepts of light in Physics.

(b) attitude to concepts of light in Physics.

H_O7: There will be no significant interaction effect of treatment, level of commitment and gender on students'

(a) achievement in concepts of light in Physics.

(b) attitude to concepts of light in Physics.

1.5 Scope of the Study

All Senior Secondary School II (SS II) students from nine selected secondary schools in Oyo State, Nigeria took part in the study. It focused on the effects of (ILDs) and (GRJIS) on students' academic performance in as well as their attitude to physics (light). It was furthermore delimited to learners' level of commitment and gender among the numerous moderating variables as well as a narrow area of concepts of light (optics) such as sources of light, rectilinear propagation of light; reflection of light, types and laws of reflection.

1.6 Significance of the Study

Results of this research work would help to boos both academic achievement in, and attitude of students to physics. Teachers of physics would also be able to make informed decisions on appropriate and effective teaching strategies that could be used to improve the performance and attitude of students in physics. Interactive-lecture-demonstrations and guided-reverse jigsaw instructional strategies are known for giving students greater sense of individual responsibility hence, outcome of this study would equally encourage and empower students to be responsible citizens.

Nevertheless, all categories of students would benefit through the conceptual learning and accomplishment of multiple tasks at once by interactive lecture demonstrations and guided reverse jigsaw instructional strategies. Similarly, teachers, school administrators and the society at large stand a chance of benefitting from the study as they would be acquainted with various strategies of assigning responsibilities to students. It would equally assist students in acquiring necessary skills for solving problems in physics as well as their day-to-day activities. Their academic achievement would undoubtedly be enhanced as well.

Findings of the study would be of immense benefit to authors of textbooks as they would have a better understanding of the strategies and consequently, incorporate them into their text for the benefit of students and teachers especially, on methodology. Curriculum planners and other education stakeholders would also find the study beneficial in the course of developing and improving the physics curriculum as well as mounting or suggesting in-service training and workshops for the teachers of physics. Nevertheless, findings of the study would serve as reference materials in physics education.

1.7 Operational Definition of Terms

Achievement in Physics: Scores obtained by students as measured by Physics Achievement Test (PAT)

Student's Attitude to Physics: Student's positive or negative feeling regarding physics as would be measured using physics students' attitude questionnaire scale (PSAQS)

Students' level of Commitment to Physics: Students' willingness to devote time, energy and other resources at their disposal to the study and learning of physics. This was measured by physics students' academic commitment scale (PSACS).

Interactive-Lecture-Demonstration Strategy: It is a student-centered teaching approach in which students are challenged to predict the outcome of an experiment, observe the outcome, and discuss it with their former predictions.

Guided-Reverse Jigsaw Instructional Strategy: It is a form of jigsaw strategies in which students are guided such that they are made to specifically focus on students' interpretations such as perceptions through active learning discussion

CHAPTER TWO
LITERATURE REVIEW

2.1 Theoretical Framework

The John Dewey's constructivist theory of interaction and Albert Bandura's social cognitive theory underpinned the study. The theories are of the conviction that students learn far better when they strive to make meaning of something or work out something on their own while the teacher guides them along the way. The theories demanded for education to be grounded in real experience.

2.1.1 John Dewey's Constructivist Theory of Interaction

Constructivism is a theory of learning that opines that, students must interact with their environment in order to adapt, learn and make their own knowledge. The theory is traceable to educational psychology in the work of Jean Piaget (1896 - 1980) and John Dewey (1859 - 1952). Their main focus was on how humans make meaning in relation to the interaction between their experiences and their ideas. In essence, the theory believes that learning is personally constructed by an individual through experience. It is thus, of strong conviction that every learning or meaning attached is a function of the interaction between one's prior knowledge and the new events.

Dewey's theory according to Neil, (2005) states that experience arises from the interaction of two principles - continuity and interaction. While continuity implies that each experience a person has can make or mar his/her future, interaction is of the view that an individual's experience is a function of the association between his past experiences and the present situation. The emphasis of John Dewey's constructivist theory of interaction is that learners should use their interaction with the learning environment to construct their own knowledge. It is of the notion that memorization, rote-learning or repetitive learning will take students nowhere in their studies. The theory therefore proposed a method of "directed living"- wherein students are made to engage in real-world, practical workshops and during which they demonstrate their knowledge through creativity and collaboration. In other words, students should be provided with opportunities to think from themselves and articulate their thoughts. Thus, they connect new knowledge to previously learnt ones.

Constructivism is thus, an important learning theory that places emphasis on the learners. It proposes that learners must actively develop their knowledge and not others such as teachers transmitting knowledge to their (the students) brain. By implication, learners must be responsible for their learning outcomes. This the teacher does by allowing learners to feel free and explore their environment, take risks in their efforts to learn, make mistakes and learn from their mistakes. The theory is germane to this research work with its emphasis on learners' active participation in a learning environment. Interactive lecture demonstration is in line with this theory as the strategy provides opportunities for learners to interact in a learning environment and develop the ability to think and make meanings, as they interact and collaborate in the learning environment with others.

Implications of John Dewey's Constructivist Theory on Teaching and Learning

The main idea of John Dewey's constructivist theory is that Knowledge is constructed rather than innate or passively absorbed: This implies that an individual's new or modified knowledge from any new experience is a function of his/her prior knowledge. That is learners build new knowledge on the foundation of the previous knowledge. Equally orbiting around this idea of constructed knowledge is that learning is an active process and not a passive process. While the passive view of teaching or learning portrays a student as a barren ship with nothing upstairs. They are in classes only to be filled with knowledge from the brain of the teacher. The active view of learning averred that, learners construct their own meaning or knowledge through active engagement with the world. It could also be deduced from the theory that knowledge is socially constructed implying that learning rather than being an abstract concept is a social activity resulting from an interaction between two or more people.

The implication of this theory in a teaching/learning process is that teaching cannot be viewed as a mere transfer of knowledge from the head of the teacher to the heads of the learners. Teachers should therefore not act as an encyclopedia of knowledge. They are just to guide the students in their learning and provide students with the much-needed opportunities to excel in their endeavors. Additionally, knowledge being based on previous knowledge of the learners requires that the teacher needs to take note of that learners' prior knowledge and make provision for a learning environment that will challenge students' firmly held preconceived notions they brought to the class about a concept. This is a big challenge for teachers simply because it will be wrong of them to think that all students learn the same way and understand at the same rate. Efforts should therefore be made by teachers to make provision for different experiences that will take care of different students so that they can advance to different levels of understanding.

Again, if learning is truly an active process, then an ample time will be needed to ensure meaningful learning. This in the words of Hoover in Mvududu, and Thiel-Burgess, (2012) will afford students great opportunity to reflect about the new experiences, how the new experiences and the prior ones contradict each other and how a different understanding will provide the students with an improved view of the world. Learning being a social activity stresses the importance of child's environment in his education. It thus requires that a very conducive learning environment must be put in place for students to assist them in their bid to learn. The environment must be a cooperative environment rather than be a competitive one and with all the needed facilities or resources at the beck and call of the students. In sum, if learning must be a constructive process then, the instruction must be designed to provide opportunities for such construction, and one way of doing this is to make teaching students- centered. In other words, if there is any legacy john Dewey's constructivist theory has bequeathed to teaching/learning process, it is an emphasis on student centered learning.

2.1.2 Albert Bandura's Social Cognitive Theory (SCT)

The theory which started as the Social Learning Theory metamorphosed into the Social Cognitive Theory (SCT) in 1986. The theory is at variance with behaviorist approach to learning which asserts that the environment alone determines the behavior. Albert Bandura came up with the idea of concept of reciprocal determinism, in which the learner (cognitive processes), behavior, and context (environment) all interact. Each factor influences and it's being influenced by other factors concurrently. While the *c*ognitive processes connote all the previously learned characteristics such as beliefs, expectations, and personality characteristics; behavior refers to anything that we do that may be rewarded or punished. The context in which the behavior occurs is simply the environment, which includes rewarding/punishing stimuli. The theory however does not suggest that the three factors in the triadic model contribute equally to behavior. Their influence depends on which factor is strongest at any particular moment.

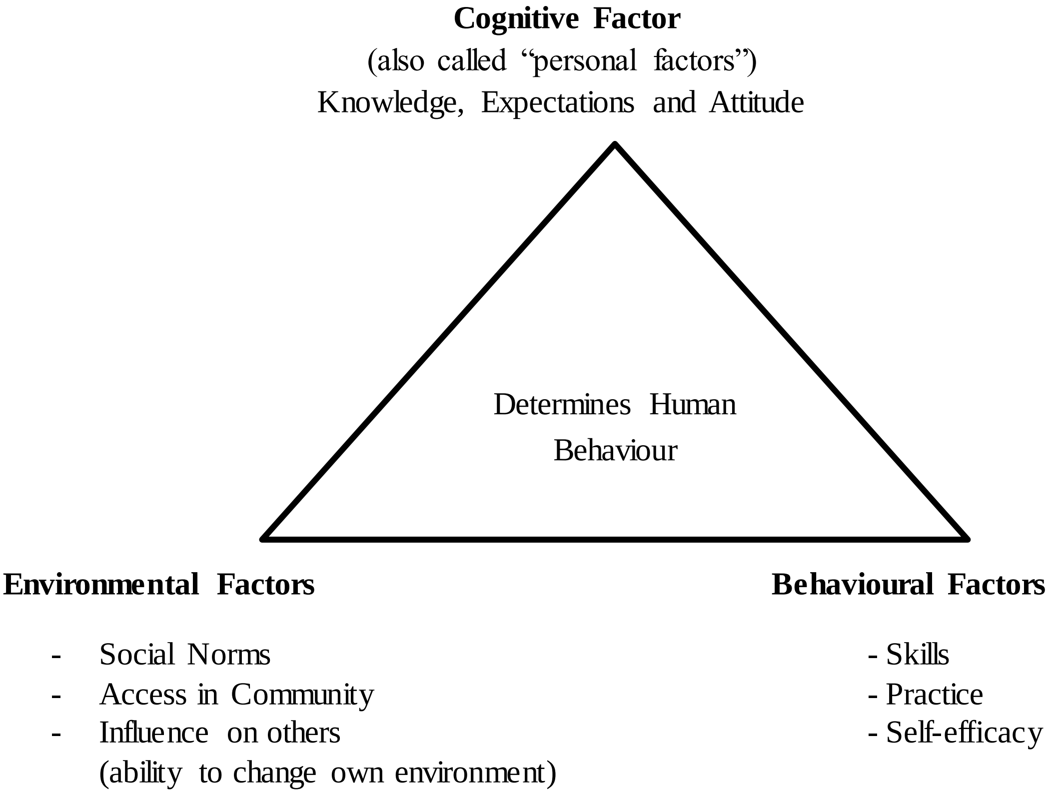


Fig 2.1: Albert Bandura Social Cognitive Theory

(Source: Future Teachers' World)

The theory presupposes that learning is a remarkably complex task that is dependent on a wide variety of factors such as observation, modeling, imitation etc. It is of the view that learning is a social context with a mutual interaction or relationship of the person, environment, and behavior. It thus focuses on the interaction between internal factors like thinking, attention etc and external determinants like rewards and reinforcement in determining the behavior. The theory appears to be a bridge between behavioral theories which advocated that all behaviors are products of conditioning; and cognitive learning theories that are mindful of the psychological influences such as attention and memory. The whole of the above assumptions according to Hammer, (2011) is summed in Albert Bandura's theory that suggests that observation and modeling play a major role in a learning process. Bandura in Saul, (2016) submitted that:

i. Learning is internal
ii. Students learn through observation/imitation of peers.
iii. Learning is an offshoot of a dynamic interaction between a person, his environment and behavior

In essence, Social Cognitive Theory of Learning asserts that portions of an individual's knowledge acquisition are directly connected to observation of others within the context of social interactions, experiences, and outside media influences. Social cognitive theory thus, advocated the use of collaborative grouping as a means of helping students to make sense of new ideas through discussion. By working together in groups, students help one another to create meaning and foster their understanding. Both interactive lecture demonstrations and jigsaw approaches are considered to be consistent with this theory especially when one considers the underlying assumptions of the theories that learning activities require the students' full participation, collaboration among students and the coaching role of the teacher.

Principles or Phases of Social Cognitive Theory of Learning

The theory as proposed by Bandura consists of four phases/processes namely attention, retention, reproduction, and motivation (Saul, 2016).

Attention implies that students' mere exposure to a model is not enough a guaranty that the model will be imitated or that learning will take place. For learning to take place, one has to be focused on the task, pays attention to the behavior/task and its consequences after which he/she forms a mental image of the behavior. As a matter of fact, before any behavior can be imitated, it has to grab attention.

Retention refers to how well a behavior is remembered. It has to do with retaining what has been learnt. A behavior may be noticed but is it not always remembered which obviously prevents imitation. Achieving this however requires students to develop a memory and easily retrievable images and verbal coding of the behavior of what they saw earlier so that the behavior can be performed later by the observer. In other words, learning results from the internalization of information in our memories

Reproduction is of the opinion that previously learned information such as behavior, skills, knowledge etc can be reproduced when needed. It thus stresses the translation of both verbal and image representation systems into overt behavior.

Motivation simply refers to the will to perform the behavior. Doing this places emphasis on the rewards, incentives or punishment that accompany a behavior. If the rewards outweigh the perceived cost or punishment, the behavior is more likely imitated otherwise, it will not be imitated.

Basic Assumptions of Social Cognitive Theory

The basic assumptions that could be helpful in understanding the Social Cognitive Theory according to Benildo, (2021) are that:

- People learn by observing others
- Learning is an internal process that may or may not lead to a behavior change
- People and their environment mutually influence each other
- Behavior is directed toward particular goals i. e. people set goals for themselves and work to achieve the goals.
- Behavior becomes increasingly self-regulated.

Implications of Social Cognitive Theory to Teaching/Learning

The theory emphasizes the critical role of self-beliefs in human cognition, motivation, and behavior. It gives prominence to a self-system that enables individuals to exercise a measure of control over their thoughts, feelings, and actions. Unquestionably, this theory can be used to teach positive behaviors to students. Teachers can use positive role models to increase desired behaviors and thus change the culture of a school. To this end, teachers are encouraged to oganize the instructional resources in such a way that the embedded concepts can be acquired easily and internalized by learners' mind.

Social learning theory can be used to encourage and teach desirable behaviors in the classroom through the use of positive reinforcement and rewards. For example, a student who is praised for raising his/her hand to speak will more than likely repeat that behavior. The theory is therefore, relevant because it allows educators to better understand the learning needs of students, and it clarifies the process of the mind. As a result, teachers should deliver lessons based on the way the students learn, their levels and experiences in order for learning to occur.

2.2.1 Concept of Physics Education

Physics as a subject is offered by students in the second three years of secondary school education in Nigeria tagged senior secondary (SS). Education at this level, according to Noah, (2019) and Tabotndip, (2021) is primarily meant to prepare the beneficiaries towards useful living within the society as well as higher education for those willing and able to withstand it. Physics as a subject, emanated from the natural philosophy in company of biology, chemistry, mathematics during the scientific revolution of 17th century. Thus, it is one of the oldest academic disciplines that are still popular till date. The term physics has its derivation in the Latin word “phusike” meaning knowledge of nature or “physika” or “physikos” which simply means natural thing (Owlcation, 2017); and it has lent itself to different descriptions. For example, Omosewo, (2009) defined it as a branch of science that deals with energy and matter and their interactions while Sewar and Jewelt, (2004) described it as a fundamental physical science concerned with the basic principles of universe; a foundation upon which other sciences are based. The same subject was remarked as a body of subjects responsible for explaining all discernible phenomena in nature while Helmenstine, (2017), described it as the study of the properties of matter, energy and their mutual relationship or as a systematic study of the natural world, particularly the interaction between matter and energy. The import of all these definitions is that physics tries to explain the material world and the natural phenomena of the universe. Its scope is so wide that it deals with not only the tinniest particles of atoms, but also dwells upon natural phenomenon like galaxy, rainbow, solar and lunar eclipse etc. It is equally concerned with the forces these constituents exert on one another as well as the results produced by these forces.

To Halliday, Resnick and Walker, (2008) physics relies heavily on experimental observations and quantitative measurements to make explanations and predictions about our environment. Thus, it utilizes mathematics as one of its many physical and abstract tools to achieve its main goal. Mathematics is therefore, the heart of physics as it is calculation-oriented. This explains why any student who is not good in mathematics may not do well in physics as submitted by Meltzer in Aina and Adedo, (2013) that there is a positive correlation between students' mathematical skills and their examination grades in physics. The authors went further to submit that mathematics is not only the language of physics; it also determines the content and meaning of physical concepts and theories.

Physics as a subject has found its applications in virtually all facets of human endeavors. For instance, its basic knowledge can help an individual sort out minor electrical faults at homes and repair personal computers among others. The knowledge of physics also accounts for the discovery and production of hydroelectric power, thermonuclear power plant, telephones, refrigerators, heaters and electric cookers (Awodun, Oni and Oyeniyi, 2015). In addition, candidates seeking admission into institutions of higher learning for courses such as medicine, engineering, pharmacy, petroleum engineering, geology and nursing science among others must have at least a credit pass in physics. Thus, it is a gateway to careers in science, technology, engineering and medicine that are critical to the future prosperity and economic competitiveness of a country. This is a pointer to the fact that technological and socioeconomic development of any nation cannot be attained without a working knowledge of physics; a submission which was corroborated by Adeyemo, (2010) when he described physics as the bedrock of scientific and technological development worldwide. Physics is thus, a unifying factor for all disciplines in life as its feats according Ogunleye, Awofala and Adekoya, (2014) are felt in every facet of human endeavors. In sum, similar to the way chemistry is called "central science" because of its role in linking all the physical sciences, physics is also called "the fundamental science" being the basis for many other sciences including chemistry, oceanography, seismology, and astronomy (Feynman, Leighton and Sands, 2011).

In the context of the foregoing, physics education can be conceived as that which deals with physics teachers' preparation and development as well as the public understanding of physics. It concentrates on the teaching of scientific concepts of physics, method of teaching and addressing the misconceptions held by learners regarding the concepts; a point to which Taber, (2021) subscribed. It is a very important subdivision within science education with its focus primarily on how to explain and study physics from the lowest to the highest echelon of education. Thus, physics education is concerned with the provision of an effective physics instruction which in the words of Weiman and Perkins, (2020) will change the way students think about physics and physics problem solving; and causes them to think like experts – practicing physicists. According to them, most people (the novices) see physics as isolated pieces of information that are not related to the real world while an effective physicist and physics teacher see physics content as a coherent structure of general concepts that describe nature. A good physics education is therefore meant to produce competent teachers for senior secondary school physics teaching (Ojediran, 2016). Products of such education will be able to move students from mindless memorization to understanding.

Like physics, physics education is very important for so many reasons. For example, many graduates of physics education are self-employed or employers of labour with many owning schools for themselves where many people earn their living. Thus, it has the tendency to boost a growing economy like Nigeria. Similarly, without physics education, information and communication technology will not be possible, likewise engineering, medicine; architecture etc will be far from being possible.

In view of its tremendous benefits as an important part of the foundation for many occupations, physics is introduced into Nigerian secondary schools' curriculum to achieve the following objectives:

- provision of basic literacy in physics for functional living in the society;
- acquisition of basic concepts and principles of physics as a preparation for further studies;
- acquisition of essential scientific skills and attitudes as a preparation for technological application of physics;
- stimulation and enhancement of creativity and;
- provision of a course, which is complete for students not proceeding to higher education, while it is at the same time a reasonably adequate foundation for a post-secondary physics course (Okeke, 2019).

The beauty of these objectives notwithstanding, the state of affairs of physics in Nigeria is unacceptable as students' achievement in the subject seems to be inadequate (Akuche and Okunola, 2017; and Usman and Abubakar, 2019) while enrolment in contemporary sciences like biology and chemistry are comparatively higher (Mbamara and Eya, 2015). What could have been the reason(s) behind this? After all, integrated science, a prerequisite subject for all sciences at the senior secondary level classes is not only compulsorily taken by all students from JSSI to JSS3; its curriculum also accords each of the component science parts equal attention and basic introductory representations Okeke, (2019). This is a very poor advertisement for physics with prominent repercussions on the manpower development in engineering, medicine, pharmacy and other related professional science fields which need qualitative physics education.

Addressing this problem in a developing country like Nigeria with little or no political support, calls for the provision of an important resource; the physics teacher, in the physics classrooms. A highly motivated and adequately trained physics teacher in the words of Omosewo, (2009) will be able to handle the constraining circumstances of paucity of material resources and government apathy. Hence, the need for mass production of effective physics teachers who will not only incessantly seek solutions to problems confronting the physics classroom but also initiate changes to improve their teaching without waiting for government or external funding to implement such changes.

2.2.2 Teaching of Physics in Nigerian Schools

In Nigeria, a student comes across physics for the first time in his fourth year of post-primary education (Senior School Level); and its branches include optics, mechanics, heat, electricity, atomic physics and physics of sub-atomic particles. The central concepts around which topics in the SSS physics curriculum content revolve are motion and energy. The curriculum also stresses the relevance of the topics in physics to the society in terms of application perhaps, with the aim of turning out new inventors of scientific and technical tools, equipment and appliances that would not only lead to a comfortable living but also make day-to-day activities much easier. This is evident from the reasons for studying physics as enshrined in the national education scheme for secondary school physics, part of which include provision of basic literary for purposeful existence in the society and acquisition of vital scientific aptitudes, abilities, talents and attitudes as a groundwork for the practical and industrial use of

Physics (Okeke, 2019). For effective comprehension by learners, it was recommended in the physics curriculum that:

- guided-discovery method should be adopted for physics teaching in place of conventional lecture method;
- there should be a genuine and helpful interaction between teachers and students so as to reduce difficulties encountered by the students;
- for physics to be appreciated by students and the community, the specific objectives of every physics topic should be realised at the completion of the lesson;
- topics should cut across each other;
- assessment of students should cover all the three domains of knowledge, application and thinking;
- emphasis should be on both theoretical and practical aspects of the subject;
- students should be exposed to every topic under each theme in a manner that shows how significance such topic to the societal norms, values etc should be supreme in the way it is taught. (Adeyemo, 2010)

Unfortunately, in Nigeria, the implementation has been fraught with many challenges which in turn lead to frustrating achievement of students in externally conducted physics examinations. Nwoye and Okafor, (2019) invariably stated the ordeals teachers in the field pass through regarding the implementation. The challenges among others according to Jegede and Adedayo, (2013) include:

- the use of curriculum content that does not identify with the peculiar needs of the society for which it was designed;
- the continuous use of teacher-centred 'chalk and talk' method thereby turning the students to mere robots;
- non-use of professional physics teachers
- negative attitude of students towards physics because of the mathematical nature of physics as well as harsh students-teachers relationship
- failure of students to relate physics to the relevant societal problems
- inadequacy of teaching materials.

Other problems facing the implementation of physics curriculum in Nigerian secondary schools according to Adeyemo, (2010) are:

- interface between physics and mathematics

- science language and communication
- inconsistencies in government policies
- time limitation

Udor, (2012) capped it all that rather than achieve the general objectives of senior secondary physics curriculum, physics education at the senior secondary level is in coma, needing urgent revival or refocusing. Based on this finding and the general notion that the future of any nation lies in the hands of the teachers, He advocated among others for:

- improved quality of existing physics teachers through extensive training programme, incentive package;
- admission of candidates into physics education based on merit, interest, oral/written examination and interviews;
- government's sponsorship of the unqualified physics teachers on the field to obtain the required qualification for proper functioning of teaching-learning process

2.2.3 Physics Teachers' Preparation

A physics teacher in the words of Omosewo, (2009) remains the only most important resource in any physics classroom especially, in developing nations like Nigeria where there is little or no political support hence, the need for quality physics education which according to Ojediran, (2016), is meant to produce competent teachers for senior secondary school physics teaching otherwise, addressing frightening problems threatening the efficient education and studying of physics anywhere will be a mirage. Physics teachers' preparation involves the training of professionals who will take up the job of educating physics students in future. In the process, the ability of an aspiring physics teacher to teach is evaluated. Although, the certification or preparation requirements vary from country to country, but generally, the aspiring physics teachers are bound to acquire at least a bachelor's degree in physics or related science discipline from a university. The process does not only enable the beneficiaries to acquire the prerequisite knowledge in physics, it equally acquaints them with the theories and principles guiding the practice of teaching.

Presently in Nigeria, Education faculties in Nigerian Universities and Colleges of education are saddled with the responsibility of producing such efficient, self-motivating, highly dedicated and effectively trained teachers who will in turn teach the subject effectively at the senior secondary level (National University Commission), (NUC, 2007). Noting that no education system can rise above the qualities of its teachers, the Federal Republic of Nigeria (FRN 2004, in Ogunyinka et al, 2015) in its National Policy on Education itemises the following as the goals of a good teacher education programme:

- production of greatly, inspired and diligent classroom instructor or tutor to handle our educational programs;
- encouragement of more spirit of inquiry and resourcefulness in teachers;
- helping of teachers to be adequate and acceptable in the community/society and boost their commitment to national goals;
- provision of teachers with rational and proficient experience adequate for their job and makes them adjustable to varying circumstances;
- enhancement of facilitators' commitment to the teaching job;

The objectives are meant to fashion out a focus on teacher education programmes. The policy according to Osokoya, (2010) also stipulates Nigeria Certificate of Education (NCE) as the minimum qualification for whoever wants to pick up teaching as a profession; while a bachelor's degree in physics education may give one an edge. NCE is awarded after a three years programme in a College of Education while B.Sc (Ed) is awarded upon completion of a four year programme in the faculty of education of a university. Anyone with such professional teaching certificates in physics is referred to as a qualified physics teacher. Such a person must have, in addition to a strong command of the subject, knowledge of the difficulties he/she presents to the students (McDermott and Shaffer (2000); Buabeng, Conner and Winter, 2016). This is a further attestation to the fact that physics teachers like other professionals, are not produced in a single act or semester, the production runs through a sequence of efforts - from students' admission into university to postgraduate mentoring- of those who eventually find themselves in classrooms.

In the course of becoming a physics teacher, an individual develops his content knowledge as well as pedagogical knowledge. While content knowledge refers to the knowledge of the discipline i. e. physics, pedagogical knowledge refers to the general knowledge of how people learn (knowledge of psychology), how they work in group and how school works. It is the physics department of the institutions that handles the former, while the latter knowledge is in the purview of the faculty or school of education (Etkina, 2010). Currently, scholars like Etkina (2010), have come to realize that the most important aspect of teachers' practical knowledge, particularly for secondary school teachers, is their pedagogical content knowledge (PCK) which includes knowledge of subject matter for teaching such as knowledge of students' difficulties and prior conceptions in the domain, knowledge of domain representations and instructional strategies, and knowledge of domain-specific assessment methods. This is represented in the Figure 2.2

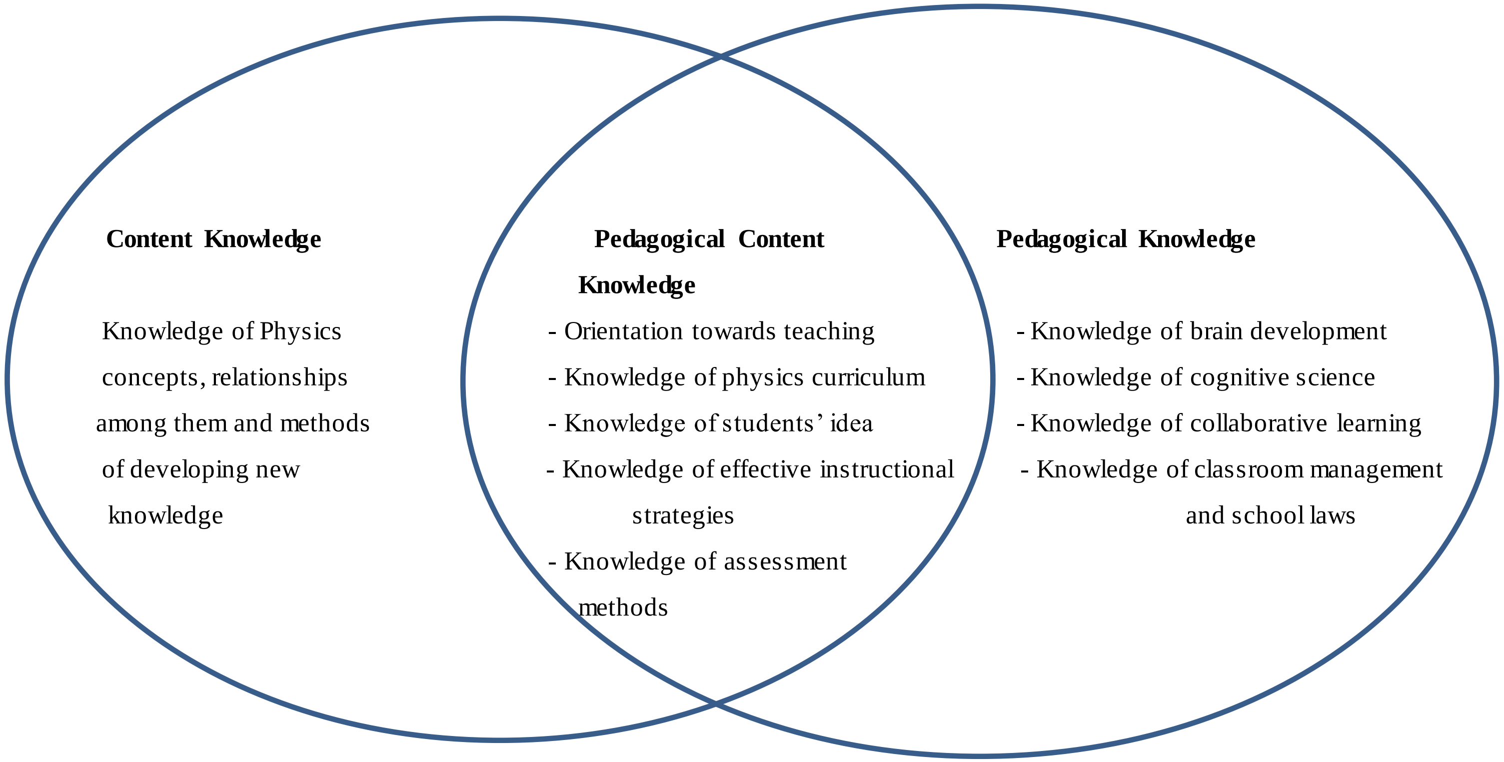


Fig. 2.2: Structure of Physics Teacher Knowledge

(Source: Etknia, 2010)

Table 2.1: Five Aspects of PCK and their Relationship to Teaching Physics

S/N	Aspect	Relationship to Teaching Physics
1.	Orientation to science teaching	Beliefs regarding the role of students' prior knowledge in their learning, the purpose of problem solving, the roles of experiments in the classrooms, what motivates students in the classroom, etc.
2.	Knowledge of curricula	The knowledge of the sequence of topics that allows a student to build the understanding of a new concept or skill on what she or he already knows.
3	Knowledge of students' prior understandings about and difficulties with key concepts and practices in science.	Knowledge of students' pre-instruction ideas when they are constructing a new concept. Knowledge of difficulties students may have interpreting physics language that is different from everyday language.
4	Knowledge of instructional strategies to scaffold students' learning of key concepts and practices in science.	Knowledge of multiple methods or specific activity sequences that make student learning more successful and an ability to choose the most productive strategy or modify a strategy for a particular group of students or an individual.
5	Knowledge of what to assess and specific strategies to assess students' understandings of key concepts and practices.	Knowledge of ways to assess student conceptual understanding and problem solving and general scientific abilities; knowledge of how to help students self-assess their work and to engage in a meaningful reflection.

Source: Etkina (2010)

Unfortunately, studies such as Udoh, (2012); and Aderonmu and Obafemi, (2015) have asserted that there are more non-qualified physics teachers than their qualified counterparts in Nigeria. This assertion was corroborated by Teaching Certification Com, (2021) when it averred that the greatest teacher shortage in secondary education is in physics. A non-qualified or an ill-prepared physics teacher according to Buabeng et al, (2016) usually teaches the same way he was taught. If he is taught through lectures, he is most likely to lecture at the secondary school level, even if this type of teaching strategy is not appropriate for his students. Hence, for a successful physics teacher preparation program, Theodore et al, (2009) advised teacher training institutions to among other things:

- talk to their students to find out what motivates them, give individual attention to future physics teachers identified and monitor their progress; and
- adopt interactive teaching methods in introductory courses, and provide talented students an opportunity to participate as peer teachers or mentors.

In addition to this, a good physics teacher according to The American Association of Physics Teachers (TAAPT) in Aderonmu and Obafemi, (2015) is expected to be friendly, approachable, passionate, ever-ready to struggle with questions, take students as partners and he should not afraid of doubts, problems or feedback from the students.

Physics Teachers' Preparedness

The term preparedness ordinarily means a state of being ready for something to happen, especially for crisis, war or a disaster. But for this study, Adeodatus, (2018)'s definition is considered suitable. Adeodatus defined it as the state of readiness to adequately respond to the implementation of science curriculum on both individual as well as institutional levels. However, an endeavor can never be successful unless there are inputs from the players. This explains why preparedness is further seen as the quality of inputs into the system from both the individual and the institution. It is expected of every institution to make provision for well standard libraries stocked with relevant and up-to-date reading materials; adequate and functioning teaching/learning materials; effective curricular as well as adequate number of qualified physics teachers among others as her own inputs, while a teacher must work to ensure an excellency of teaching/learning processes.

From the foregoing, it is obvious that it is one thing for a teacher to be qualified in terms of certificate acquisition, it is another thing for him/her to be fully ready to face the often complex and changing challenges in the classrooms. This is what the term teacher's preparedness is all about. It incorporates what the teacher brings to the classroom from both pre-service and on-the-job learning. This is to say that teachers' feelings of preparedness are one important indicator of the extent to which they are prepared to meet the challenges that characterize the profession of teaching. This might not be too far from being in line with a popular old adage that "full or adequate preparation is half won the battle".

The significance of that adage in relation to physics teaching is that no physics teacher can teach effectively or meaningfully well without enough preparation/planning for his/her lessons. Planning entails organization of all the human and material resources for learning process. It has to do with knowing every detail of what is to be done, using what, by who and at what time. Applying this to classroom settings, planning guarantees achievement of stated objectives. This is suggesting that every physics teacher must plan his work very well so that effective teaching and learning can actually take place. One the ways of doing this is for every teacher of physics to have a very strong command of the subject matter content knowledge and an understanding about the difficulties this content presents to students (McDermott and Shaffer, 2000). This is in agreement with the submission of Mapolelo and Akinsola, (2015) that teachers of science and mathematics should have a strong knowledge of science and mathematics concepts to enable them to guide students to explore these concepts.

In addition, a well-prepared physics teacher is also expected to be fully armed with his/her lesson plan or lesson note. A lesson plan refers to a step-by-step plan of how the teacher is going to conduct the lesson. It includes the objectives, contents, and methods through which he/she plans to impart the knowledge to the learners. It is a teacher's pre-planned daily lesson guide that indicates what the educator is planning to teach the students during a particular period, how he or she should teach it, and how he or she is going to evaluate the learning process. Basically, a lesson plan includes a well-outlined routine to be followed during each lesson (Anuradha, 2022).

Apart from those listed above, other classroom demands according to National Centre for Education Statistics, NCES, (2022) that might need physics teacher's full preparedness are in the areas of maintaining order and discipline in the classroom; implementing new methods of teaching; addressing the needs of students with disabilities; integrating educational technologies into the grade or subject taught and addressing the needs of the needs of students with limited English proficiency or from diverse cultural backgrounds.

On the maintenance of order and discipline in physics classrooms, physics teachers should change their notion about discipline as getting kids to do what they want them to do. That's what dictators do. But as a teacher, discipline should be seen as providing an environment in where meaningful learning can take place. To achieve this, TeacherVision, (2022) recommends that a physics teacher should cultivate the habits of interacting with students at personal level, modeling the behavior you want them to exhibit such as respectfulness, trust, courtesy, enthusiasm etc; and getting students focused before starting a lesson i. e. one must get their attention before he/she begins the teaching.

Teaching students with learning disabilities definitely poses some unique and distinctive challenges to teachers as their cases demand more of teacher's time, specialized instructional strategies and patience. A well-prepared physics teacher packs along with him to the class culture of giving immediate feedback to such students; making activities concise and short where possible as well as cultivating the habits of using concrete objects as instructional materials among others.

2.2.4 Strategies for Teaching Physics

Of all the core sciences, physics still remains the knottiest for most students due to its many derivations, abstract nature, formulae and laws among others. It's so dry and mentally exhausting with a dearth of fun. Hence, for the subject to win the mind-set of students, teachers of physics need to play a very crucial role in selecting the most effective and suitable instructional strategies that will not only help in engaging students in the classroom but also help to develop critical thinking among students. Such selection according to Awandia, (2021) is however a function of the concepts to be taught and students' interest. Traditional lecture method of teaching is about the oldest and the most common method of teaching everywhere. Experiences have equally shown that many teachers in most of Nigerian secondary schools follow the conventional mode of learning and teaching physics.

In the method, the role of teacher is supreme while students remain only passive listeners of information. Mini and Abdul, (2015) reported that in lecturing, a physics teacher delivers lectures, gives notes and solves problems without any active participation from the students. The process is thereafter backed up with assessment, testing and feedback. Thus, it is the teacher that manages the class from the beginning to the end. The resultant effect of this format of teaching is nothing other than dullness in the classroom. For most of the teachers, it remains the preferred format, most convenient and inexpensive way to impart and study physics since it seldom requires usage of scientific apparatus and experiment apart from the chalkboard.

However, it's been realized that there are some weaknesses in the traditional teaching approach. Only exceptional teachers are capable of holding students' attention for an entire teaching period. It's even more difficult to provide adequate opportunity for students to critically think. The approach often leads to surface learning as much of the content is too abstract and students find it hard to relate to real life. A Chinese proverb says 'We just see a small part; we can't see the whole picture'. It is the same here. Thus, the method is not in any way the best way to develop a conceptual understanding of physics concepts and principles. Moreover, those students who cannot answer the questions gradually become frustrated. Knowing about these negative points of competitive and individualistic way of teaching, there should be a change in the way of teaching physics. As Nunan, (2001) puts it:

> " ….Our greatest challenge now is not to throw out well-established practice, as so often happen in the past, but to incorporate new ways of doing things into existing practice. In this sense, change will be evolutionary rather than revolutionary."

One way of achieving this i. e. fulfilling the insatiable desires of students and improving physics teaching in schools is by adopting new and contemporary instructional strategies to teach (Jatsho and Richen, 2016). That is, engaging students in active learning.

Active learning as used here does not lend itself to only one acceptable definition. It has as many definitions as there are authors. However, some of the generally accepted definitions of active learning include an instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing (Bonwell and Eison, 1991; and Prince, 2004). Karamustafaoglu, (2009) described an active learning strategy as an instructional strategy through which learners become active participants in the teaching/learning process. This implies that in active learning process, students move from being passive recipients of knowledge to being participants in activities that encompass analysis, synthesis and evaluation besides developing skills, values and attitudes. In other words, all learning is in some sense active, but active learning refers to the level of engagement by the student in the instructional process. Weltman, (2007), described it as a method of learning in which students engaged in the process of learning and where there are different levels of active learning, depending on student's involvement. Whichever way the term is defined, it focuses the responsibility of learning on learners. It suggests that students must do more than just listen: They must read, write, discuss, or be engaged in solving problems. Taking cue from this submission, one is poised to describe active learning as instructional activities involving students in doing things and thinking about what they are doing.

In effect, active learning environment (ALE) differs from a passive learning environment (PLE) in a number of ways such as it is presented in the Table 2.2.

Table 2.2: Differences between Passive and Active Learning Environment

S/N	Passive Learning Environment (PLE)	Active Learning Environment (ALE)
1.	Instructors and textbooks are sources of authority.	Real observations of the physical world are the authority.
2.	Students' beliefs are rarely overtly challenged	Students are challenged to compare their predictions (based on their beliefs) to observations of real experiments
3.	Students may never recognize the differences between their beliefs and what they are told in the class.	ALE changes students' beliefs when they are confronted with the differences between their beliefs and their observations
4.	Instructor's role in PLE is as authority	Instructor's role in ALE is as guide in the learning process.
5.	In PLE, Collaboration with peers is often discouraged	Collaboration is encouraged and with peers
6	In PLE, the use of laboratory work is mainly to confirm "learned theories"	In ALE, laboratory work is used to learn basic concepts.

(Source: Sokoloff, 2012)

It should also be noted that the ideas about active learning have a very long history as shown by several ancient Chinese proverbs about experiential learning which are commonly cited. A good number of the proverbs are attributable to the philosopher Lao-Tse (5^{th} century B.C.) who is quoted to have said: "If you tell me, I will listen. If you show me, I will see. But if you let me experience, I will learn." Weltman, (2007) also quoted Benjamin Franklin to have written that "Tell me, and I may fail to recall. Teach me, and I may recollect. Get me involved, and I will learn." These thoughts according to the author have withstood the test of time and are of course testimony to the potential of learning through active involvement.

The use of active learning strategy is vital because of its impact on students' learning in classrooms. For example, studies like Gifkins, (2015) observed that the strategy promotes recall and deeper understandings of material as students are engaging with the content rather than simply listening to it. Similarly, the use of different delivery modes in active learning supports students who have different learning styles. It also helps to maintain students' concentration and deepen learning towards higher level skills like critical thinking. Last but not the least; it increases enthusiasm for learning in both students and instructors.

Examples of active learning strategies are many and inexhaustible. These include strategies such as peer review, discussion, role playing, game-based learning, just in time teaching, problem solving using real data. Other examples according to Wang, (2005) are concept mapping, problem-based learning, team work; and mini-lecture and assessment. Whichever one is adopted; it should be spiced with activities such as:

- use of simpler words and relevant examples;
- frequent demonstrations and investigations;
- use of humorous questions and explanations;
- use of diagrams to solve questions;
- evaluation of students' work and achievement;
- evaluation of teaching among others (Tamang in Jatsho and Richen, 2016).

2.2.5 The Scope and Objectives of Senior Secondary School Physics in Nigeria

Physics is very broad such that it deals with energy, matter, and their interactions at all levels - from the tiniest fundamental particles of matter to the entire universe. Dishadi and Saeed, (2015) summed it up by describing physics as the study of everything. Physics is taught in Nigerian secondary schools with the sole aim of familiarizing the students with the trend of modern developments which can be achieved if the physics syllabus is implemented effectively. Its teaching like that of other sciences is thus essential for developing scientific attitudes in view of the fact that its teaching or learning according to Rudolph in Dishadi and Saeed, (2015) provides more possibilities of involving children in meaningful interactive activities. However, achieving this objective may be a mirage if the curriculum and the syllabus are not well implemented. Corroborating this view, Onyeachu (2008) posited that no matter how well the curriculum of any subject is planned, designed and documented, implementation is important, while Babalola (2004) and Mkpa (2005) remarked that it is at the implementation stage that many excellent curricula plans and other educational policies are marred without any trace. Curriculum implementation as used here refers to the transformation of the objectives of the curriculum from paper to practice (Okebukola, 2004).

Any course as well as the syllabus accompanying it provides an outline and summary of topics to be covered in a course of study. They could both be fused together and handed over to the teachers and students for use as a guide in the discharge of their duties. The case is not different with physics curriculum and/or syllabus. The syllabus for the senior secondary school certificate examinations otherwise called ordinary level is broadly meant to provide an introduction to, and an overview of, physics. Specifically, its main objectives are itemized as follows.

- **Knowledge**: Students should be able to acquire knowledge of the basic physical principles, terminologies and facts, and how they contribute to the social historical technology advancement.
- **Understanding**: The students should have a better understanding of the basic physical principles and other knowledge they have learnt, and be able to use them to solve everyday problems.

- **Skills**: Students should be able to use scientific equipment appropriately to measure physical quantities in the appropriate S.I units. They should also be able to use experimental data appropriately and work safely in the laboratory.
- **Competence**: Students should be able to report concisely on any experimental procedure and result. They should as well be competent and self-reliant t relate scientific concepts to issues in everyday life.
- **Attitudes**: It is anticipated that students after exposure to physics lessons should be able to appreciate the knowledge of physics and contribution of physics to the social and economic development of society.

In line with the above objectives, the new physics curriculum at this level has been loaded and packaged in a way that will facilitate the attainment of these objectives. For this study the WAEC operational curriculum structure for the Senior Secondary School Physics Students of SS II class is highlighted below.

1st term

1. **Equilibrium of forces:** Concept of equilibrium, resultant and equilibrant - Moments, triangle of forces - Conditions for equilibrium - Centre of gravity and stability
2. **Equilibrium in fluids** - Archimedes' principle - Floatation - Density and upthrust
3. **Machines**
4. **Temperature and its measurements**. - Temperature measurements and scales - Types of thermometers - Molecular theory explanation of temperature
5. **Measurement of heat energy**. - Specific heat and latent heat - Evaporation, boiling, melting, - relative humidity and dew point
6. **Introduction to waves:** Production and propagation of waves, types and properties of waves.
7. **Reflection of light** - Laws of reflection, reflection at plane and curved surfaces.

2nd term

1. **Refraction**: Refraction through rectangular block and triangular prism - Critical angle and total internal reflection. - Dispersion of white light - Refraction through lenses
2. **Application of light Waves:** The camera and the human eye. -Projectors, microscopes

and telescopes.

3. Sound Waves: Noise, music and characteristics of musical note. -Resonance and forced vibration - Harmonics, overtone, vibration in strings and pipes - Application of Sound waves.

4. Electromagnetic waves

5. Electrolysis

6. Electricity conduction through gases - cold cathode and hot cathode emission

7. Magnetic field: - Concept and patterns of magnetic field; - Methods of making Magnets - Electromagnets and applications of EM field - The earth's magnetic field - Force on a charge moving in a magnetic field

<u>3rd term</u>

1. Pressure

2. Gravitational Field: - Concept of gravitational field and gravitational potential. – Escape velocity - Satellites and rockets

3. Current electricity (II): - Capacitors and capacitance - Galvanometer conversions - Principle of potentiometer, meterbridge and Wheatstone bridge

4. Electric Field: - Coulomb's Law -Electric field intensity and electric potential

5. Models of atom

6. Electromagnetic Field: - Force on current carrying conductors in magnetic field - Electromagnetic induction - A.C and D.C generators - Moving coil galvanometer, induction coil and transformers. - Power transmission

7. Simple alternating current.

The examination body has started testing students on these topics in the 2014 May/June examination.

2.2.6 Interactive Lecture Demonstrations (ILDs) Strategy

Interactive Lecture Demonstrations are a 3-step-students-centered instructional strategy involving teacher setting up a demonstration/an experiment for the students, who make predictions about the outcome on a prediction sheet, and thereafter join forces with fellow students to discuss their predictions in small groups. The strategy stemmed from an attempt to address the ineffectiveness of the lecture method of teaching and the difficulty encountered while engaging students in a large class environment using conventional method. The challenges in the words of Muhammad et al, (2016) include its tendency to kill students' initiatives as it makes them passive listeners. In other words, it fails to encourage students to indulge themselves in independent thinking and self-exploration processes thereby failing to achieve an important objective of getting an all-round development of the students. It is for this reason that scholars such as Šlekienė and Ragulienė, (2010) have called for the adoption of method(s) that would make students understand whatever concepts or principles that are being taught. There are however, varieties of such methods for teaching and learning physics amongst which are inquiry, problem-solving, case studies, field trips and demonstration. Each of these methods relies on various forms of teacher- students' activities; though, some have more activities than others. One of such, is demonstration method which according to Muhammad et al, (2016) utilizes several senses; students can see, hear and possibly experience an actual event, it stimulates interest, presents ideas and concepts more clearly, provides direct experiences and reinforces learning. It was however asserted by Šlekienė and Ragulienė, (2010) that it's not enough just to demonstrate the experiment. This is because according to them, pupils who watch demonstration passively, and do not adopt information connected to the experiment are not better than pupils, who did not see demonstration at all.

However, by changing method of demonstration through an improvement of students' involvement to participate in it, much better learning results will be achieved. Hence the need for a "blended learning strategy" that will engage students in a range of activities which will involve them in doing things and thinking about the things they are doing. In other words, such strategy in the words of Mazzolini et al, (2012) will incorporate both traditional lecture instruction followed by active learning instruction. One of such strategies is Interactive lecture demonstrations (ILDs).

The strategy in the words of John, (2009) was first developed in 1991 by a team at the University of Oregon. It was developed on account of the belief that each student enters a physics class with a preconceived notion about the workings of the physical world around him/her and which are often at odds with the scientific understanding. Such notions according to Sharman, Johnston, Johnston, Varvell, Robertson, Hopkins, Stewart, Cooper and Thornton, (2010) are firmly held and are extremely difficult to change just by the students being told differently. But when demonstrations are performed, students' preconceived notions are challenged. Though, they may resurface after a while. In effect, ILDs are designed primarily to enhance conceptual learning in classes by engaging students in the learning process. The strategy engages students by finding ways for them to interact with the content, their teacher and their classmates. It thus enables students to observe real demonstrations, make predictions on prediction sheets and thereafter collaborate with fellow students by discussing their predictions in small groups. Thus, Interactive lecture demonstrations popularly called (ILDs) can be described as a learning strategy that requires students to predict the outcome of a demonstration prior to conducting the demonstration.

Taking cue from the above submission, one can make bold to say that a typical interactive lecture demonstration is made up of three (3) steps which are Predict, Observe and Experience (POE) or better still, Predict, Experience and Reflect (PER).

Fig 2.3: An Illustration of the Three Stages of a Typical Interactive Lecture Demonstration

(Source: Carleton Science Education Resource Centre, 2021)

At the prediction stage, students pick one out of a set of possible outcomes that is most likely to occur. The essence of the prediction stage of the strategy is to connect the in-class demonstration with the students' prior experience. This hopefully enables such students to display significantly greater understanding. The second and the experience phase of the strategy involves making students to work in small groups to conduct an experiment or take a survey so as to determine whether their initial beliefs can stand the test of the time or not; while the reflection and the third step enables the students to identify and consolidate what they have learnt. This, they do by thinking about why they chose their initial beliefs and in what ways have their initial beliefs have been confirmed or contradicted by the demonstration.

Adoption of this teaching approach becomes necessary considering the fact that each child typically comes to the class with misconception (otherwise called prior concepts) on the concepts to be learned. Each student starts building his understanding for something that he saw by his own ideas and as the child grows up to be a student in formal class, he is still holding on to his beliefs about nature and his surroundings. It is going to be a big problem in learning process if students' idea is not same with scientists' idea. Physics is one of the sciences that have many misconceptions and which if not remediated, may continue to cause obstacles in learning as students advance in their studies. Consequent upon this, there is need for correct teaching strategy/learning approach such as interactive lecture demonstrations (ILDs) for each level of misconception experienced in order to make learning become meaningful.

Procedure for Interactive Lecture Demonstrations (ILDs)

A typical interactive lecture demonstration (ILD) in the words of Thornton, (2003); Sokoloff and Thornton, (2006) and Duffy, (2018) is structured as follows:

i. The teacher describes all the components of the experiment or demonstration. He/she may carry it out without recording data. The activity carried out at this stage is best described as an exploration. The exploration should however be well articulated by the teacher while students should be allowed to ask questions for clarification.

ii. Students are requested to make their individual predictions of the outcome of the experiment on a prediction sheet. The stage is significant as it stimulates individual risk taking and exposes students' assumptions or preconceptions.

iii. Students are instructed to engage in pair discussion in small groups during which they share their answer with students next to them. They are also allowed to change their answer (s) if they choose. The benefit of this small group discussion to students is in the boosting of their listening skills, communication skills as well as in the self-reflection of preconceptions.

iv. The teacher ensures that every student has a prediction on a prediction sheet or hand out.

v. The teacher solicits for the predictions and thereafter highlights common predictions. The fourth and fifth stages combined brings about a broader sharing of ideas and preconceptions. It equally leads to engagement of all students in the class.

vi. The teacher now runs the experiment and collects real data in a manner in which all students can observe the results.

vii. If a student has a correct prediction, he/she is instructed to discuss the results to the class. If not, the teacher is expected to discuss the correct outcome with the class. The students then write the correct solutions on a separate hand-out or note.

viii. Finally, the teacher leads the class in a brief discussion on other real-word applications of the theory. The stage establishes a connection to the students' world.

Below is a learning cycle of a typical interactive lecture demonstration as documented by Wattanakasiwich, khamcharean, Taleab and Sharma, (2012).

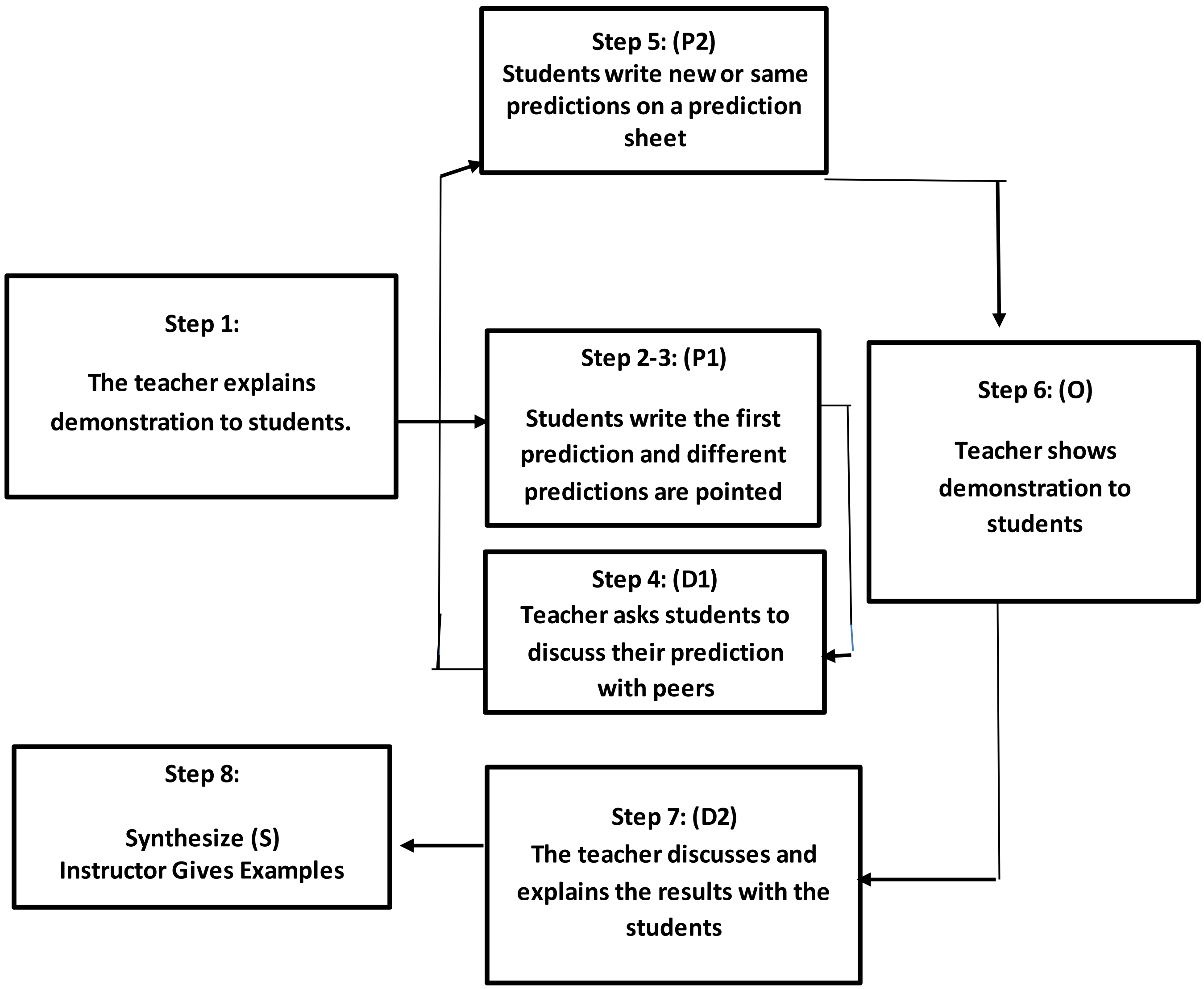


Fig 2.4: Learning Cycle of an Interactive Lecture Demonstration

(Source: Wattanakasiwich, Khamcharean, Taleab and Sharma, 2012)

At this juncture, one cannot but reiterates the fact that the strategy i. e. the interactive lecture demonstration was originally designed to address the ineffectiveness of the lecture method of teaching at the University level during which students are engaged in the teaching/learning process thereby turning the usually passive lecture environment to a more active one. Not much of the utilization of the approach has been heard at the lower educational levels especially in Nigeria. It is therefore the purpose of this study to adapt and apply Thornton, (2003) and Duffy, (2018)' s idea of interactive lecture demonstration in physics classes as a way of helping students to have a better understanding of physics concepts.

On the importance and benefits of ILDs, Bolotin, et al, (2007) in their study on the role and place of interactive lecture experiments in large introductory science courses observed that for many students, exciting demonstrations such as well-performed interactive lecture demonstrations do not only keep them interested and motivated, they equally prevent them from losing their concentration beyond the average attention span of 15 – 20 minutes for college students. It was observed from their results that students who had a chance of predicting an outcome of demonstration prior to seeing it achieved a significantly higher success rate of 25% - 30% while students who were opportune to make a prediction, discuss it with peers, and thereafter only observe the demonstration got the most out of this learning experience with a higher rate of correct responses of 50% and above.

It could be inferred from the discussion so far that each and every step of the strategy greatly improves students' learning. The prediction stage establishes a strong connection between students' prior knowledge or experience and that of the in-class work. Corroborating this assertion Crouch, Fagen, Callan and Mazur (2004), submits that students who predict the outcome of an upcoming demonstration before seeing it display greater understanding. It equally enables students to be more engaged as well as empowering them to keep track of their prior experiences.

The reflection stage of the strategy encourages students' independent thinking in addition to boosting their academic achievement in schools. The primary purpose of the experience stage is to put to test students' assumptions. This it does better most especially when the outcome of the experiment produces a surprise effect. Interactive lecture demonstrations in the words of Slekiene and Raguliene, (2010) like every other demonstrational experiment causes teachers to change their working methods, improve programme of lessons and lesson activity. To Carleton Science Education Resource Centre (CSERC), (2018) highlighted the following are the benefits of interactive lecture demonstrations:

- Fostering of active engagement and accountability;
- Promotion of students' retention and learning of material presented during lecture;
- Giving students practice in developing critical-thinking skills; and
- Enabling the instructors to assess how well the class is learning that day.

In sum, interactive lecture demonstrations allow all students to participate rather than having only individual students answer questions when called upon.

2.2.7 Jigsaw Instructional Strategy

Jigsaw instructional strategy is a grouping strategy that enables students to be dependent on each other, rather than on the teacher to succeed. In the strategy, members of the class are organized into groups, and the class activities split into pieces for the group to assemble. Thereafter, the students are rearranged in new groups, the expert groups to share their learning. This therefore lives the students with no choice than to collaborate and rely on one another in the task of learning a concept. This is in view of the fact that every individual in a group has something unique to contribute to their group's task as no two students in the group do the same task, so each student experiences a higher sense of ownership and accountability to the members of their group. By implication students in a particular group are dependent on each other to succeed. The strategy thus appears as an excellent way of making students to be engaged in their learning as well as making them accountable for their own learning. It equally improves students' teamwork.

The strategy in the words of Social Psychology Network, (2019) came into being as a matter of necessity to alleviate a volatile situation of hatred and hostile classroom in the city schools of Texas in the 70s. It was invented by Elliot Aronson and his graduate students primarily to put an end to racial discrimination and distrust among the white youngsters, African-American youngsters, and Hispanic youngsters who found themselves in the same classrooms for the first time (Aronson, 2005; The National Association of

Geoscience Teachers {NAGT}, 2018). Their coming together to learn under the same roof was accompanied with a long-standing suspicion, fear and distrust between groups, and which ultimately led to an unceasingly intense atmosphere of turmoil and hostility with fist-fights erupting in corridors and schoolyards across the city. The situation therefore calls for creation of a more cooperative atmosphere.

The strategy breaks the day's lesson into 4-5 segments and students are organized into groups with one member in each group assigned to each segment. Working separately, each student learns his/her own segment and becomes master in it, after which he presents it to the group. The strategy thereafter puts the representatives who completed the same segment together into an "Expert group" to talk about and process the details of their segment. Students in the same-topic group (the expert group) reconcile their points of view, harmonize it and produce a final report on it. Next, the students return to their original "Jigsaw" groups and take turns to share the segments they have become experts on. From the final presentation, the students seem to procure a better meaning of the whole idea. Thus, there exists no doubt that jigsaw teaching strategy is an efficient way for students to become engaged in their learning, learn a lot of material quickly, share information with other groups, minimize listening time, and be individually accountable for their learning. Since each group needs its members to do well in order for the whole group to do well, jigsaw maximizes interaction and establishes an atmosphere of cooperation and respect for other students. The implication of this assertion is that, if each student's part is essential; then each student is essential and that is precisely what makes this strategy so effective.

In as much as each group needs its members to do well so that the whole group will do well, the strategy in the words of TeacherVision, (2022) makes-the-most-of the interaction and initiates an atmosphere of cooperation and respect for other students. Corroborating this view, Gonsalez, (2015) stated that because students in a jigsaw group could not succeed without another, they had to learn to get along. The strategy thus reduces attempt by students to try to out-perform each other after all, one student's learning enhances the performance of other students instead of inhibiting it as it's the case of a competitive, teacher-centered class. The strategy brings students of different levels of ability to work together to achieve a common purpose (Akinbola, 2006). In a study conducted by Hänze and Berger, (2007) comparing Jigsaw with traditional direct instruction, students taught with the Jigsaw method demonstrated increased feelings of autonomy, competence, and intrinsic motivation. The finding was attested to by Walker and Crogan, in Gonsalez, (2015) that the Jigsaw students demonstrated improved attitudes toward their peers and reduced indicators of racial prejudice. This was their observation in their study to compare Jigsaw with cooperative learning that didn't include interdependence (a hallmark of Jigsaw).

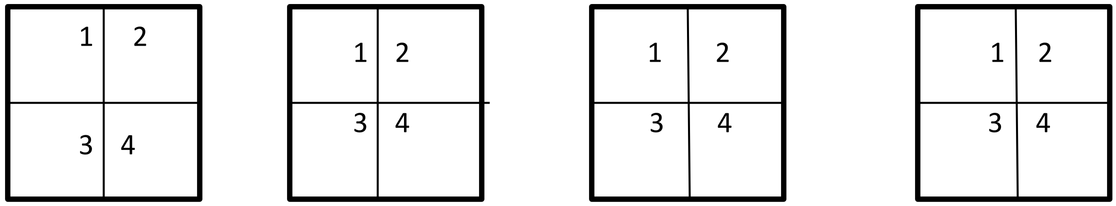
Procedures for Jigsaw Instructional Strategy

Below is the step-by-step structure of the jigsaw instructional technique as proposed by Aronson, (2005) and Okeke, (2015):

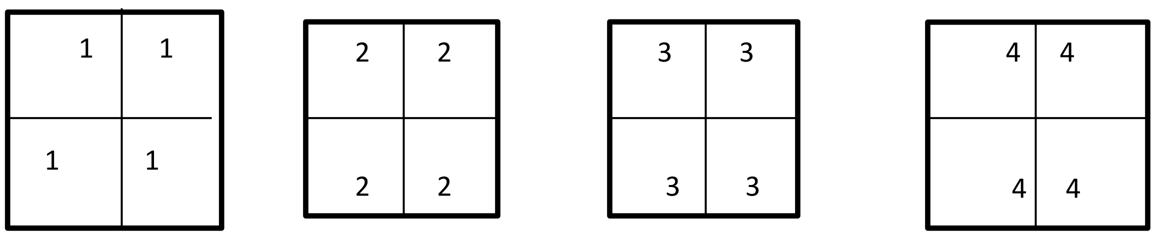
i. Each student is randomly assigned to a home group of 3-5 students taking into account their gender, ethnic group, race and ability.
ii. The teacher divides the day's lesson into segments and assigns each student from the home group to learn one segment.
iii. The teacher makes provision for teaching resources essential for students to grasp the topic and become experts.
iv. The teacher gives students time duration to study their segments at least twice and become familiar with it.
v. The teacher forms temporary "expert groups" by picking a representative from each jigsaw group to join other students assigned to the same segment.
vi. Students in the expert group are given time to discuss the main points of their segment and rehearse the presentation they will make to their home group.
vii. Students are brought back into their home groups and each of them is asked to present his or her segment to the home group. Other students in the home group are encouraged to ask questions for clarification.
viii. At the end of the session, the teacher gives a quiz on the material so that students can quickly come to realize that their sessions are not just for fun and games but really count.

A cursory look at the procedures listed above reveals that it can be collapsed into three phases. The first phase is when the students meet in the home group, while the second phase is when they meet at the expert groups. The third phase is when the students return to their home group to share the learning with others. The phases are as illustrated in the figure below.

Phase 1: Students Meeting in the Home Groups



Phase 2: Students Meeting in the Expert Groups



Phase 3: Students returning to their Home Groups to share their Learning

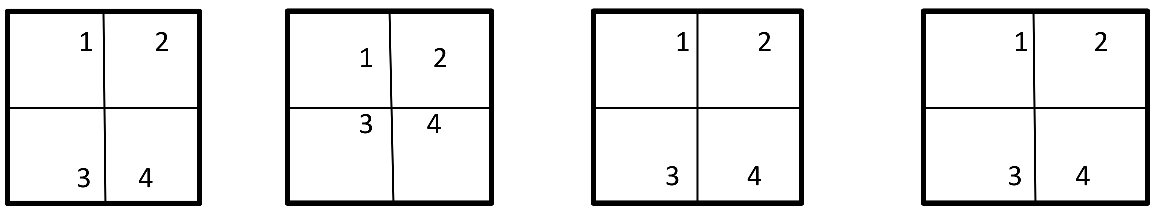


Table 2.3: Phases of the Procedures for a Typical Jigsaw Classroom Instructional Strategy

Phase 1: The phase takes care of the first four steps in the procedures with the each student being randomly assigned to a segment of the topic. Each student is given all the resources needed to execute the task and are given time to read over the segment for them to become familiar with it.

Phase 2: The students from different home groups but with the same task are brought together to form the expert groups where they brainstorm on their task and come up with a harmonized report.

Phase 3: The students in the expert groups are asked to go back to their original home groups to share their findings with the members so that all members of the group become better informed.

Consequent upon some modifications made to the strategy in the practice process, five types of Jigsaw strategies have emerged and are now available for teachers to use in their classroom. The types according to Maden, (2011) are the original jigsaw which was invented in 1978 by Aronson; jigsaw II developed by Robert Slavin in 1987; jigsaw III developed by Stahl in 1994; jigsaw IV developed in the year 2000 by Holliday Bowen and the reverse Jigsaw strategy by Timothy Hedeen in 2003

Jigsaw II is similar to the original jigsaw, with the exception that students in jigsaw groups read the entire assignment or all of the materials to acquire the information or specialize in only one aspect for their expert groups. Group members then take an individual test on the material, the results of which contribute to a team score. The type has an advantage of ensuring that all groups work harder in order to ensure that all members learn.

In the case of Jigsaw III, there is in addition a cooperative test review process which according to Ali, Bichi, Mari and Lakpini, (2017), involves reconvening the home group and reviewing the process. Jigsaw IV comprises of three new important features: an introduction, quizzes, and re-teaching after individual assessment. The reverse jigsaw technique differs from the original jigsaw during the teaching portion of the activity.

2.2.8 The Reverse Jigsaw Instructional Strategy

The reverse jigsaw strategy was authored by Timothy Hedeen in 2003. It operates on the same principles of the original jigsaw only that it has its objectives to attain. In the reverse jigsaw technique, students in the expert groups teach the whole class rather than return to their home groups to teach the content (Agu and Samuel, 2018). Another feature distinguishing the reversed jigsaw from other types is its focus on the participants' interpretations such as perceptions and judgments through a very active discussion contrary to students' comprehension on which others focus on (Samuel, 2018). The method was however mainly created to cater for higher class students. What would be its effects if adopted for teaching at the lower educational levels? This explains why it will be adapted for use in this study. Efforts would however be made to give explanation before the discussion of the topics in order not to only save time but also to ensure learners' effectiveness in their discussions.

The process involved in the reversed jigsaw according to Hedeen, (2003) is explained in three steps as follows:

- Students come together in mixed groups during which each of them is presented with a challenge to discuss for a number of a given a time. Each member of the team is given a unique topic and hence a discussion is initiated within the mixed group and the main points and the outcomes are noted.
- Expert groups are formed in the usual way where the group topic is discussed, points and outcome are considered. A final report is prepared compiling all the common and divergent themes and is presented to the whole class by the appointed group leader.
- The class gathers as a whole and the reporters from the individual topic group present their report to the whole class following which the instructor debriefs the whole exercise with review or evaluation of the process.

In this study, the strategy (reverse jigsaw) is spiced with teacher's guide to make it workable at the lower levels of education. It is thus, tagged guided reverse jigsaw instructional strategy (GRJIS).

Variations in the different types notwithstanding, the basic parts of the strategies are the same. Each jigsaw is cooperative in design and cooperativeness according to Onuaha, Eneogu, Asogwa and Ngwuchukwu, (2016) helps to facilitate interaction among all students in the class leading them to value each other as contributors to their common task. The strategy in the words of Hakkarainen, (2018) is also multifunctional as it enables students to engage in group activities such as active listening, engagement, speaking, cooperation, creative thinking and reflective thinking. The jigsaw method enables every student to focus his or her energy on a given task and provides both structure and process for the learning. It is also endowed with components both inter- and intra-personal that allows students to process information, move and interact with a variety of class members to gain a greater perspective on the knowledge or skills that are targeted for learning. The overall benefits of the jigsaw instructional technique were summarized by NAGT, (2018) as follows:

- Direct engagement of students with the material to be learned instead of having material presented to them. This fosters students' deep understanding of the concepts learned.
- Students gain practice in self-teaching, which is one of the most valuable skills we can help them learn.
- Students gain practice in peer teaching, which requires them to understand the material at a deeper level than students typically do when simply asked to produce on an exam.
- During a jigsaw, students speak the language of the discipline and become more fluent in the use of discipline-based terminology.
- Each student develops an expertise and has something important to contribute to the group.
- Each student also has a chance to contribute meaningfully to a discussion, something that is more difficult to achieve in large-group discussion.
- The group's task that follows individual peer teaching promotes discussion, problem-solving, and learning.
- Jigsaw encourages cooperation and active learning and promotes valuing all students' contributions.

Aronson, (2005) in his contribution summed up the benefits of jigsaw by submitting that it creates a cooperative classroom rather than a competitive one. "In the cooperative classroom, the students achieved success as a consequence of paying attention to their peers, asking good questions, helping each other, teaching each other, and helping each other teach." Students are not pitted against one another in competitions to earn the teacher's limited time and attention. Instead, they are encouraged to embrace the knowledge from individuals all around them.

For a successful implementation of the jigsaw model in a physics class, the following steps according to Foyle and Lyman in Mbacho and Changeiywo, (2013) must be taken by a teacher. He

- Identifies the content to be taught and determines the criteria for mastery. Assignment of students to groups.
- Arranges the classroom in a way that will facilitate group interaction. The grouping must neither be gender biased nor ethnic/race biased.
- Presents the initial material as appropriate, using whatever techniques she or he chooses.
- Monitors student's interaction in the groups, and provides assistance and clarification as needed. The teacher reviews group skills and facilitates problem-solving when necessary.
- Student outcomes are evaluated. Students must individually demonstrate mastery of important skills or concepts of the learning. Evaluation is based on observations of student performance or oral responses to questions; paper and pencil need not be used.
- Groups are rewarded for success. Verbal praise by the teacher or recognition in the class newsletter or on the bulletin board can be used to reward high-achieving groups.

Equally worthy of note is the need to take into consideration as well as improve upon the weaknesses of the strategy. This becomes necessary for the reason that a jigsaw is dependent on a teacher explaining how to properly implement the approach. Therefore, the teachers of the experimental groups would be encouraged to develop a culture of group work among their learners which includes low levels of noise allowed in the group, and willingness to help each other. If there is no such culture, the likelihood of success is limited. In addition, such teachers (in experimental schools) would be mandated to organize groups in a way that students would be mixed as heterogeneously as possible according to gender, academic abilities and race. Similarly, in order to avoid dominance in the groups by the more talkative students, the teachers in the experimental schools should select a leader in each group in a fair manner so as to keep the discussion moving on well. The teachers can as well move around the classroom to monitor the students‟ discussions.

2.2.9 Academic Commitment of Students

A secondary school in the words of Merriam-Webster, (2022) is an intermediate school between college and elementary schools. Such schools offer core, technical, vocational, or college preparatory courses. A student who attends such school is referred to as a secondary school student, and one of his/her major tasks is learning task. This is to say that a lot of tasks such as task to study, to do religious activities, to take a rest etc beckon for students' attention. In view of this, students need to cultivate the habit of managing their time very well by prioritizing the tasks before them. It has however been established that no matter the time chosen to do a task, it will not have effect if the students themselves do not have commitment to do the task, (Fitriani, 2017).

Learning like every other task is a complex and demanding task that calls for enormous dedication otherwise known as commitment. The term commitment is often used to imply a task or relationship that requires a significant amount of time and effort to maintain. Corroborating this, Cox, (2018) simply described it as somebody's attitude towards a cause or an activity, while the Oxford Living Dictionary, (2018) defined it as a state or quality of being dedicated to a cause or activity. Commitment is thus perceived as a feeling of being very interested in a cause or something and/or being excited by it. Perhaps, this explains why it is defined by Gomez, (2020) as an allotted amount of dedication, attention, and focus toward a specific domain that evokes psychological and behavioral changes. Commitment thus, obligates one to do something.

Toeing the same line, Abdul Salam, (2009) sees it as the relative strength of an individual's identification with and involvement in a particular task or organization. Commitment is therefore truly, the spirit and giving of one's time and energy completely to finish a task which in this case is students' learning of physics. Taking cue from these definitions, one is poised to see commitment to physics learning as a state or quality in which learners are willing, and desire to devote more time, energy, work, interest, affection and values to the study of physics. This assertion agrees with that of Ibrahim and

Jamil, (2012) that students' commitment towards learning is often related to their attitude, including affect, belief and behavioral intention towards learning. An individual who is committed to a cause/something always abide by the rules, regulations and requirements governing the thing for the purpose of achieving the anticipated goals. By extension, a student who is academically committed will be very dedicated to his/her studies or academic works. In sum, academic commitment could be abstracted as a psychological measure of the extent to which a student aspires to learn, attends school regularly and promptly; how promptly he does and submits his assignments for assessment; and/or the extent to which he abides by the school's rules and regulations concerning his academics. Perhaps, this explains why Ogunleye and Babajide, (2011), submitted that commitment to science is not merely defined in terms of students' desire to major in science courses but defined in terms of students' desire to take more courses in science, to continue reading about science, to explore new scientific topics and to be involved in science - related social issues. It is a life-long learning urge associated with science in the broadest sense.

In the context of the above submissions, it won't be out of place to describe commitment as being central to the success of academic issues and any endeavor in life. An opinion to which Awang, (2013) and Godson and Ngussa, (2020) subscribed. These authors further averred that commitment to learning focuses on the behavior of students in the whole process of learning simply because it includes ability to think critically and solve complex problems, work collaboratively, communicate effectively and pursue self-directed learning or metacognition. Commitment to learning can as well be conceptualized in terms of the percentage of effort and time that an individual devotes to his or her educational purposeful activities. Strydom, Mentz and Kuh, (2010) agreed with this description while Human-Vogel, (2015) argues that time and effort invested into studies is merely an indication of the extent to which the student is actively involved in his studies and as such can be more accurately described as engagement. This according to her is regarded as a consequence of academic commitment and not academic commitment itself. Tinto (1975) however provided a soft landing by submitting that commitment and engagement are interconnected. He is of the belief that a student's strong initial commitment will result in increased engagement within the academic context.

Alternatively, the more students engage academically and socially, the more they would be committed to their own academic success.

Adhering to the view of Celep, (2000), who classified teachers' commitment into four domains of:

i. commitment to school,

ii. commitment to teaching work,

iii. commitment to work group, and

iv. commitment to teaching occupation,

one is left with no choice than viewing students' academic commitment from the angles of their commitment to school, to their learning, to group work and to higher academic achievement. Students' commitment to school is used here to refer to their belief, acceptance and readiness to identify with the goals and values of the school as well as their desire to keep up attending the school, while their commitment to learning is manifested in their attitudes towards learning. The extent or the desire of the students to study in collaboration with peers in school is ascribed to commitment to group work.

Fitriani, (2017) in his further submission limited the definition of task commitment to five dimensions as follows:

- tough, diligent, and not easy to get bored,
- independent,
- deciding realistic aspiration goal,
- love to learn and want to improve themselves
- strong desire to get success in academic field.

These in short, are the attributes expected of a student who is strongly committed to his learning. As the case may be Brown (2018) identified the following as some of the qualities of committed people:

- They make commitments and stick to their commitment because they said they would. Words like maybe, should or can't are absent in their vocabulary.
- They believe strongly they can fulfill their commitments. Not fulfilling their goals is not at all part of their equation.
- They invest money, energy and time into their commitments

- They are realistic about their commitments. That is, they explore different avenues not minding the different setbacks encountered along the way.
- They have passion about their commitment.

Students have always thought of physics as the toughest among sciences possibly because of its abstract and mathematical nature. This is enough a proof that there is need to drive up students' commitment to physics in secondary schools. Studies such as Felfe, Schyns and Tymon, (2014) revealed that students' commitment to a subject is positively related to performance just as Korpershoek, (2016) submitted that commitment is an essential component of learning. It should however be noted that teacher's instructional strategies and students' level of commitment could be interconnected. According to Ogunleye and Babajide (2011), learners who are more committed (in terms of their time, effort and energy) to given scientific tasks and related socio-scientific issues tend to achieve more academically and have their practical skills improved. However, this can only be possible is science lessons are full of learners' activities and fun that would make them to be more committed or dedicated to the lessons.

Physics teaching in Nigerian Secondary Schools is fraught with many challenges one of which is the continuous use of teacher-centred "çhalk and talk" method thereby reducing the students to mere robots. As the name goes, the method does not encourage students' dedication and engagement in physics activities. Interactive learning demonstrations and guided reverse jigsaw learning strategies contains more than speaking and reading about science. They are activity-based and condone interactions between the teacher and the students on one hand and among the students on the other hand. Consequently, meaningful commitment is predicted by exposure to science which implies that the quality of exposure is critical in attracting students' affective commitment to physics.

Academic commitment being an underlying principle of learning becomes a form of responsibility through self-consciousness of each student. It does not only reinforce the will to take responsibility, it is also a tonic that sparks creativity in problem solving situations. That is why it is central to each course in the school curriculum. It must however be noted that commitment to learning does not occur naturally in all young people. Its occurrence in young man calls for a combination of values and skills, and these are strongly influenced by the school environment and relationships with friends and family members. Five of these values and skills otherwise referred to as elements were identified by Sheltering Wings, (2022). They include achievement motivation, school engagement, homework, bonding to school and reading for pleasure.

Achievement Motivation: The greatest incentive for young people to do their best in schools aside getting good grades, pleasing one's parents or earning a place of honor is their personal pride of knowing that they are giving their best regarding learning, which is an intrinsic form of satisfaction otherwise known as motivation. By implication, scoring distinctions all through may not be the only reason to say one has done well academically, as their efforts of putting in their best can as well give them more reason to be proud later. This might not be unconnected with the fact that when people try to do their best in school, they do come out with better grades, they are more likely to complete their secondary school education and know how to handle stress later. This is in agreement with the findings of Fitriani, (2017) who showed that motivation to get achievement and student commitment to doing lecture task (task commitment) had significant relation.

To get students academically motivated, teacher and parents should strive to find out from them, what motivates them to excel in school, their challenges and discuss ways to address the issues focusing on their interest instead of their grades.

School Engagement: Kuh (2009) described student or school engagement as the amount of time and effort students dedicates to educational undertakings that are empirically linked to desired outcomes and what institutions do to induce students to participate in these activities. A look at this definition implies that school engagement appears to encompass students' commitments in learning, their identification and belonging at their educational institution, as well as, describing their participation.

For students who actively take part in learning, there is tendency that they will exhibit more positive behavior while others who are not actively participating, the reverse is the case. Such students might be having other individual goals and interest. It is therefore the duty of parents and teachers to pay attention to them, identify these goals and interest, and thereafter, link the said goals/interests with things they learn in and out of school or search for additional learning activities that complement the school curriculum in order to keep them engaged.

Homework: Any goal worth achieving like learning demands a lot of hard work which can take place anywhere, in the classroom or at home. Young students might not know this, resulting in some of them loving classes but jettisoning homework and tests. Unknown to them, apart from assisting young ones to achieve their learning, homework also enables them to organize their time and work independently. This seems to be in agreement with the view of Tingley, (2022) that kids who do homework are more committed to doing well in school while Harris Cooper in Tingley, (2022), recommends students should receive 10 minutes of homework per day in first grade, and 10 additional minutes each subsequent year, so that by twelfth grade they are completing 120 minutes of homework daily.

To change students' poor attitude to homework, young students must be taught the rudiments of homework like organization, planning one's time and study skills. With this they become better for it in terms of being more creative in their study strategies.

Bonding to School: The point here is that some youth might feel disinterested and do not feel connected to school hence, they stay away of school while others stay continue with their study and perform very well. Going to school or not is a function of experience. Those who go to school regularly might be having friends and family who are proud of what they do at school. These young people are encouraged, challenged, have fun and enjoy learning at school. The opposite is the case for those who do not like going to school. It won't therefore be out of place suggesting that schools should be improved to make it a place that cares about young people.

Reading for Pleasure: Young people who read for fun learn of the variation concerning reading for an examination and reading for pleasure. They learn when to read very carefully, ask questions, or consult a dictionary (for a test) and when they can simply enjoy a book. Reading — whether we have to or we want to — can open up a whole new world for all of us, transporting us to very distant places, times past or lives of which we have only dreamed. Reading is important. If we inspire young people to read for pleasure, they will have a much richer life. Corroborating this, Fuglei and Resilient Educator, (2022) submitted that reading for pleasure helps students develop academically and supports their commitment to reading as well as learning.

2.2.10 Gender in Physics Education

Gender as a factor has been of great concern to educators. It is one of such factors frequently mentioned in literatures to have substantial effects on students' academic performance especially in science subjects. Gender is a term that is mostly used mutually and reciprocally with sex but this is far from being correct as they are different from each other. While sex is concerned with only the distinction between male and female based on biological characteristics, gender encompasses other personality attributes as roles, orientation and identity based on individual's conceptualization of self. A person has his/her sex assigned based on his/her physiological characteristics like his/her chromosomes' composition. But gender on the other hand connotes social and cultural functioning and responsibility of male and female (Adejoh, 2015). This establishes why Hopkins, (2018) defined gender as a sociocultural expression of particular characteristics and roles that are associated with certain groups of people with reference to their sexes and sexuality. While validating this definition, the world Health Organisation (WHO, 2018) described it as socially constructed characteristics of men and women such as norms, roles and relationship of and between groups of men and women, (WHO, 2018). Such roles and expectations as determined and assigned each sex are learned by individuals and can change over time. They can as well vary within and between societies. An individual in any society who does not fit the established norms is bound to face stigma, discrimination, persecution or social exclusion.

Examining the relationships between gender and academic performance becomes primarily necessary in view of the observed wide gap in the mean academic performance in respect of gender as noted in studies such as Nwona and Akogun, (2015) in his study on science, technology and mathematics. Similar observation had earlier been noted by Machin and Mcnally, (2006) in their study on gender and students' achievement in English schools. The study further noted that the gap appears more controversial for students taking national examinations at the end of their compulsory secondary education.

Regarding these discrepancies in the performance of boys and girls, it was noted by Megary in Nwiigi, (2014) that immediately the students complete their primary school education, females tend to underachieve in a variety of subjects. This was corroborated by a research work carried out by Raimi and Adeoye, (2002) on secondary school science where they discovered that boys significantly outperformed the girls. He thereafter came up with an assertion that there exist some things in learning process that cause this differential achievement between boys and girls. Unlike other scholars, Arigbabu and Mji (2004) reported no distinguishing difference in cognitive, affective and psychomotor skills achievement of students in respect of gender. This conflicting reports about the effect of gender on students' performance is an indication that the study is inconclusive

Another reason for investigating the influence of gender on students' academic performance and their attitude to learning is because of the socio-cultural differences between boys and girls, and between men and women. For instance, in most societies, some vocations and professions namely arts and crafts, engineering, agriculture etc. have been designated as men's while others for example, catering, typing, nursing etc are for women. As it may be, this explains why tasks like car washing, grass cutting, bulbs fixing, climbing ladders to fix or remove things etc are assigned to boys while chores like dishes washing, cooking, cleaning and so on are assigned to the girls. In short, boys are the ones taking up the jobs which are perceived as complex and difficult while girls are considered weaker vessels and so, they are to handle the relatively easy and less demanding tasks. As a result of this way of thinking the larger society tends to see girls as lesser a man. In effect, an average Nigerian girl goes to school with these mindsets. This in the words of Joel and Aride, in Nnamani and Oyibe, (2016) has created a big psychological alienation or depression in the minds of the female students. As a result, boys dominate social studies, chemistry, physics, mathematics and environmental studies classes while the girls go into reading biology, languages and arts. The same alienation is observed in the larger society in Nigeria and many African societies as witnessed in most elective positions contestable by man and woman. People always see women as not fit to govern or rule since men are involved. By extension, women must be submissive to men; the action which has automatically put the girls in a disadvantaged position for achievement in classroom interaction especially in physics and other sciences.

In another investigation conducted by Fabunmi in the year 2004 on the extent to which gender influenced students' achievement in Nigerian secondary schools, gender was found to be one of the factors that influence differences in the academic performance of students. Nevertheless, the focus of his study is general, the current study will be subject specific, which turns out to be one of the gaps the current study intends to fill.

2.2.11 Optics as a Concept in Physics

Optics according to the National Academy of Science (2022) is a field of science and engineering that encompasses the physical phenomena and technologies associated with the generation, transmission, manipulation, detection and utilization of light. The definition appears to be in line as well as more encompassing than that of McGraw-Hill, (1993) which sees it as a branch of physics that is concerned with the behavior and properties of light including its interactions with matters as well as the construction of instruments that use or detect it. The significance of optical science cannot be undermined considering how relevant it is to many related disciplines amongst which are astronomy, photography, various engineering fields, medicine especially the physiological aspects which are mainly optometry and ophthalmology. Aside this, its practical applications abound in various technologies and everyday objects such as mirrors, lenses, telescopes, microscopes, lasers and fibre optics. The concept is contained in all physics curricula across the globe including the one curriculum being used in Nigeria, which is tailored towards the undergraduate program of physics and engineering at the tertiary education level. The topic in most cases is divided into different categories in such a way that the knowledge of the prior category is a prerequisite to understand the next division. This is however done without being unmindful of the National Curriculum as well as the syllabus of the internationally recognized and accredited examination body, the West African Examinations Council (WAEC) and that of the National Examinations Council (NECO). The contents therein were carefully selected to provide an introduction to, and an overview of, physics. It is expected of students to develop an appreciation of the fundamental laws and principles, and their application to everyday life after they might have been exposed to the details of the content.

The content selected for this study i. e. optics is meant to be taken at the SS 2 class and precisely in the third term of the session. For easy comprehension by students, it is split into

(a) Sources of light (Natural and artificial. Luminous and non-luminous bodies) including the nature of light; the properties of light; the transmission of light; the rays and beams of light.

(b) Rectilinear propagation of light

(c) Reflection of light at plane surface: plane mirror

(d) Reflection of light at curved surfaces: concave and convex mirrors

(e) Refraction of light at plane surfaces: rectangular glass prism (block) and triangular prism.

(f) Refraction of light at curved surfaces: Converging and diverging lenses

(g) Application of lenses in optical instruments.

(h) Dispersion of white light by a triangular glass prism.

(g) Formation of Shadows and eclipse. Pinhole camera. Simple numerical problems may be set.

(h) Regular and irregular reflections; Verification of laws of reflection; Formation of images; Inclined plane mirrors; Rotation of mirrors; Applications in periscope, sextant and kaleidoscope.

(i) Laws of reflection; Formation of images; Characteristics of images; Use of mirror formulae: $\mathbf{1/f = 1/u + 1/v}$; and magnification $\mathbf{m = V/U}$ to solve numerical problems. (Derivation of formulae is not required)

(j) Experimental determination of the focal length of concave mirror; Applications in searchlight, parabolic and driving mirrors, car headlamps etc.

(k) Laws of refraction. Formation of images, real and apparent depths; Critical angle and total internal reflection; Lateral displacement and angle of deviation; Use of minimum deviation equation:

$$\frac{\mathbf{Sin\ (A + Dm)}}{\mathbf{Sin\ A/2}} \mathbf{= n}$$

(Derivation of the formula is not required) Applications: periscope, prism binoculars, optical fibres; the mirage.

(l) Formation of images. Use of lens formulae + = and magnification to solve numerical Problems (derivation of the formulae not required); Experimental determination of the focal length of converging lens; Power of lens in dioptres (D)

(m) Simple camera, the human eye, film projector, simple and compound microscopes, terrestrial and astronomical telescopes. Angular magnification. Prism binoculars. The structure and function of the camera and the human eye should be compared; Defects of the human eye and their corrections.

(n) Production of pure spectrum of a white light; Recombination of the components of the spectrum. Colours of objects. Mixing coloured lights (Spidalworks, 2022)

The table below is an illustration of the scheme of work for SS 2 physics in the third term of the session in a typical secondary school in Nigeria.

Table 2.4: Scheme of Work for Physics SS 2 Third Term

Weeks	Contents
1	The Concept of light, The Nature of Light, The Sources of Light, The Properties of Light, The transmission of Light, The Rays and Beams of Light, The Rectilinear Propagation of Light, Shadows, The Eclipse
2	Reflection of light at plane surfaces. Laws of reflection and application of reflection at plane surfaces e. g. formation of images by plane mirrors, simple periscope, sextant, etc.
3	Reflection of light by curved mirrors. Formation of images by curved mirrors. Applications. Simple problems on curved mirrors.
4	Refraction of light through rectangular glass block; Laws of refraction; real and apparent depth; critical angle and total internal reflection.
5	Refraction of light through a triangular glass prism; Angle of deviation; Dispersion of white light and production of pure spectrum; Recombination of the components of a spectrum.
6	Refraction of light through converging and diverging lenses. Formation of images by converging and diverging lenses; Simple problems on lenses; Application of lenses; Compound microscopes, telescopes, simple camera and film projector.
7	The Human eye; Comparison of the eye and the camera; defects of vision and correction of defects

On the benefits of studying optics to students, society and the scientific professionals, Crownson (2022) submitted that a basic understanding of light can give students knowledge on how they perceive the world around them as well as knowledge about the instruments they use to enhance this (microscope, telescope, ...). The same topic gives the society the ability to observe the world. The study of optics has led scientists to produce ground breaking inventions like the lasers and the holograph. Nowadays, the most dramatic use of optics today is lasers. With lasers, some cancer can be treated. The study further submitted that the professional scientists require knowledge of optics as nearly all instruments require sight and thus optics. Any scientist doing experiments uses these instruments. To use and read them correctly, scientists need the knowledge of optics. Scientists need to learn how to manipulate errors that occur from parallax or aberrations from lenses. From optics, all scientists can achieve higher accuracy from experimentation.

2.1 **Empirical Review**

The section focuses on a review of earlier scholars' empirical studies on this topic or similar ones that are relevant to this research work.

2.3.1 Academic Achievement of Students in Physics

The foremost responsibility of every teacher is to educate his/her students towards mastery of a set of standards and objectives that has been outlined by the ministry of education. The extent to which each student is able to meet or exceed the required minimum content standards is term achievement. Achievement is not only a key feature in education but also the center around which the whole education process spins. Aligning with this position, Farooq et al. in Abaidoo, (2018) emphasized that the top most priority of all educators is academic performance of students. This might be because of its recognition as the most important indicators of the effectiveness of teaching. It is of eminent concern to education stakeholders as it remains the most debatable concepts in educational institutions at all levels due to the disturbing examination performance of students.

Academic achievement is used to describe the learning outcomes that indicate the extent to which a student or a school has achieved either their long- or short-term learning or educational goals in any interactive process involving a teacher and a student(s). This is to say that it is expected of any interactive activity to produce an attitudinal change as well as a change in the academic achievements of students. In line with the above definition, Mimrot, (2016) describes it as the performance outcomes that indicate the extent to which a person has accomplished specific goals which were the focus of activities in instructional environments like school, college, or university. Meanwhile, academic achievement has been described as multidimensional in nature. Agreeing to this, Pickard in Ludigo Mugimu and Mugagga, (2019) listed the different dimensions of academic achievement to include factual, conceptual, procedural and meta-cognitive achievement. While the terminologies, specific details, facts and basic elements that experts use when communicating about their discipline, understanding it, and organizing it systematically are termed factual knowledge, conceptual knowledge refers to students' ability to explain the concepts in their own words and transfer information to new situations. Procedural knowledge on the other hand connotes the mastery of the criteria of when to use various procedures and reflects knowledge of different process, while Meta-cognitive knowledge refers to awareness of the learning process by the learner and the ability to adapt to challenges that occur during this process through effective strategies (Güner and Erbay, 2021).

As simple as the term might seem, its impact in any nation cannot be underestimated. For instance, at the basic level, students' academic achievement determines the success or failure of any academic institution, (Narad and Abdullah, 2016). Their study further reiterated the general belief that good academic performance signals better career prospects and thus a secure future. This is to say that the impact of academic achievement can also be felt in all areas including places of work after graduation, this is because academic achievement is associated with a combination of cognitive skills (technical knowledge, expertise and abilities), and personal or behavioural characteristics (principles, attitudes, values and motives), which are a function of an individual's personality. It is therefore not an overstatement that academic achievement is a determinant of successful work performance and by extension, a factor upon which the economic as well as the social development of any country depends.

The term in the words of York, Gibson and Rankin, (2015) has been applied with increasing frequency as a catchall phrase encompassing numerous student outcomes. Corroborating this position, Kumar, Agarwal and Agarwal, (2021) averred that academic performance/achievement is amorphous in nature as it could be viewed from different perspectives such as in terms of gaining knowledge; acquiring skills and competencies; securing high grades and similar academic achievements; securing a progressive career; and intention and persistence towards education. Of all the dimensions, studies such as York et al., (2015) accorded the highest magnitude of significance to the version that has to do with securing high grades and similar academic achievement. This explains why the term is being used interchangeably with academic success or academic performance. Below is a figure highlighting the various genres of the definitions of academic performance.

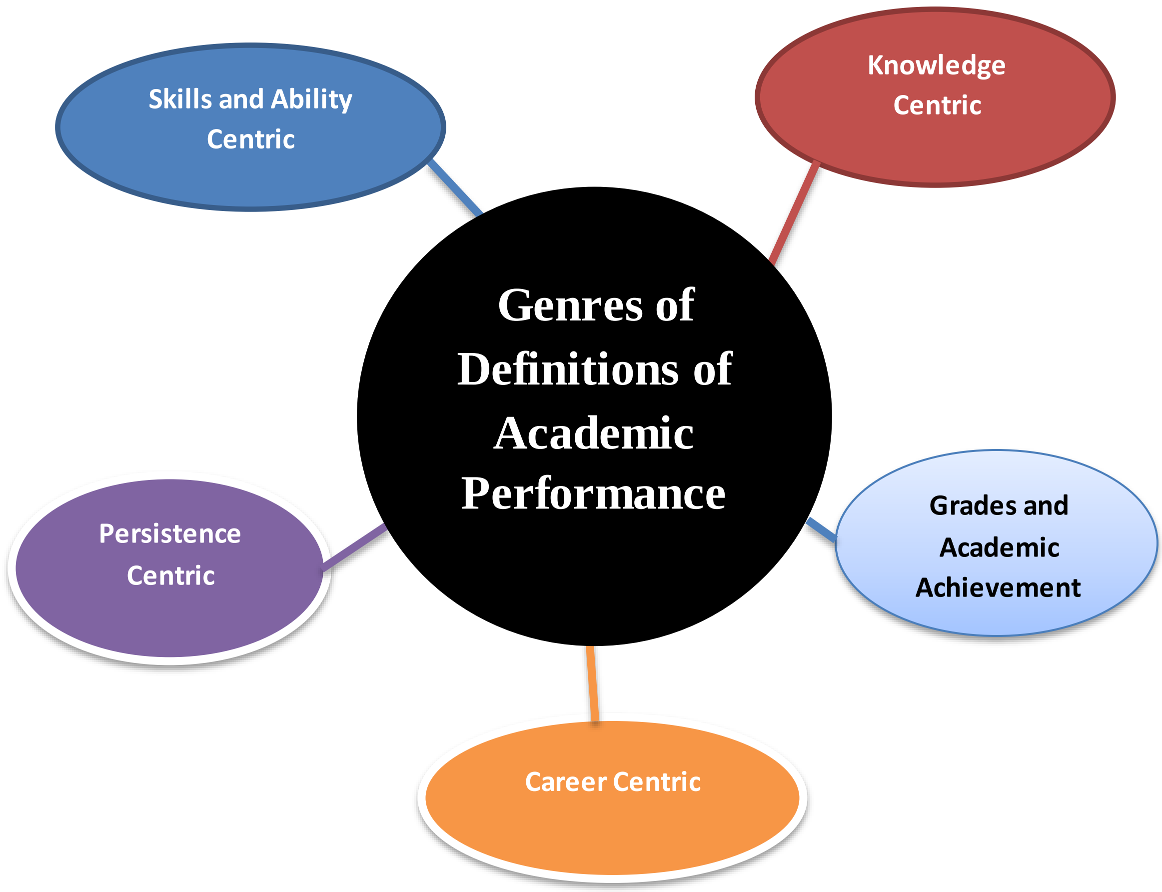


Fig 2.5: Genres of Definitions Regarding Academic Performance

(Source: Kumar et al., 2021)

Singh, Malik and Singh, (2016) categorized the factors that can determine achievement of students into five. These include psychological, economic and social factors. Others are personal and environmental factors. Personal factors refer to the particular background of an individual's life and living, such as the features of the individual that are not part of a health condition or health states, and which can impact functioning positively or negatively. Examples include gender, age, personality, learning styles, learning ability, prior experience, study habits among others. Psychological factors according to Budianto, (2011) are factors that are mentally or spiritually concerned with the aspects in students' acquisition. These include elements of one's personality that limit or enhance the ways he/she thinks. Examples of such factors are mental set-up, thinking pattern, thought process and psychological attitude. Environmental factors as used here make up the physical, social and attitudinal environment in which people live and conduct their lives. Environment at home and in the institution is a good example of environmental factors affecting students' performance. While the economic background of the students and parents fall under the economic factors, interactions between students and teachers on one hand and between students and peer groups make up the social factors. A summary of factors influencing students' academic performance is as compiled in the Figure below.

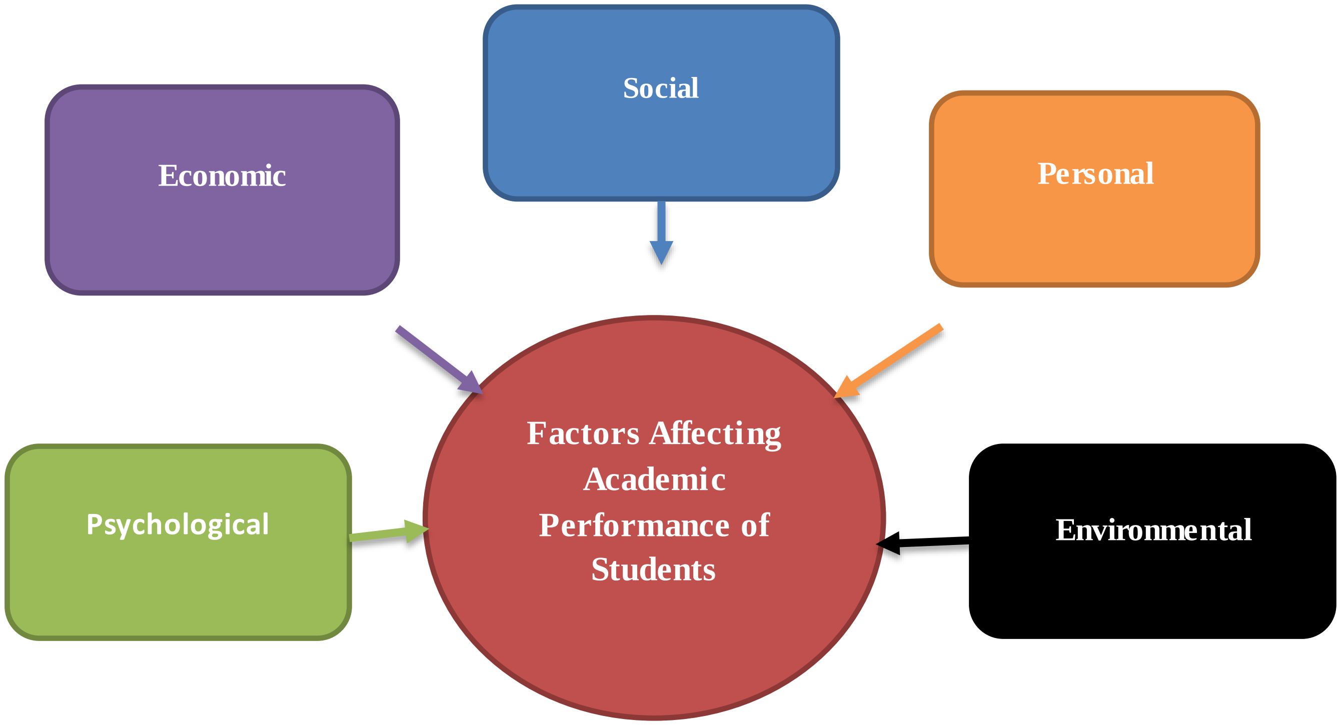


Fig. 2.6: Factors Affecting Academic Performance of Students

(Source: Kumar et al, 2021)

In view of the amorphous nature of academic achievement, there has been no agreement on how academic achievement is best measured, neither has there been any agreement on which aspects of it are more important than the others. However, the most common way of quantifying it is in terms of assessment grades which could be obtained through examinations or continuous assessments results. However, at higher institutions level, a new dimension to it is through the use of Grade Point Average (GPA) at the end of a semester. A student's grade point average is calculated by adding up all accumulated final grades and dividing that figure by the number of grades awarded. In some other cases, students' academic achievement is assessed with the use of students' previous year results. At whatever level, grades are assigned as letters, as a range, as a percentage, or as a number out of a possible total. For this study, the grading system adopted by the foremost credible examination body in Nigeria, the WAEC would be the point of reference. The grading system is as stated below: A1–Excellent; B2–Very good; B3–Good; C4–C6– Credit; D7 – D8 – Pass and F9 – Fail.

In Nigeria, the National Examinations Council (NECO) and the West African Examinations Council (WAEC) are the two bodies saddled with the responsibility of conducting the final examinations. While WAEC has its tentacles spread to other West African nations of Ghana, Sierra Leone, Gambia and Liberia, NECO is charged with the conduct of examinations in Nigeria and has its headquarters at Minna, Niger State. WAEC as a body was established in 1952 with a vision to be the world class examining body. It has as its duties the determination of the examinations required in the public interest in the English-speaking West African countries, conduct of Senior School Certificate Examinations (SSCE) as well as the awarding of internationally credible and acceptable certificates (WAEC, 2020). In its seventy years of existence, the council according to Ogunleye, (2011) has substantially accomplished its mission part of which includes administration of standard examinations that are relevant to the educational aspirations of member countries including; promotion of ideals of hard work through awards for outstanding performances and reprimand for cases of examination malpractices. The body organizes two examinations in a year viz-a-viz West May/June WASSCE for school candidates and November/December examinations for private candidates in Nigeria.

In addition, the certificates awarded by WAEC enjoy international recognition. The body has also been promoting the ideals of hard work and honesty in the youth through its awards for outstanding performance in its examinations and pronouncement of sanctions on cases of examinations malpractices. The Council conducts several international and national examinations in all member countries except Nigeria where it has shed all but one of its examinations. The West African Senior School Certificate Examination (WASSCE) for school candidates in May/June and private candidates in November/December every year. The grading system used by the body is as stated below: A1 – Excellent; B2 – Very good; B3 – Good; C4 – C6 – Credit; D7 – D8 – Pass and F9 – Fail.

Meanwhile, as earlier submitted in the introduction part of this study, physics is a prerequisite for admission into several courses amongst which are engineering, medicine, pharmacy, technology etc. such that without a credit in the subject, candidates who wished to pursue the above listed courses would not be able to do so. This explains why in most cases, A1 to C6 are taken as passes while D7 to F9 are regarded as failure. This is in line with the admission requirements into institutions of higher learning in the country requesting for a minimum of five credit pass in relevant subjects for any discipline.

The performance of students in WASSCE, NECO and JAMB has been of concern to all stakeholders in education such that one begins to wonder whether students and teachers of physics are recording any achievement or not. This is in view of the submissions from studies such as Adolphus and Aderonmu, (2013) that the current trend of academic achievement of physics students at the post-primary school level is unfortunate. This is further exemplified in the Table below.

Table 2.5: Students' Physics Performance in WASSCE (2007 - 2019) with Percentage of D7-F9

Year	Candidates that sat for the Exam	A1–C6	% of A1-C6	D7–E8	% of D7–E8	F9	% of F9	% of D7 -F9
2007	418,593	180,797	43.19	140,172	33.49	97,624	23.32	56.81
2008	415,113	200,345	48.26	91,116	21.95	123,652	29.79	51.74
2009	465,636	222,722	47.83	149,595	32.13	93,319	20.04	52.17
2010	463,755	192,180	41.44	125,770	27.12	141.805	30.57	57.69
2011	563,161	247,171	43.89	143,009	25.39	172,981	30.71	56.10
2012	624,658	279,472	44.74	182,837	29.27	151,167	24.20	53.47
2013	637,037	297,189	46.65	175,987	27.63	163,861	25.72	53.35
2014	639,311	273,689	42.81	161,937	25.33	195,246	30.54	55.87
2015	658,442	298,867	45.39	213,467	32.42	146,101	22.19	54.61
2016	658,393	319,188	48.48	212,792	32.32	125,094	18.99	51.31
2017	704,504	307,586	43.66	208,462	29.59	188,173	26.70	56.29
2018	727,733	570,542	78.40	101,518	13.95	55,673	7.65	21.60
2019	742,394	571,272	76.95	109,058	14.69	62,064	8.35	23.04

Source: *Research and Statistics unit WAEC Yaba, Lagos, Nigeria*

Table 2.5 shows that a total of 418, 593 students took the examination in 2007 and this kept wavering across the years but reaching the climax in the year 2019 with a total of 742,394 candidates sitting for the examinations. For instance, the figure dropped from 418,593 in the year 2007 to 415,113 in the year 2008 by a difference of 3,480 candidates. This later rose to 465,636 in the year 2009. The enrolment figure later became 463,755 in 2010. This is a revelation of a slight decrease of 1,881 in the number of candidates that sat for the examinations. The fluctuation in students' enrolment across the years is represented in the Figure below.

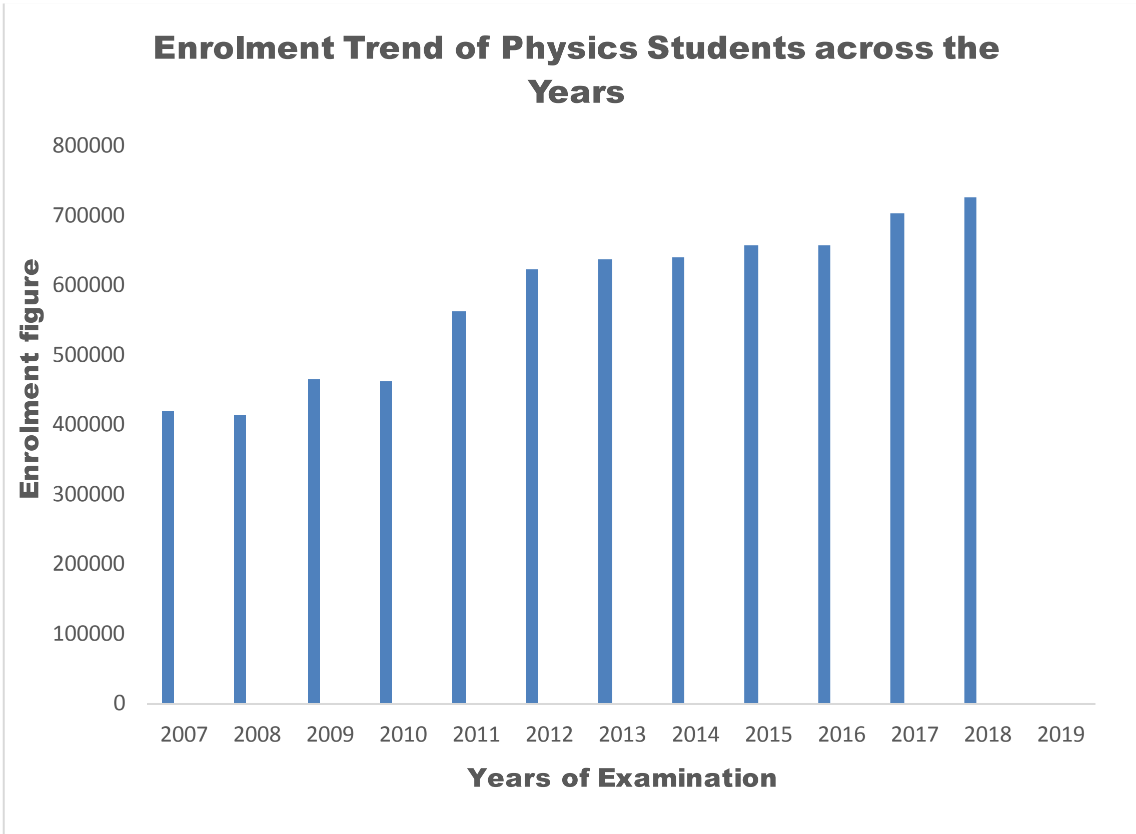
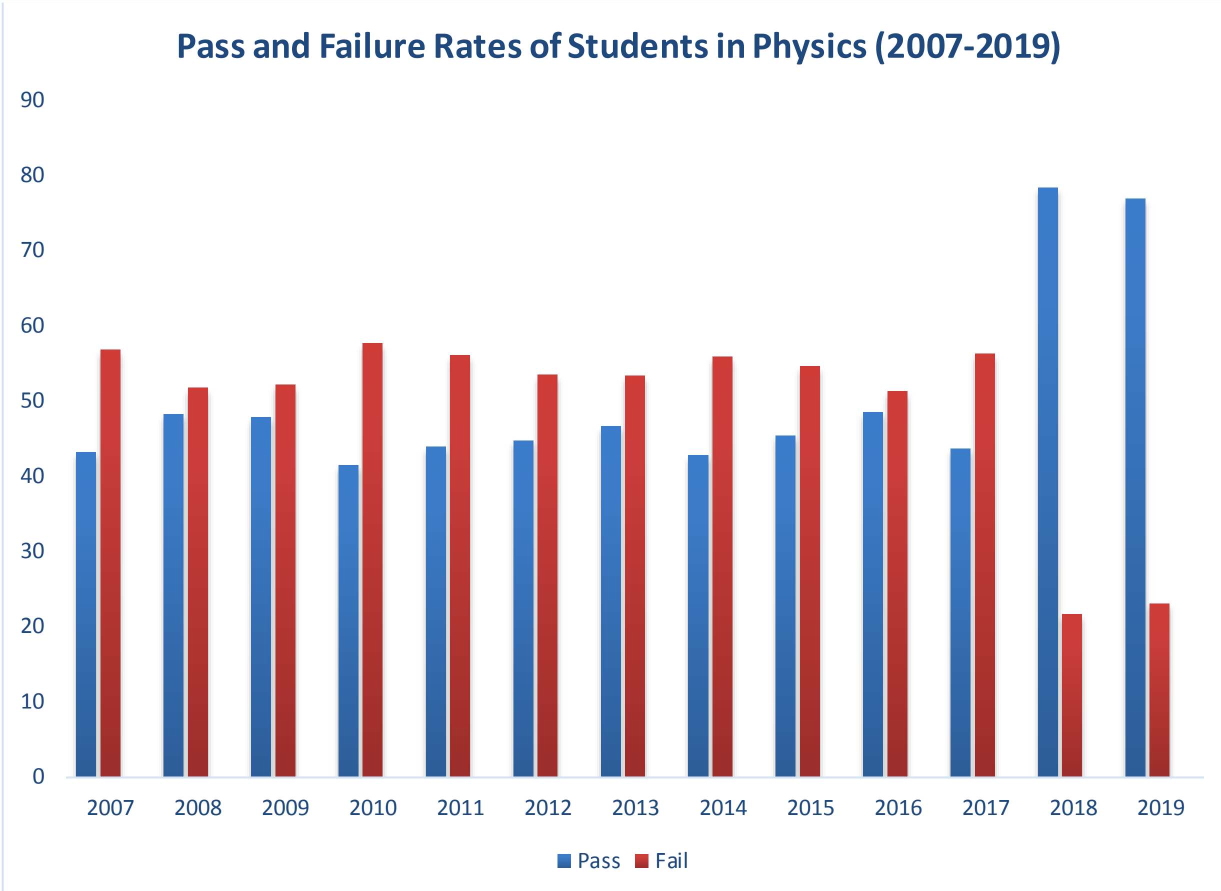


Fig. 2.7: Bar Chart of Students' Enrolment for WASSCE from 2007 - 2019

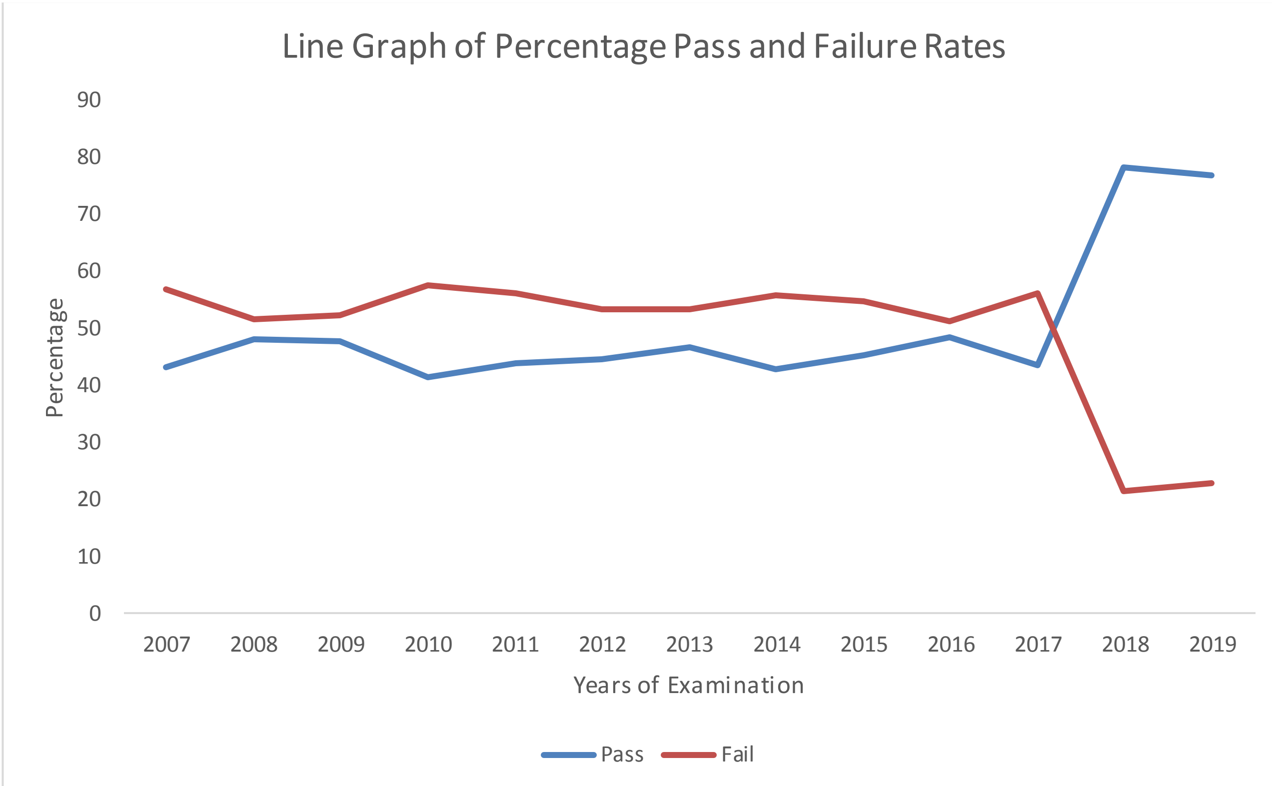
Talking about the students' academic achievement in physics across the years, it started with an ascending trend in the number of students with grades 1-6 from 43.19% in 2007 rising to 48.26% in 2008. There was a downward change in the trend from 48.26% in 2008 through 41.44% in 2010. The trend changes from 2010 with fluctuation of the figures along 2011, 2012, 2013 to 2017 after which it started to rise again to 78.40% in 2018 and 76.95% in 2019. The highest was in 2018 with 78.40% pass. The data are represented in Figure 2.8 below.



Red line (Series 1): Percentage Pass

Orange line (Series 2): Percentage Fail

Fig. 2.8: Bar-Chart of Students Pass and Failure Rates in Physics 2007 - 2019



Brown line: Percentage Pass

Orange line: Percentage Failure

Fig. 2.9: Line Graph of Pass and Failure Rates in Physics from 2007 - 2019

It is obvious from the Fig. 2.9 that for all the years under consideration except 2018 and 2019, the percentage of students who failed surpassed those who passed. It is also noteworthy that over 50% of the students failed across the years except 2018 and 2019 when it was 21.60% and 23.04%

The fluctuations in the enrolment figures as well as pass and failure rates are pointing to the fact that the enrolment as well as the pass rate cannot be sustained across the years. This is a trend that was once echoed by Ogunleye, (2011). This is in disagreement with the Nigeria National policy which recommended 60:40 % admission ratios into tertiary institutions in favor of sciences.

2.3.2 Studies on Students' Attitude to Physics

Nowadays, many students can neither give evidence of more than superficial understanding of concepts and relationship they have studied in a subject in the school nor give evidence of an ability to apply what they have gained or acquired while studying the contents into real-life situations. This is unfortunate and it's attributable to many factors, amongst which are school, classroom, students and teachers' factors. All of these impinge on the learning of physics which eventually culminated in the age- long reputation of physics as the most problematic area within the realm of science. With this, students find it difficult to be favorably disposed to the learning of physics. It is this, their disposition or feelings (be it favorable or unfavorable) about something, a person, an event or a school subject like physics that Craker in Sitotaw and Tadele, (2016) termed attitude. The same term was described by Awolere, (2015) as someone's extent of likes or dislikes for things like a person, a place, a process or an event. It connotes somebody's tendency or predisposition to respond either positively or negatively towards a certain idea, object, person, or situation. Taking cue from the submissions above and borrowing from the opinion of Suarez et al., (2021), students' attitude to physics can be defined as the dispositions, tendencies, or inclinations to respond to all the elements (actions, people, situations, or ideas) involved in learning physics. This definition includes elements such as liking physics classes, preference for physics careers, physics as an institution and specific topics. The dispositions or tendencies referred to in the definition can be operationally assessed through the cognitive, affective, and behavioral components towards a previously delimited attitudinal object. This is more or less referring to students' individual way of looking at physics.

Meanwhile, three structural components of attitude have been identified, (Rana, Farouque and Rahman, 2020). They are the cognitive, affective and behavioral components.

The cognitive component of attitude can be described as somebody's belief and perception about something, an object or subject. In other words, it is somebody's idea about the object which is not different from that person's opinion about the object in question. That's why opinion is often used as a substitute for cognitive component of an attitude.

The affective component of attitude is simply the emotional aspect of attitude which indicates the direction and intensity of an individual's evaluation. Somebody's emotion towards an object such as negative, positive or neutral, or love and hatred are good examples of affective component of attitude i. e. individual's feeling about an object, a subject or another person. The component is considered so strong and always stands on the way of attitude change.

The behavioral component of attitude is simply the predisposition of an individual to react in a way towards the object of attitude. It controls the way an individual acts on the basis of cognitive and affective components of attitude.

It should however be noted that the three components are interconnected such that a change in any one of them will cause a change in the others. The first two are bases for somebody's behavior/attitude. The first cannot be seen but the last one the behavioral component can be seen.

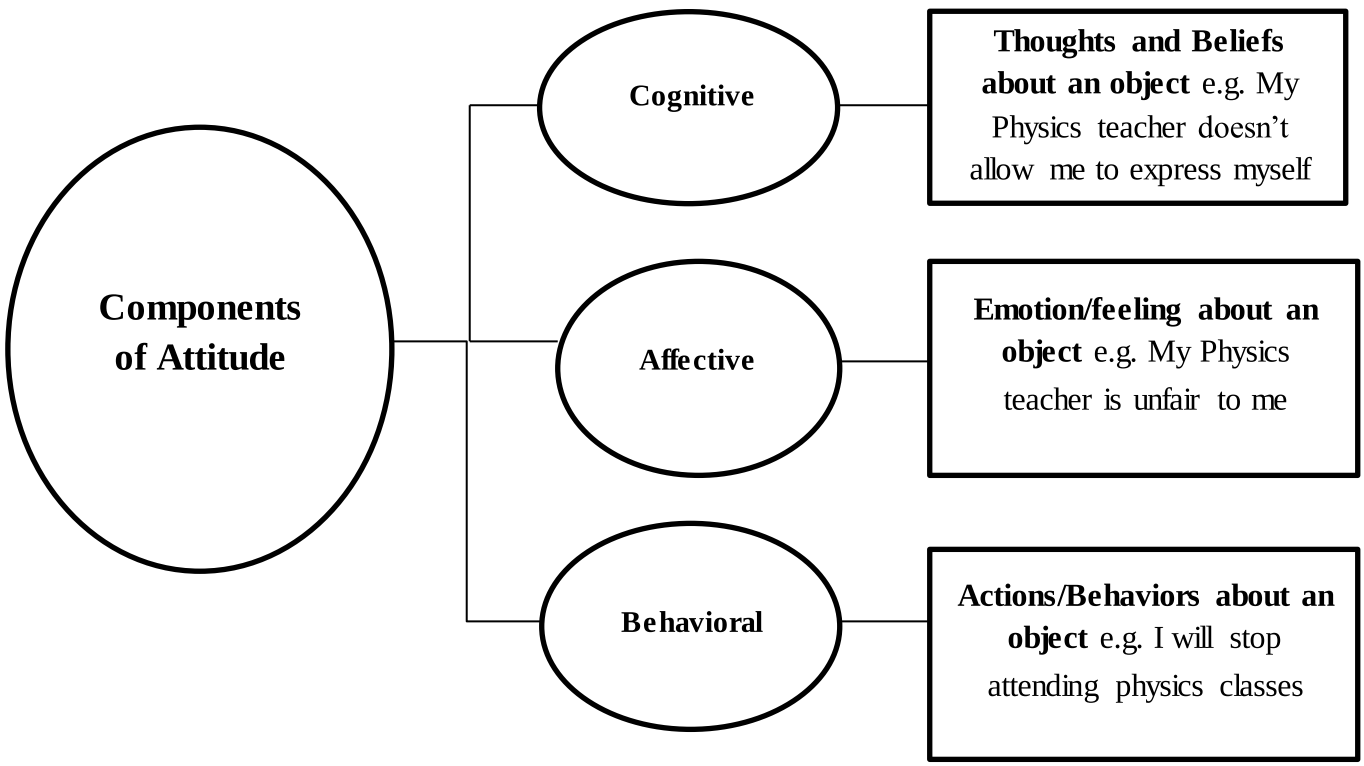


Fig. 2.10: Diagrammatic Representation of Components of Attitude

(Source: Geek tonight, 2022)

Attitude of Students to Learning

Students' attitude towards physics may be incredibly significant bearing in mind that physics, one of the most prevailing subjects in the field of engineering, is the most challenging subject in the realm of science, as in the words of Saleh, (2014) it requires the learners to deal with different types of illustrations, such as formulas, calculations, graphics representations, and also a theoretical understanding at an abstract level. Each of these aspects of physics requires patience, persistence, perseverance and willingness to accept risk. This of course culminates in physics as a subject attracting fewer pupils than chemistry and biology. The long and short of this assertion is that somebody's feelings (or attitude) about something may influence his/her choice of action, and responses to challenges, incentives, and rewards. Thus, there is a close relationship between attitude of a person and his/her behaviors. This explains why Fishbein and Ajzen (1975) in Kapucu, (2017) described attitudes as serious predictors of certain behaviours. On the strength of the discussion above, it can be assumed that there exists a close link between attitude and students' academic performance or achievement. For someone expecting students to work harder in their studies, he/she needs to encourage them to develop positive attitude towards any subject or topic. With this, better academic performance becomes achievable. In other words, attitude can affect students' achievement in the subject just the same way students' performance in the subject can influence it.

Attitude is a concept that deals with the beliefs, interest, perceptions and aspirations, feelings, habits, persistence and self-concept of students in dealing with a subject. It has a very serious implication for the learners and it's crucial to the learners' attainment of good performance in any endeavor. This is because according to Miller in Erdimer, (2009), achievement, motivation and student interest are influenced by positive and negative attitudes. The import of this submission is that if a students' attitude towards physics is positive, performance in the subject will be optimal. Such students usually develop positive attitudes towards their physics teacher, physics curriculum and physics classroom climate. In the same vein, if students have negative attitudes towards science, they also do not like physics courses and physics teachers. This explains why if a student is forced to take a course that he/she has negative attitude to; it might be very difficult for the student to perform well. It is therefore in the opinion of this study that whatever a man becomes in life, it is a product of his attitude. Their attitude towards physics and other sciences lead to their career choices.

A good teacher in the words of Watson, (2002) has high yet realistic expectations about enhancing students' capacity to think, reason, communicate, reflect upon and critique their own practice. They equally provide students with opportunities to ask why the class is doing certain things and with what effect. Thus, it is expected of every good teacher to facilitate his students' learning by providing an enabling environment for them to study. However, reports such as Yara, (2009) have it that many students developed negative attitudes to science learning (physics inclusive), probably due to the fact that their teachers are unable to satisfy their aspiration or goals. Such students do not have enough and correct information. They also lack problem solving skills, lack self-confidence, use formula incorrectly and fail to act like experts when solving physics problems. In short, students with negative attitude lack motivation for class engagement. Buttressing this view, Guido, (2013) in his study on attitude and motivation towards learning physics submitted that most students feel good when they are successful in physics. He however quickly added that students' success is not unconnected with the role of their teachers in taking pain to explain a lot per detail in their class. The implication of this submission is that in order to increase the level of attitude and success in physics education, new teaching methods and technology need to be implemented into physics education. This is because the kind of learning experiences a student goes through could go a long way in shaping his/her own attitude. Thus, a student draws from his teacher's disposition to form his own assertiveness otherwise known as attitude.

2.3.3 Interactive-Lecture Demonstrations and Academic Achievement of Students in Physics

Several researches have been carried out on the effect of demonstration instructional strategy on students' academic achievement in schools. One of such studies is that of Ibe and Nwosu, (2003) which investigated the effect of guided-inquiry, demonstration and lecture methods of teaching secondary school biology students. The study submitted that students taught with guided-inquiry and demonstration methods performed significantly better than those taught with lecture method. Atsua and Abdullahi, (2015) studied the effect of demonstration and lecture methods in teaching economics in secondary schools in Benue state and came up with the finding that demonstration was significantly more effective than lecture method in teaching economics. Similarly, a study was conducted by Lawrence in 2018. The study was aimed at determining the relative effectiveness of enriched demonstration and lecture instructional strategies on senior secondary school students' achievement in Chemistry. A quasi-experimental design basically, the pre-test, post-test, non-equivalent and non-randomized control group was adopted for the study using a total sample of 166 SSI students selected using multi-stage sampling technique. The instrument used for data collection was a Chemistry Achievement Test (r=0.82) while data collected were analyzed using Analysis of covariance (ANCOVA). The results revealed that there was a difference in the achievement of students exposed to enriched-demonstration strategy compared to their counterparts taught with enriched lecture strategy and this difference was significant. Consequent upon the findings, the use of enriched demonstration strategy was recommended for teachers in their classroom interactions, among others. The studies relate to the present study because of the demonstration method of teaching used in the study. However, while the above studies were conducted using biology, economics and chemistry respectively, the present study will be conducted using physics and the demonstration method used will be improved upon to make more interactive

Muhammad et al., (2016) compared the effectiveness of demonstration and lecture methods in learning concepts in economics among secondary school students in Borno State. A quasi-experimental design was used in a classroom setting where classes were intact. After treatment results were collected and analyzed by t-test. The results of the study revealed that though demonstration and lecture methods in learning concepts in economics among secondary school students in Borno state were both effective. But when the two methods were compared, demonstration method was more effective than lecture method in learning concepts in economics among secondary school students in Borno state as their results were significantly higher than those of lecture groups. In consequence, the study recommended that economics teachers should maximize the use of demonstration method while teaching and learning certain economics concepts. Furthermore, Adekoya and Olatoye, (2011) investigated the effect of three teaching strategies; demonstration, peer-tutoring, and lecture strategies of teaching on students' achievement in pasture and forage crops which is an aspect of agricultural science. A 3 x 2 x 2 pretest-posttest experimental design with a control group was used in which a hundred and fifty randomly selected Senior Secondary School II Agricultural Science students were drawn from three schools. The data was analyzed using ANCOVA and Scheffe post–hoc analysis. Finding indicated that demonstration strategy alongside peer-tutoring is potent in raising students' achievement. The studies so far considered are on ordinary demonstration strategy and not on the interactive lecture demonstrations. This therefore makes it imperative to strive to review the ones that are directly related to the strategy in question. These studies are related to the present study because of their interest in demonstrations only that they were carried out in subjects other than physics, and the strategy used is ordinary demonstration and not an interactive lecture demonstration strategy that the present study is working on.

The submissions above are a pointer to the fact that demonstrations are very relevant to the teaching of science perhaps because exciting demonstrations in the words of Milner-Bolotin et al., (2007) keep students motivated and interested; and help teacher to prevent students from losing their concentration. It should however be noted that as much as students enjoy the demonstrations, there is ample evidence that just seeing a demonstration is insufficient for the majority of them (Crouch et al., 2004). Contrary to a common belief that seeing a demonstration makes students understand or at least remember the phenomena, many science instructors have documented that after seeing a demonstration, the majority of students comes out with an incorrect interpretation of what they saw, and may even "remember" witnessing a phenomenon that did not occur during the demonstration. This is attesting to the fact that students do not gain thorough conceptual understanding just from observing a demonstration. However, for students who had a chance to predict an outcome of a demonstration prior to seeing the demonstration, they achieved a significantly higher success rate of 25%–35%. Furthermore, students who had the opportunity to make a prediction, discuss it with peers, and only then observe the demonstration as in the case of Milner-Bolotin et al., (2006), were found to be getting the most out of this learning experience, their rate of correct responses was higher than 50%.

Moll and Milner-Bolotin (2009) further examined the effects of computer-based Interactive Lecture Experiments (ILEs) in a large introductory physics course on student academic achievement and attitudes towards physics. ILEs build on interactive lecture demonstrations by requiring students to analyze data during and after lecture demonstrations. Findings of the study showed a general positive shift (about average for an interactive course) but could not detect improvements in student's understanding of specific topics addressed by ILEs. The study also revealed possible improvements to implementing ILEs such as working in groups, ongoing feedback for students, and linking assessment to pedagogical practices. In sum, when demonstration is made enriched and interactive, the pedagogy promotes conceptual understanding of the subject matter (Moll and Milner-Bolotin, 2009). This could be due to the fact that when lecture demonstrations are made interactive; students are motivated to be active participants of education process. Perhaps, because through the technique, students are made to observe real situations themselves, predict the outcome of the demonstration and thereafter, engage in small group discussions with their fellow students. Šlekienė and Ragulienė (2010) carried out a study that dealt with the application of interactive lecture demonstrations (IALD) during lectures of general physics as a way of helping students to better understand functional dependences of physics phenomenon. IALD was described as an active engagement learning environment in a lecture setting. Students of Faculty of Natural Science studying Ecology and environmental studies, Siauliai University were used for the study. Assumption, observation and explanation cycles were used during interactive lesson demonstration. The same course of kinematics and dynamics were lectured traditionally for students studying applied biology. It was observed that in those lectures, where IALD was used, achievements of students were better than those of students learning in traditional method. Using IALD students are motivated to be not passive observers, but active participants of education process. However, as relevant as these studies are to the present study in the use of interactive lecture demonstration method on students' achievement in physics, the studies were conducted in higher institutions of learning and not with lower cadre students that this study is using. In addition, their topics of interest were kinematics and dynamics while the present study will be conducted using optics.

2.3.4 Interactive Lecture Demonstrations and Students' Attitude to Physics

Although, there were dearth of literatures on the relationship between interactive lecture demonstrations and attitude of students towards learning, studies have been conducted to find out the extent to which ordinary demonstrations affect students' attitude and achievement in schools. For instance, Ahmad, Muhammad, Naji and Avi, (2007) in their study on the effect of demonstration on students' understanding of and learning of oxidation-reduction concept using a sample of 131 Israeli 8^{th} graders in middle schools (junior high schools). Instruments used for data collection were attitude questionnaire and oral interviews, and data gathered were analyzed with means, standard deviation and t-tests. Findings of the study revealed that students are more interested in learning when taught with demonstration method as the strategy has the tendency to bring the subject closer to their heart, make studying the subject easier, increase the extent of interest and attractiveness and elevate students' level of motivation and satisfaction. It was further agreed upon that in addition to demonstrations; laboratory sessions or manual activity sessions could be useful as follow-up activities after the demonstration sessions. The study is related to the present study as it investigated demonstration method only that it is ordinary demonstration and not an interactive lecture demonstration as will be used in this present study. Besides, the study was carried out using economics while this study will be conducted in an aspect of physics.

Amadi, (2016) studied the effect of demonstration and project method of teaching on students' achievement and interest in some graph related concepts in Economics. The study adopted quasi-experimental design – a non-equivalent control group design. The population of the study comprised of all SS II students in Ikeduru LGA of Imo state. It adopted Economics Achievement Test (r=0.97) and Economics Graph Interest Scale (r=0.85) for data collection. Kendel coefficient of concordance and Cronbach's Alpha were used to establish the reliability factors for EAT and EGIS respectively. Mean and standard deviation were used to provide answers for the research questions while analysis of covariance (ANCOVA) was used to test the hypotheses at .05 level of significance. The result of the study, among others showed a significant difference in the mean interest scores of the students exposed to demonstration and project method of teaching graph related concepts in Economics with those taught using project method having a higher mean gain. The subject used for the study is economics making it to be slightly different from this present study.

Awandia, (2021) carried out a study to investigate how teacher's teaching methods can change students' negative attitudes towards physics to positive. 41 form three students from Fako Division, South West Region of Cameroon took part in the study. The study adopted a pre-test post-test quasi-experimental design to verify the four hypotheses formulated. Data collection for the research work was done using a standardized test and an attitude questionnaire. Reliability factor for questionnaire on student's attitude towards physics had Cronbach's alpha coefficient of 0.80. The data collected were analysed using frequencies, means, percentages and one-way ANOVA. The results showed that, students taught using lecture – demonstration teaching method performed best followed by those taught using cooperative teaching method and the lecture – inquiry teaching method while those taught using traditional lecture method performed last. This empirical study is in line with this present study as it adopted lecture demonstration as the method of teaching, and physics as the subject used in the investigation. It however differs from the present study because it was carried out in Cameroon with the use of form three students while the present study is being carried out in Nigeria using SS II students.

Moll and Milner-Bolotin, (2009) examined the effects of computer-based Interactive Lecture Experiments (ILEs) in a large introductory physics course on student academic achievement and attitudes towards physics. ILEs build on interactive lecture demonstrations by requiring students to analyze data during and after lecture demonstrations. Student attitudes were measured using a Colorado Learning Attitudes about Science Survey (CLASS). Attitude survey results showed a negative shift in student attitudes over the semester, which is a typical result for an introductory physics course. This finding suggests that ILE pedagogy alone is insufficient to significantly improve student attitudes toward science. The study also revealed possible improvements to implementing ILEs such as working in groups, ongoing feedback for students, and linking assessment to pedagogical practices. This study adopted the use of interactive lecture experiments unlike the present study that has its focus on interactive lecture demonstrations.

2.3.5 Jigsaw Instructional Strategy and Students' Achievement in Physics

Ojekwu and Ogunleye, (2020) worked on the effects of Jigsaw instructional strategy on senior secondary school students' performance and interest in Biology in Eleme Local Government Area of Rivers State, Nigeria. It used the pretest-posttest, control group quasi experimental design. 92 students from intact Science classes in public coeducational senior secondary schools participated in the study. Instruments include: Biology Performance Test (r=0.88) and Biology Students Interest Scale (r=0.85) in addition to the stimulus instruments for the Jigsaw and conventional lecture. Treatment procedures for the experimental and control group lasted six weeks. Data obtained were analyzed using Analysis of Covariance. The findings indicated among others a significant difference in the science students' interest scores across the experimental and control groups ($P<0.05$). Students taught with the Jigsaw strategy achieved greater improvement in their mean scores than those taught with the conventional lecture method.

In a study conducted by Timayi et al., (2016) on the impacts of jigsaw IV instructional strategy (J4IS) on interest and students' performance in geometry in Kaduna State, Nigeria, an attempt was made to solve the persistent poor secondary school students' achievement in geometry in Kaduna State, Nigeria. A quasi-experimental research design involving a pretest and posttest was used. The population of the study comprised of 4624 randomly selected senior secondary school year two (SS2) students of the public secondary schools in Zaria Educational Zone. The sample for the study comprised of 144 students from two schools from intact classes (Experimental = 72 and Control = 72). The Geometry Performance Test (GPT) was used as instrument for collecting data. Descriptive statistics and t-test with the Statistical Packages for Social Sciences (SPSS) version 21 were used to analyze the data collected. The study revealed a significant difference in performance in favor of students exposed to the J4CLS.

The finding was further corroborated by Isa and Muhammad, (2019) in their study on effects of jigsaw iv cooperative learning strategy on students' academic performance in organic chemistry in Zaria education zone, Kaduna state, Nigeria. A pretest and posttest

Quasi-experimental research design was used for the study. One group of students was instructed using Jigsaw IV approach just as the other group was tutored with Lecture mode of teaching tagged (CLMT). A total of 234 students from two Senior Secondary Schools in Zaria Education zone made up the sample for the study.. The instrument for the study was an Organic Chemistry Performance Test (r=0.88). Data collected were analysed using Analysis of Covariate and t-test statistics at $p<0.05$ significance level. The findings of the study indicated that, there is significant difference between the mean performance scores of science students taught Organic Chemistry concepts with Jigsaw IV Cooperative Learning Strategy and their counterparts taught with CMT in Zaria Education zone. In a similar study carried out by Nwankwo and Okigbo, (2021) to assess the effect of jigsaw teaching strategy (JTS) on academic achievement and retention of senior secondary two (SS2) students in chemistry, two research questions and two hypotheses guided the study on a sample of 71 participants. Statistical tools of ANCOVA, mean and standard deviation were used to analyse data collected. It is observed from the findings that JTS strategy significantly enhanced achievement and retention scores of SS2 students in chemistry than those in the conventional teaching strategy. Based on this finding, the study recommended amongst others that the Anambra state ministry of education should organize seminars, workshops and conferences for teachers, most especially, chemistry teachers on how to use JTS in teaching chemistry. Similar result was obtained by Mbacho and Changeiywo, (2013) in a study conducted in Kenya on the impacts of jigsaw instructional strategy on the performance of students in mathematics. The studies are related to the present study as they examined the impacts of jigsaw on students' academic performance. They were however conducted in chemistry and mathematics while the interest of the present study is on Physics.

Pelobillo, (2018) also studied the efficiency of jigsaw technique in learning physics and problem-solving dimensions of senior high school students in Davao city, Philippines. Findings of the study revealed that students' exposure to jigsaw technique improved physics learning. Similarly, Gambari et al., (2013) conducted a research on the effectiveness of computer-supported jigsaw ii cooperative learning strategy on the performance of secondary school students in physics. The study reported that students taught using computer-supported jigsaw ii cooperative learning strategy performed better than those who used individualized computer instruction. The same students were observed to have positive attitude to physics than those taught with individualized computer instruction. Similar result was obtained when Amosa and Mudasiru, (2017) conducted a study on the relative effectiveness of computer-supported Jigsaw II, STAD and TAI cooperative learning strategies on performance, attitude, and retention of secondary school students in physics. Though the three studies referenced here are carried out in physics but the strategies adopted are the main jigsaw and jigsaw II contrary to Guided reverse jigsaw that the present study is focussing.

Equally worthy of mention is the fact that education provided in our laboratories is based upon practice and teachers may experience difficulty in reaching all the students. To address this difficulty, the jigsaw technique has been found to be a necessary tool as it creates a more effective learning environment in laboratory practices. This was the finding of Abdullah and Filiz, (2017) in their study titled the effect of jigsaw technique on the students' laboratory material recognition and usage skills in general physics laboratory course. Ndukwe and Timayi, (2018) also observed that students exposed to J4CLS had lower anxiety level compared to their counterpart in the control group. It was concluded that J4CLS is effective in the teaching of computer science practical sessions. But how effective is it in teaching physics? This is where the study differs from the present study.

2.3.6 Studies on Reversed-Jigsaw and Academic Achievement of Students

The Reversed Jigsaw instructional strategy is one of the latest forms of jigsaw cooperative learning strategies and as such, it follows the same approach as the original jigsaw strategy only that it has its own objectives to fulfill. Besides, the strategy was meant for the purpose of handling higher level students. It is in respect of this fact that the present study reviews relevant literatures on the strategy. For example, in a study carried out by Agu and Samuel, (2018), to investigate the effect of Reversed Jigsaw, Team-Assisted Instruction and Guided Discovery instructional strategies on the interest and achievement of Basic Science and Technology students in Doma Local Government area of Nasarawa State, a quasi-experimental research design was employed for the study which has a population of JSS II students in public co-educational secondary schools in the Local Government Area. The sample for the study was 147 JSS II Basic Science and

Technology students from four intact classes. The instruments used for collect data for the study were Students' Interest Rating Scale in Basic Science and Technology (SIRSBST) and Basic Science and Technology Student's Achievement Test (BSTSAT). While the reliability coefficient of SIRSBST was determined using Cronbach Alpha and found to be 0.82, that of BSTSAT was determined using K-R21 formula and the reliability coefficient obtained was 0.85. Mean, Standard Deviation, Analysis of Covariance (ANCOVA) and Scheffe's Post-hoc test were the statistical tools used to analyze the data collected. The findings of the study revealed that there were significant differences in the interest and achievement of students taught using Reversed Jigsaw, Team-Assisted Instruction, Guided Discovery instructional strategies and the conventional (lecture) method. The reversed jigsaw strategy recorded the highest mean post achievement score..

Saribaglou, Vahedi, Eskandar and Abidi, (2019) investigated the effect of reversed jigsaw method on university students' academic performance and statistics anxiety in statistics course. A pretest posttest quasi experimental design was adopted for the study. A sample of 43 university undergraduate students took part in the study. While the 20 students in the experimental group used reversed Jigsaw method, the remaining 23 students of the control group were instructed using instructional teacher-centered teaching method. The instruments used for data collection were statistics anxiety Scale and academic performance test. One way univariate and multivariate analysis of covariance was used for data analysis. Findings from the study revealed that there were significant differences between the experimental and control groups in terms of their academic performance and statistics anxiety ($p<0.001$). The results of mean comparisons indicated that, the mean of experimental group is significantly higher than control group. Also, in statistics anxiety the mean of experimental group is significantly lower than control group. In general research finding indicated that, reversed jigsaw method has positive effect on students' academic outcomes such as anxiety and performance. In the other words, by using this method, students' academic performance will increase and their statistics anxiety will decrease. Like the earlier study reviewed, undergraduate students of a university outside Nigeria were the participants used for this study whereas the present study aimed at using the students of physics in secondary schools in Nigeria.

In a similar study, Komang and Basori, (2019) studied the efficacy of Jigsaw IV and Reverse Jigsaw instructional model on participation as well as performance (cognitive abilities) of students using a 2x2 factorial design. Interviews, observation, questionnaire, and testing were used as instruments for data collection. Collected data were subjected to ANOVA. Result indicated that there was different influence between application of Jigsaw IV and Reverse Jigsaw cooperative learning model based on students' cognitive ability. The positive influence of Jigsaw IV was however found to be higher than that of Reversed jigsaw. This is however a bad advertisement for the reversed jigsaw instructional strategy. The study however took place in a place called Surakarta, Indonesia while the present study is being conducted in Nigeria.

Samuel, (2018) also investigated the effect of Jigsaw IV, Group Investigation and Reversed Jigsaw cooperative instructional strategies on achievement and retention of Basic Science students. A simple random sampling procedure was employed to select 167 JSS II students from four public co-education schools in Benue North Senatorial Zone, Benue State, Nigeria. Quasi experimental research design was employed for the study. Two research questions and two research hypotheses guided the study. Basic Science Student's Achievement Test (BSSAT) was used as instruments for data collection. The reliability of BSSAT was determined using K-R21 formula and the reliability coefficient obtained was 0.85. Mean and Standard Deviation were used to answer the research questions while the hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). Scheffe's Post-hoc test was used to determine the magnitude of the differences among the strategies of instruction used. The findings of the study revealed that significant differences were found in the mean achievement and retention scores of students taught using Jigsaw IV, Group Investigation, Reversed Jigsaw cooperative instructional strategies and the conventional demonstration method in favor of the three cooperative instructional strategies. However, of the three cooperative instructional strategies, it is the reversed jigsaw strategy that recorded the third highest post achievement score after jigsaw iv and group investigation strategies. It is obvious from the discussion so far that the reversed jigsaw method if well implemented can positively influence the students' achievement in and retention of Basic Science concepts. None of the literature reviewed investigated the effect of the strategy in question i. e the reversed jigsaw on students' performance in senior secondary schools in Nigeria which is the thrust of the present study.

2.3.7 Jigsaw Instructional Strategy and Students' Attitude to Physics

Van and Ramon, (2012) in their experimental study on the effects of jigsaw learning on Vietnamese tertiary students' achievement and knowledge retention, students' attitudes towards six weeks of instruction in a mathematics course tagged MAE were assessed. Findings of the study reported that students in the experimental group (N = 40), who perceived their instruction as more cooperative and more student-centered, had significantly greater improvement on both achievement and retention measures than did the students in the control group (N = 40). This paper furthers that analysis by examining students' attitudes towards learning via jigsaw grouping. The results indicate that in general, students in the experimental group (jigsaw group) appreciated most working with others and getting help, discussing and sharing information and teaching others, and they enjoyed the jigsaw context. In consequence, it is upheld that students' attitudes towards jigsaw learning are overwhelmingly positive. The study relates to the present study because it investigated the effect of jigsaw strategy on students' attitudes. However, the study was conducted using mathematics in a higher institution outside Nigeria while the present study will be carried out using secondary school physics students in Nigeria.

Similarly, Amosa and Mudasiru, (2017) investigated the impacts of computer-supported jigsaw II instructional strategies on the achievement of physics students using gender and attitude to physics as moderating variables. A purposive sampling technique was used to select two senior secondary school class II physics students from four intact classes in Minna, Niger State, Nigeria, while the sample consisted of 80 students from two intact classes. Computer-Assisted Learning Package (CALP) on physics and Physics Achievement Test (PAT) were used as treatment and test instruments. ANCOVA and Scheffe's post-hoc test were used to analyse the data. Findings indicated among others that students taught physics using Jigsaw II cooperative learning strategy had positive attitude to physics than those taught with ICI. The submission is consistent with that of Ajitoni and Salako, (2014) who assessed the influence of jigsaw procedure as well as gender on attitude of students to cultural integration and viable advancement in Nigeria. This was done to see how the strategy can be used to promote national unity through education. The study was carried out in Ogun state, Nigeria, adopting a pretest- posttest, control group, quasi experimental design. The sample for the study consisted of 126 junior secondary school students in the south-west region of Nigeria while a 30-item achievement test was used as the research instrument for the study. Data collected were analyzed using analysis of co-variance. The findings of this study revealed that jigsaw technique benefited students who form jigsaw group (experimental group) than the conventional learning group (control group) in terms of promotion of unity and peaceful co-existence among students. This could further translate into better integration and sustainable development in Nigeria. The study interrelates with the ongoing study as it investigated the effect of jigsaw on students' attitude. Though, it was carried out in the area of social studies while the present study has its focus on physics.

To Crone and Portillo, (2013) in their exploration on whether the jigsaw classroom would have an effect on students' attitudes about their own academic abilities and practices at the university level, it was submitted that students given the full jigsaw exposure report an increased ability to teach psychological concepts to other students compared to the control condition. It was equally revealed that the jigsaw technique increases the students' ability to communicate orally as well as increasing their belief in themselves as scholars. Thus, it alters their attitude positively after exposure to jigsaw learning strategy. But the study was conducted using students of higher institution of learning while the current study will be conducted using secondary school students.

All these findings are however at variance with that of Alghamdi, (2017) who investigated the impact of cooperative learning instruction, specifically by using the Jigsaw instructional strategy on science achievement and attitudes towards science among 11th grade students. 50 participants took part in the study. The students' achievement was measured through the implementation of 30-item achievement test used as a pre-test, as well as a post-test and deferred (follow-up) test. A group of learners was with jigsaw mode of teaching while the traditional teaching method was used for students in the other group. A 30-item Likert scale called Test of Science Related Attitudes (TOSRA) was used to determine the students' attitudes ranging between strongly agree to strongly disagree. The data were analysed through repeated measure analysis and multivariate analysis of variance with a .05 level of significance. The results of the study showed that though, using Jigsaw as a cooperative learning strategy improved the students' achievement, it however, revealed no significant change on the students' attitudes towards science. Similar result was reported by Arra, D’Antonio and D’Antonio, (2011) that some students preferred not to work in groups, implying that they negative attitudes towards cooperative learning of which jigsaw is one. This study has its main focus on science generally while the on-going study would be specific about physics.

2.3.8 Gender and Academic Achievement of Students in Physics

Students’ underachievement in senior school physics has been a much - discussed educational issue in Nigeria; and many causes amongst which is gender, have been understudied as the starting point for investigating these phenomena of school failure or success. The investigation of academic achievement in relation to gender according to UNESCO, (2000) becomes necessary in view of the observation that gender has roles based on the women folk, preventing their participating in, and benefiting from development efforts. This has created a big psychological alienation or depression in the minds of the female students. Consequent upon this, boys dominate Social Studies, Chemistry, Physics, Mathematics and Environmental studies classes while the girls go into reading Biology, languages and Arts.

Researches have been carried out on the impact of gender differences on academic achievement of students. Examples of such studies include Oriakhi, and Ujiro (2015); Nnamani and Oyibe, (2016) and Adigun et al., (2015). There are variations in the reports of these studies. For instance, in a study carried out by Adigun et al. (2015) to investigate the relationship between student’s gender and academic performance in computer science in New Bussa, Borgu local government of Niger state. Questionnaire which consisted of 30 multiple-choice items was used as the research instrument. A total of 275 students from both private and public schools in the study area took part in the study while t-test was used to analyzed the data collected. The results of the study showed that though, the male students had slightly better performance compared to the female students, it was not significant. This better performance was found to be pronounced in the private school which was shown to possess the best male brains found in the study area. Based on the findings of this study, recommendations were made that there should be a deliberate Federal Government policy to encourage absorbance of female students into further study in computer science. Similarly, Attah and Ita, (2017), examined the influence of gender on academic achievement in English Language among senior secondary school students in Calabar metropolis, Cross River State. The researchers adopted survey design for the study. The study sample comprised 660 Senior Secondary School two (SSS II) students drawn from 22 public secondary schools from Calabar South Local Government Area, Cross River State, using Stratified Random and Purposive sampling techniques. Data were generated through ''English Language Academic Achievement Rating Scale" (ELAARS). The data generated were analyzed using independent t-test at 0.05 level of significance. The result of the analysis showed that gender has no significant influence on academic performance in English Language among senior secondary school students in Calabar metropolis. These studies though investigated the impact of gender on academic achievement but they were conducted in computer science and English language and not in physics. Other studies which reported no significant gender difference in students' academic achievement and retention in various subjects include Ingels and Dalton, (2008).

Conversely, others studies found significant difference with either the boys or the girls performing better. One of such in the latter group is Obafemi, (2015) who investigated the influence of students' gender on their understanding, application and analysis of Light waves concept in physics in Ikwerre Local Government Area of Rivers State, Nigeria. A quasi-experimental pretest posttest design comprising of three experimental and one control group was used. A purposively selected sample of fifty- five (55) physics students of Senior Secondary 2 (SS2) class was involved in the study. Mathematics Ability Test (MAT) and Physics Performance Test on Light Waves (PPTLW) with reliability coefficients of 0.97 and 0.89 respectively were used as instruments for the study. Data collected was analysed using Mean scores and Percentages for the research questions, while 4x2 Multivariate Analysis of Covariance was used to test the hypotheses. Analysis of results showed among others that there is a significant difference between the performance of male and female students in the application of Light waves while there was no significant difference between the performance of male and female students in the understanding and analysis of Light waves. The Post hoc analysis indicates that male students taught using Guided-discovery method contributed more to the significant difference between the performance of male and female students in the application of Light waves.

Oriakhi and Ujiro, (2015) conducted a study on the influence of gender on students' academic achievement in government subject in public secondary schools in Oredo Local Government Area of Edo State, Nigeria. The study was guided by three research questions. Of the 822 population of the study, 412 participants took part in the study. The study adopted a multistage sampling technique to select the students. It adopted the ex-post-facto research design. Data collected through examination proforma were analyzed using frequency counts, percentages and proportion. The finding indicated that there gender had influence on students' achievement of the study in favor of female (51%) while the male has 49%. But Alordia, Akpadaka and Oviogbodu, 2015 investigated the influence of gender, school location, and socio-economic status (SES) on students' academic achievement in mathematics using an ex-post factor design in which the variables were neither manipulated nor controlled. Sample for the study consisted of 1900 students. The instruments used for the study were Mathematics Objective Test (MOT) and Socio-Economic Status Questionnaire (SESQ). The result showed among others, that male students performed better than female students. The study therefore recommended that teachers should put into consideration the disparities that exist between male and female when teaching mathematics.

Obafemi, (2015) observed that the benefits of physics have not been the same for males and females as girls are underachieving and under-represented in physics. In line with this submission, Gonzuk and Chagok (2001) found that girls are easily discouraged towards taking physics because of the negative impression that physics is just difficult. Conversely, Onah et al, (2010) in an investigation to ascertain the elements which foretell achievement in post-primary school physics asserted that sex is a very good predictor of performance in physics at secondary school level. In the same vein, Ariyo, (2006) in a study on school and students' factors as determinants of students' achievement in physics at the secondary school level in Oyo state revealed significant gender difference in achievement in favor of boys.

Okwo and Otubah (2007) also reported that boys do better than girls in physics essay test as well as other tests that are based on physics concepts that require learners of higher numerical ability otherwise, females achieved better (Adeoye, 2010). Science subjects such as physics and chemistry in the words of Babajide, (2010) are further portrayed as masculine in outlook by stakeholders in education. Male supremacy over female in sciences has been partly attributed to fewer females attaining degrees in science and technology –related fields (Hazari, Tai and Saddler, 2007) and partly to the acknowledgment of the tale that young men are better in sciences than their female counterparts (Babajide, 2010). While giving reasons for girls' under-representation in physics, Aina and Akintunde, (2013) quoted Mari as attributing it to gender discrimination in employment. Mari believed that many employers of labor, female employers inclusive, prefer employing men to women. To Abdullahi, Kalejaiye-Matti, Garba and Balogun (2007), socialization patterns in Nigerian and most African setting is the cause of girls' low participation in physics as it places enormous restrictions on the female gender and demand from her a higher input of daily domestic labor than from the male. This perception automatically has a potential to scheme female out from any consideration for serious professional discipline even in cases where the female appears to be more brilliant than their male counterpart. In other words, it prevents women empowerment and limits the full participation of women in national development. It also limits their potentials for full human capital development to the optimum.

2.3.9 Gender and Students' Attitude to Physics

Attitude in the words of Afari, (2015) has been a very difficult concept to describe since it cannot be directly observed. This has led to a variety of definitions. There is also a variety of study reports on its association with students' gender towards learning, thereby making the reports to be inconclusive. In other words, there have been conflicting reports on the correlation of gender to the attitude of students to sciences. Sofianiet, Maulida, Fadhillah and Sihite, (2017) investigated gender differences in students' attitude towards science and the effect of gender on students' attitude. A total of 77 secondary school students from various schools of Bandung, Indonesia participated in the study. The attitude questionnaire as an instrument for the study consisted of 23 items related to four dimensions: enjoyment, self-confidence, value and motivation. Data collected by questionnaire were converted into interval scale using Method of Successive Interval (MSI) and further analyzed using Statistical Package for Social Science (SPSS). Results of the study showed that students' positive attitude towards science was at medium level and there was no significant difference in attitude towards science between the female and male students. Bain and Rice, (2006) also investigated whether gender has an effect on students' attitudes toward, and their uses of, technology. A mixed method approach that combined qualitative and quantitative research techniques was adopted for the study. The instruments used for the study include the computer survey adapted from the Computer Attitude Questionnaire (CAQ) and the Pupil's Attitude Towards Technology (PATT). Data were collected from 59 sixth grade students to examine their attitudes toward and uses of technology by means of The Computer Survey (TCS), computer logs, interviews, classroom observations, field notes, and student work. It was indicated that there was a gender differences in attitudes, perceptions, and uses of computers were not found to be significant. The studies relate to the present study because of the focus on gender and attitude. The studies were however conducted outside the shore of Nigeria unlike the present study.

The above finding is in agreement with that of Leelakrishna, (2007) who in his study on gender differences in attitudes to learning science observed no significant difference in the attitude between boys and girls. However, in terms of subject preference, he posited that boys were more inclined to physics and chemistry, while girls had a preference for biology. To Eryilmaz, Yildiz and Akin, (2011) who examined the relationship between attitudes of high school students towards physics laboratory and being motivated for class engagement or not; they concluded that students (irrespective of gender) who have high-level motivation for class engagement have also positive attitudes towards physics laboratory. In contrast with this conclusion, students who have low-level motivation for class engagement have negative attitudes

Conversely, Oluwatelure, (2015) worked on gender difference in attitude and academic performance of students in selected public secondary schools in Akoko Land. Three hypotheses were raised to guide the study on a sample of 1626 student JSS 3 students. Teacher's classroom records and questionnaire on attitude of students were the instruments used for data collection. Inferential statistical tool, i.e., t-test and correlation were employed in the analysis of the data. Findings of the study revealed a significant difference in the attitude of male and female students. A positive relationship was also observed between attitude towards science and scientific attitudes of the respondents. The study recommended that sex of learners is a key element that must be echoed in the teaching as well as learning of science. Similarly, Abubakar, (2020) carried out a study on gender differences in the attitude of students towards science subjects in some selected secondary schools in Gusau. A descriptive research design was used to solicit information from 10 teachers and 100 students selected through a simple stratified random sampling technique. A self-developed questionnaire was used to collect the data. Data collected were analysed using frequency tables, percentages and means. Result of the study indicated that gender is a factor on which attitude of students to science subjects depends. It was further revealed that boys have more positive attitude towards science subjects than their female counterparts. These studies were conducted on general science as against the present study that focuses on physics.

Corroborating the above findings, Wimer, Ridenour and Place, (2001), reported that both boys and girls showed the most enthusiasm for mathematics and physical sciences in the elementary years, but by early adolescence, the percentages of boys' enthusiasm dropped from 84% to 72%, and for girls from 81% to 61%. Then by high school, only 25% of boys and 15% of girls considered themselves good at mathematics. The explanation for this finding according to Orenstein in Gugliotta, (2010) is that girls are not encouraged in mathematics and science. Consequent upon this, girls are not likely to retain affection for mathematics and science like boys. Their confidence continues to diminish as they get older, and so does their understanding of the subjects. Finally, that leaves boys outperforming girls in either subject, which is proven to have an effect on their earning potential later in life'

In short, it could be inferred from the account above that the interests as well as attitude of girls and boys to science and their opinions about science careers and scientists are at variance. The assertion appears to be consistent with the findings of Riegle – Crumb and Moore, (2013) in their study on gender gap in high school physics that at the secondary school level, female students continue to lag behind male students in rates of physics course-taking in high school with this disparity remaining fairly constant over the past three decades even as the overall percentage of students taking physics has increased. The reason for these findings may not be too far from the "out – of – school experiences" or "extra-curricular experiences" of boys that are related to the physical sciences such as prior use of rifles, batteries, electric toys, fuses, and pulleys, whereas girls have more experiences in biology such as watching birds or planting seeds. One interpretation of these findings according to Jones, Howe and Rua, (1999) could be that females' lack of physical science experiences puts them at a deficit for learning physics concepts. The import of this deficit interpretation is that, if females had more frequent and early experiences, then their attitude, achievement and interest in the physical sciences would be greater as they continue in their education.

2.3.10 Level of Commitment and Students' Achievement in Physics

One's commitment is believed to be central to any successful endeavor in life. Students' commitment to physics as used here is abstracted as a psychological link between students and their physics subject/learning. It is a strong belief that something e. g. physics knowledge is good and that one should work hard for it. Learners' commitment to science of which physics is one has been identified as one of the factors in the learning process that determine achievement in science (Babajide 2010). The achievement in this sense encompasses knowledge, skills and attitudes as they are essential ingredients for any learner to function as a competent citizen in the contemporary technology-based society. Muhammad and Ghulam, (2014) carried out an investigation to analyze commitment, engagement and locus of control as determinants of achievement at higher education level. The researchers selected 369 students using multistage sampling technique from three public sector general universities of the Punjab (Pakistan). Three instruments namely commitment scale, engagement scale and academic locus of control scale were used for data collection through personal visits of the sampled universities. After data cleaning 315 responses were found fit for statistical analysis. Analysis was done using correlation and regression. There was a significant positive impact of commitment, engagement and locus of control on academic achievement. In a similar study carried out by Akumu, (2019) to examine the relationship between active learning, student commitment and academic achievement among secondary school students, a correlation research design was employed. 80 secondary school students random selected participated. Results for Pearson product-moment correlation coefficient (r) indicated that there was a positive significant relationship student commitment and academic achievement (r=-2.39*, p =0.35). Therefore, recommendation to educators is that they should improve the learning environments of their students by ensuring effective learning practices and make them succeed academically. The studies discussed above are related to this study because of the use of variables, commitment and academic achievement. The studies were however not conducted in Nigeria hence, the need to test the truth of the assertion in Nigerian secondary schools.

In another exploration, Akpan, Mbaba and Udofia, (2012) worked on the influence of students' understanding and goal commitment on their academic achievement in Introductory Technology in secondary schools in Akwa Ibom State, Nigeria using an ex-post facto survey design. The sample for the study was 2,500 junior secondary three of ages in the state public schools in 2008/2009 session. A students' Understanding and Goal Commitment in Introductory Technology (SUGCIT) was the instrument used for data collection. Data collected were analyzed using the Z-test statistics and multiple analysis of variance. Results of the study showed that 70 per-cent of the respondents were not committed to the pursuit of engineering/technology after the high school, while 30 per-cent were committed; Students who were committed to technology had higher achievement in Introductory Technology than those who were not. To this end, the authors recommended that more proactive policies should be put in place by government and other agencies to provide technology – friendly environment and qualified staff in schools for effective teaching of Introductory Technology in order to stimulate youth interest in technology.

Conversely, in a study carried out by Ketula, (2019) to examine the relationship between active learning, student commitment and academic performance among secondary school students in Kawempe Division, a correlation research design was adopted. A sample of 50 students (23 males and 27 females) took part using simple random sampling method. Data was collected and analysed with self-administered questionnaires and SPSS respectively. Analysis of results showed no significant relationship between student commitment and academic performance. It was therefore recommended that administrators should facilitate independent, critical and creative thinking in students. As relevant as this study is to the present study, it was conducted outside shore of Nigeria. The finding of the study compared to the earlier ones referenced above shows that the investigation is still inconclusive.

To Agoro (2002), learners learn effectively when it originates from their own mind. This implies that successful learning is related to intrinsic motivation. She went further to submit that learners should devote greater percentage of their time to scientific activities as well as involving themselves in science-related social issues, as these will possibly improve their achievement and practical skills. However, for this to be achieved, science lessons should be full of learners' activities and fun that would encourage them to make self-contributions to lessons. This is in alignment with the findings of RezeiGazki et al. (2019) who tested the pre-hypothesized model of the connection between active learning. Student's commitment and academic performance. The research method was a correlational and structural equation modeling brand. The sampling method was multi – phase while the sample size was 600 female pre-university students in Bandar Abbas. Data collection tools were Hosseinchari and Dehghanizadeh Educational Well-being Questionnaire (391), and Human-Vogel and Rabe Academic Commitment (2015), and an announced high school final exam score. 562 questionnaires were included in the study. Spearman correlation test and factor analysis in AMOS software were used for analysis. Results of a simple correlation between variables indicated a significant relationship between academic commitment and academic achievement.

In a study carried out by Mustapha and Sadiq, (2016), it was reported that Sonsteng et al (2007) in their work on legal education renaissance submitted that lecturers who are committed to their students usually have positive engagements with their students through hard work. Borrowing from this submission, this study is tempted to believe that a student who is committed to his physics learning will definitely have positive engagements with the learning of physics through hard work. This can be done in classrooms through their involvement or responsibility in their own academic success in schools. With these submissions, it may perhaps be concluded that students who are committed to their learning would have a very strong positive sense towards it than those with less commitment to physics learning.

2.3.12 Level of Commitment and Students' Attitude to Physics

Commitment to something (science), which according to Agoro, (2002) is a state in which learners are willing, and desire to devote more time, energy, work, interest, attitude, affection and values to that thing(science) has been identified by Babajide, (2010) as being central to any successful endeavour in life. Corroborating this point, Okeke (1986), Ogunleye, (2002) and Babajide (2010) posited that learners' commitment to the learning materials coupled with their deep drive or motivation to learn among other factors in the learning process determine achievement which has been analysed to encapsulate knowledge, skills and attitudes (Ogunleye, 2002). These are essential ingredients for any learner to function as a competent citizen in the contemporary technology-based society.

There is a dearth of researches on the influence of students' level of commitment on their attitude towards learning and vice versa. To this end, majority of the available literatures reviewed, worked on the influence of instructors' commitment on learners' achievement. The present research work then tries to pick up pieces of findings gathered and establish a connection between it and the target of the current study. For instance, in a study carried out by Mart, (2013) on teachers' commitment to school and students, it was observed that teachers with high level of commitment do not only work harder, they are also emotionally attached to their schools and make more efforts to carry out the goal of teaching. By extension, if a student is highly committed to his/her studies, there is tendency that he/she will work harder and be emotionally attached to his/her studies. There will definitely be a change of attitude in such a way that more efforts will be made to carry out the goal of learning. Commitment is therefore one of the key factors that influence students' study as well as their attitude to learning.

Andrew, et al., (2018) carried out a study on trust, growth mindset and student commitment to active learning in a college science course. A total of 245 undergraduate students of the University of Connecticut took part in the study. The materials were distributed to students using the Qualtrics survey software and completed online outside course meeting times. Participant attitudes toward learning were assessed using a validated three-item measure, with higher scores indicating a greater growth mindset.

Student commitment to active learning was assessed using a measure in which student self-reported their commitment to 16 active-learning practices, and a commitment score was computed for each student based on responses to four subscales. Analysis of the data collected progressed from scale-level descriptive statistics to examination of bivariate and multivariate relationships using correlation and regression, respectively. ANOVA was the instrument adopted to identify potential differences in mean scores of each variable among groups based on gender, race/ethnicity, and school year. Findings of the study revealed among others that students' attitude such as students' lack of trust was associated with decreased commitment to (and engagement in) active learning. Students who do not trust their instructor may view active learning as a set of meaningless activities rather than an opportunity to learn. As related as the work is to the current one, it utilised university undergraduates as participants while the present study targeted secondary school students of physics. It was also conducted outside Nigeria unlike the present study.

2.4 Appraisal of Literature Reviewed

The resume of literature is a validation of the earlier studies' concentration on students' performance and attitude to physics either concentrated on lecture and demonstration methods as separate entities at the detriment of interactive-lecture demonstrations as a strategy on its own. Besides, most of the studies were carried out elsewhere other than Nigeria. Fewer attempts in Nigeria used junior students by improving their attitude and academic achievement using reverse-jigsaw strategy. In this study, the reverse-jigsaw was modified with teachers' guide which was not found in literature especially for teaching physics.

For other variables such as students' level of commitment to physics and gender that may mediate with the activity of teachers in physics classrooms. No studies so far reviewed used the two variables together in a single study. Predominantly, earlier researches were not conducted in Nigeria but somewhere else. There is no known literature in this regard using physics students in Oyo State specifically, Oyo Central senatorial district. Also, the strategies were used elsewhere to enhance other concepts in other subjects rather than light concepts in physics. Thus there is need to study the effect of the two strategies as well as the moderating effects of gender and students' commitment on their achievement in and attitude to physics.

CHAPTER THREE

METHODOLOGY

This section discussed the organization and procedures of data collection as well as the selection of participants for the study. Other sections discussed in the chapter include the research design, variables of the study, selection of topics and method of data analysis. The chapter has the following sub-sections.

3.1 Research Design

The study made use of the pretest-posttest control group quasi-experimental design. This becomes necessary in view of the need to manipulate the independent variable. The design is represented schematically as follows:

O_1 X_1 O_2 -------------------- E_1 (Experimental group 1);

O_3 X_2 O_4 -------------------- E_2 (Experimental group 2);

O_5 C O_6 ------------------- C (Control group)

Where O_1, O_3, O_5 = pretest scores for the three groups respectively.

O_2, O_4, O_6 = posttest scores for the three groups respectively.

X_1 = Treatment for experimental group 1. (Interactive Lecture Demonstrations Strategy)

X_2 = Treatment for experimental group II. (Guided Reverse Jigsaw Instructional Strategy)

C = Represents control group (Conventional Strategy).

The study adopted a 3 x 2 x 2 factorial matrix as illustrated in Table 3.1.

Table 3.1: 3 x 2 x 2 Factorial Matrix of the Research Design

Treatment	Gender	Level of Commitment to Physics	
		High	Low
Experimental Group E_1	Male		
	Female		
Experimental Group E_2	Male		
	Female		
Control Group C	Male		
	Female		

3.2 Variables of the Study

The variables for the study include:

a. **Independent Variable** of Instructional strategy deployed at three levels as listed thus.

   i. Interactive-lecture-demonstrations

   ii. Guided-reverse jigsaw instructional strategy

   iii. Conventional teaching strategy

b. Moderating Variables which are**:**

   i. Students' level of commitment to physics. This exists at two levels:

      (a) Low Level of Commitment to physics.

      (b) High Level of Commitment to physics.

   ii. Gender. These are (a). Male (b). Female

c. Dependent Variables:

   i. Students' Achievement in Concepts of Light in Physics

   ii. Students' Attitude to Concepts of Light in Physics

3.3 Selection of Participants

Students who took part in the study were drawn from all public Senior School II in Oyo State. A local government area was randomly selected from each of the three senatorial constituencies in the state after which three schools were purposively selected from each of the local government areas using the availability of qualified physics teachers, willingness of selected schools to take part in the research work and distance of the selected schools from each other as the criteria. Other criteria used include:

- The chosen schools are co-educational.
- The schools have been presenting students for WASSCE for at least, 10 years.

In all, a total of nine schools participated in the study. Intact class of SSII students in each of the three schools was thereafter allocated to the experimental and control groups apiece. Intact classes were primarily chosen so that the normal academic activities of the participating schools would not be interrupted; while the choice of SSS 2 students was not only because the concepts selected for the study are taught at this level as stipulated by the curriculum but also, because they were not as at the time of carrying out the study, preparing for any public examinations that may disrupt the study.

3.4 Selection of Topics for the Study

Light waves, mirrors and images were selected for this study considering the frequency at which they emerged in the lists of the most perceived difficult concepts in physics. Also, Chief Examiner's Report, (2018) reported that a good number of candidates after plotting light-related graphs were unable to give the correct interpretation of the slope of the graph hence, presented the concept as difficult. Besides this, the topics were selected in order to avoid disruption of normal school calendar.

3.5 Research Instruments

The under listed research instruments were adopted and used in this study for data collection. The instruments are classified into two viz-a-viz stimulus and response instruments.

1. Stimulus Instruments

i. Instructional Guide for Interactive Lecture Demonstrations (IGFILDs)

ii. Instructional Guide for Guided-Reverse Jigsaw Instructional Strategy (IGGRJIS)

iii. Instructional Guide for Conventional (Lecture) Strategy (IGFCS)

iv. Research Assistant Evaluation Sheet (RAES)

2. Response Instruments

i. Physics Achievement Test (PAT)

ii. Physics Students' Academic Commitment Scale (PSACS)

iii.. Physics Students' Attitude Questionnaire (PSAQ)

3.5.1 Instructional Guide for Interactive Lecture Demonstrations (ILDs)

This is an instructional guide designed to provide students opportunity to predict the outcome of a demonstration prior to conducting the demonstration. Opportunity for meaningful engagement of students in the learning process was provided by allowing them (the students) to observe real demonstrations, make predictions on a paper and thereafter collaborate with fellow students by discussing their predictions in small groups.

The guide enabled the teacher to effectively map out the stages in the instructional process and the instructional materials to be in accord with the three phases of which the interactive lecture demonstration (ILD) is composed. Every step to be taken by the students was well addressed by the guide. The major phases in the strategy are: Predict, Observe and Experience (POE).

The instructional guide was validated by giving it to professionals in science education for criticisms, modification and suggestions. The edited copies of the instrument were ratified by the researcher's supervisor after which it was administered to a group of students who were not part of the study. The guide was subjected to ratings by four raters after which the ratings were subjected to Fleiss' Kappa inter-rater reliability scale. The inter-rater index of 0.73 was obtained suggesting that the instrument is reliable and valid for use.

3.5.2 Instructional Guide for the Guided-Reverse Jigsaw Instructional Strategy

This is an instructional guide designed to provide students an opportunity to learn a concept through collaboration with co-students in the class. The guide is a grouping strategy that makes students in a particular group to be dependent on each other to succeed as every student in a group has something distinctive to contribute to the group's task with no two students in a group carrying out the same task. The guide enabled the teacher to organise the students in a way that aligns with the behavioral objectives of the lesson for the day as well as the different stages in the instructional process that make up the guided-reverse jigsaw instructional strategy.

The face and content validity of the instructional package was determined by giving it to scholars in science education for their comment, corrections and criticisms. The instructional guide was thereafter presented to a group of students who were not participants in the research work. Four research assistants were employed to observe and rate the instrument after which the ratings were subjected to Fleiss's Kappa's inter-rater index. A value of 0.75 was obtained attesting to the reliability and validity of the instrument for use.

3.5.3 Instructional Guide for Conventional Lecture Strategy

The guide is an instrument that the facilitators in the conventional (control) group used. It was designed by the researcher and comprised of lectures and teachers-directed instructions. Components of the instructional package include topic of the lesson for the day, behavioral objectives, teaching aids and step-by-step presentation of the instruction by the physics teachers.

Four raters were engaged to rate the instrument like the earlier ones after which it was subjected to Fleiss's Kappa inter-rater reliability scale. A reliability index of 0.73 was obtained which was considered well enough for use.

3.5.4 Research Assistants' Evaluation Rating Sheet (RAERS)

The instrument was developed by the researcher to assess the research assistants' level of performance during training prior to the treatment period. Each of the evaluation sheets was designed to monitor and measure the facilitators' knowledge and skills of the teachers via the deployment of instructional guides throughout the treatment stage of the study. Skills measured include extent of mastery of instructional strategy to effect conceptual change in the students, coherence with steps in the instructional guide, teacher-students interaction, aptitude to convey details of the subject matter and skill to involve all students in the discussion.

Drafts of the evaluation sheets were validated by experts in science education as well as in measurement and evaluation. Comments and corrections made by the experts were incorporated into the final drafts before use.

3.5.5 Lesson Note

The lesson note is an instrument developed by the researcher to guide teachers while teaching in the class using the instructional guides. The step-by-step structure of the instrument is made up of statement of the topic, duration of the lesson, instructional materials used, behavioral objectives, step-by-step presentation of the lesson, summary, evaluation and assignment**.**

The face and content validity of the instructional package was determined by giving it to scholars in science education for their comment, corrections and criticisms. Comments and corrections made by the experts were effected in the final draft and presented to the researcher's supervisor for approval before use.

3.5.6 Physics Achievement Test (PAT)

The instrument, which enabled the researcher to assess physics students' level of knowledge was developed by the researcher and designed using four available options lettered A–D among which only one is correct as the acceptable answer. It consisted of two sections labelled A and B. While section A contained personal information of the students such as name of school, student's number, gender and class. Section B is composed of multiple-choice objective questions aimed at examining students' achievement in optics-related physics. The instrument was constructed with a table of specification on SSII light related topics selected from physics syllabus. Topics on which the test was based are Rectilinear Propagation of Light, Reflection of Light at Plane Surfaces and Reflection of Light at Curved Surfaces. The specification of the items for the Physics Achievement Test is as presented below.

Table 3.2: Table of Specification for Physics Achievement Test (PAT)

S/N	Selected Concepts	Behavioral Objectives			
		Knowing	**Applying**	**Thinking**	**Total**
1	Rectilinear Propagation of Light	(3) 5; 6; 19	(3) 7; 10; 12	(2) 11; 16;	8
2	Reflection of Light at plane surfaces	(2) 9; 13	(2) 1; 4;	(3) 8;17; 20	7
3	Reflection of light at curved surfaces	(1) 3	(2) 14; 18	(2) 2; 15	5
	Total	6	7	7	20

Note: The numbers in bracket represent the number of items in each cell, while the other numbers stand for the serial number of the items in PAT

Draft prints of the instrument were validated by authorities in physics education. Their comments, observations as well as the modifications made remained carefully integrated into the final draft to ensure the validity of the instrument. The instrument was administered to 24 students outside the scope of the participants for this study to determine the difficulty index as well as the index of discrimination of the items. Items with difficulty index from 0.45 to 0.65 were carefully chosen. The reliability test of the instrument was carried out using Kuder-Richardson 20 (K-R 20) formula and was found as 0.78

3.5.7 Physics Students' Academic Commitment Scale (PSACS)

The scale was adapted from Human-Vogel (2015). It consisted of sections A and B. Section A required the students to supply bio-data information such as gender, student's number and name of school, while section B is composed of 20 items to elicit responses on the participants' level of commitment to the study of light aspect of physics on a modified Likert-type rating scale from strongly agree (SA) through agree (A), disagree (D) to strongly disagree (SD). The factors such as long term persistence with their studies, satisfaction, level of investment, the quality of alternatives, and meaningfulness in relation to the students' academics were taken into consideration.

The obtainable maximum score is 100%. Those that scored 51% and above were considered as participants with high level of commitment while those that scored 50% and below were considered as participants with low level of commitment.

The instrument was presented to experts in physics education for their expert review and face-validity. Corrections made by the experts were adopted and a final draft was produced for use. A trial-test was conducted with the instrument using 30 students who were not part of the study. The reliability index was determined using a test-retest method and the index was 0.8 which was considered fit for the study. The Physics Students Academic Commitment Scale (PSACS) was used to establish the students' level of commitment to their studies whether high or low.

3.5.8 Physics Students' Attitude Questionnaire (PSAQ)

The questionnaire was developed by the researcher to gather information from students on their feelings towards light-related concepts in physics. It contained 20 items carefully selected to elicit proper response from the participating students on their level of agreement or disagreement on a 4-point Likert scale rating scale of strongly agree (SA) through agree (A), disagree (D) to strongly disagree (SD). Factors such as students' points of view towards physics as a subject, their level of understanding and confidence in solving light-related problems as well as the extent to which they enjoy physics lessons and activities were taken into consideration when selecting the items.

Copies of PSAQ were presented to science education and educational psychology professionals for validation with emphasis on clarity, adequacy, breadth and language used. Their suggestions and corrections were injected into the final draft. The instrument was later trial tested on a group of 30 students outside the participating students for this study. Subsequently, it was subjected to a reliability test of Cronbach's alpha coefficient and the reliability factor was found to be 0.87.

3.6 Procedure for Data Collection

The Physics Achievement Test (PAT) as well as Physics Students' Attitude Questionnaire (PSAQ) were first administered as a pretest to the students before the treatment and their scores were recorded. Thereafter, the researcher exposed the experimental groups I and II to concepts of light in physics using Interactive-lecture-demonstrations and guided-reverse jigsaw learning strategies for 10 weeks. The control group was simultaneously subjected to conventional strategy for the same number of weeks. This was followed by the administration of post-test to the students and data collation. The study lasted 13 weeks.

Work Schedule

The schedule and duration of work for this study was as stated thus:

Week 1 - Selection of participating schools/familiarization.

Week 2 - Training of research assistants/ pretest administration of instruments.

Week 3 – 12 - Treatment

Week 13 - Posttest administration of the research instruments

Total - 13 weeks

3.6.1 Pretreatment Activities

A letter of introduction was formally collected from the Head, Department of Science and Technology Education marking the approval to proceed to the field. The official letter was presented by the researcher to the principals of the schools used for the study for permission. Thereafter, the researcher got acquainted with physics teachers in the selected schools for their maximum support and cooperation for the period the research work lasted.

3.6.2 Selection and Training of Research Assistants

All physics instructors in the schools that satisfied stated criteria within the rubrics or evaluation sheet were trained for two weeks on the implementation of instructional strategies by means of the self-designed instructional guides. Every research assistant got graded or assessed by at least three assessors after which corrections were made to ascertain competence on their part. Second, the selected physics teachers who have been chosen as research aides or facilitators were further updated on the instructional strategies in addition to the procedures. Third, the research assistants were asked to demonstrate to the students. The demonstration was rated using the research assistant evaluation sheet. Each of the selected research assistants was given copies of instructional guides and take-home materials as appropriate for the part(s) he/she was going to play. This was be done after the training session to complement the teachers' own regular lesson notes. Both the pretreatment activities and training of research assistants continued for two weeks.

3.6.3 Administration of Pretest

All SS II physics students who took part in the study were first pretested using the following instruments, Physics Achievement Test (PAT), Physics Students' Attitude Questionnaire (PSAQ) and Physics Students Academic Commitment Scale (PSACS) with the assistance of the research assistants. The students' scripts were collected and evaluated, and their results were collated. The scores obtained were used to make a judgment on the prerequisite skills to benefit from instructions during treatment.

3.6.4 Treatment Procedure

At the implementation phase, all the three groups were exposed to treatment by the research assistants using the instructional guides prepared by the researcher (Interactive-lecture demonstrations and guided-reverse jigsaw learning strategy) for the experimental groups and conventional strategy (CS) that is the control group.

Instructional Guide:

a. Instructional Guide for Experimental Group I (Interactive Lecture Demonstrations)

Step 1: Introduction

Activity i. The teacher described components of an experiment without recording the data.

Activity ii. Students attempted to ruminate over the demonstration and cited their everyday examples that are related to the ones given by the teacher.

Step 2: Prediction

Activity i. Students attempted individual predictions of the outcome of the experiment.

Activity ii. Students wrote down their predictions on a sheet of paper or a prediction sheet.

Activity iii. Students discuss their predictions with peers in the class.

Activity iv. Students write new or same prediction on the prediction sheet.

Step 3. Presentation

Activity i. The teacher or any good student in the class carried out the experiment.

Activity ii. The teacher collected the real data in a manner in which all students can observe the results.

Step 4: Discussion

Activity i. The teacher or any student with a correct prediction discusses the results with the class.

Activity ii. The students then copied the correct solutions on a separate hand-out or note.

Activity iii. The teacher led the class in a brief discussion on other real-word applications of the theory.

Step 5: Evaluation of Learning Objectives

Activity i. The teacher asks students questions on the task carried out and take note of the students' responses.

Activity ii. The teacher appreciates and rewards correct responses and takes time to explain better where necessary.

Activity iii. Diagrams, formulae, worked examples involved in the lesson are discussed for detailed knowledge of the concept.

Step 6: Summary

Activity i. The teacher summarizes the important points of the topic on the board.

Activity ii. Students copy the important points into their notebooks.

Step 7: Assignment

Students are given take-home assignment

b. Instructional Guide for Experimental Group II (Guided Reverse Jigsaw Learning Strategy)

Step 1: Introduction

Activity i. The teacher introduces the lesson with the provision of relevant instructional materials.

Activity ii. Students are asked questions on the topic or the related one to launch them into the new topic.

Step 2: Splitting of Students into Home Groups and Topic into Segments

Activity i. Students are divided into 4- to 5- jigsaw groups taking into consideration their academic ability, gender, age etc

Activity ii. A student from each group was appointed to be the leader.

Activity iii. The teacher divides the day's lesson into 5 or 6 segments.

Activity iv. Each student was assigned by the leader to learn one segment.

Step 3: Task Performance by Students

Activity i. Students were given instructions and enough time to read over their segments to become familiar with it.

Activity ii. The students carried out the task presented to them.

Activity iii. They listed the common features, properties or solve mathematical problems where necessary.

Activity iv. The students analyze the components of the task before them and list the various aspects of the segments.

Activity v. Students come up with new ideas and new knowledge about what they learnt.

Step 4: Meeting at the Expert Groups

Activity i. Temporary "expert groups" were then formed by picking one student from each jigsaw group to join other students assigned to the same segment.

Activity ii. Students in the expert group are given time to discuss the main points of their segments and rehearse the presentation they will make to their home group and the whole class.

Activity iii. Students in the expert groups return to their home groups and each of them is asked to present his or her segment to the home group and the class.

Activity iv. Other students in the class are encouraged to ask questions for clarification.

Step 5: Evaluation

Activity i. The teacher gives a quiz on the material so that students can quickly come to realize that their sessions are not just for fun and games but really count.

Activity ii. Teachers take note of the students' responses and rewards them accordingly.

Step 6: Summary

Activity i. The teacher summarizes the important points after which the students copy them into their notes.

Step 7: Assignment

Activity i. Students are given take-home assignment on related questions.

c. Instructional Guide for Control Group (Conventional Learning Strategy)

Step 1: Introduction

Activity i. The teacher writes the topic on the board.

Activity ii. The teacher asks questions requesting information on their prior knowledge of the topic.

Activity iii. The students respond to the questions asked by the teacher.

Activity iv. The teacher establishes a link between their appropriate responses and the lesson for the day.

Step 2: Presentation

Activity i. The teacher describes/defines/ explains the new concept for the day to students.

Activity ii. The teacher demonstrates to the students the processes of each concept

Activity iii: The students observe teacher's demonstration and make comments on their observations.

Step 3: Evaluation

Activity i. The teacher examines students on the concepts taught.

Step 4: Summary

Activity i. The teacher dictated the note to the students for them to copy

Step 5: Assignment

Activity i. The students are given take-home assignments against next lesson.

3.7 Administration of Posttest

The completion of the treatment was followed by the administration of the posttest by the research assistants to the students in both experimental and control groups using the instruments (PAT and PSAQ). The students' scripts were thereafter collected and assessed. The students' scores were collated, coded and analysed.

3.8. Method of Data Analysis

Analysis of covariance was used to the data using the pretest scores as covariates. In addition, the Estimated Marginal Means were used to ascertain the mean scores of the different groups. Bonfernoni post hoc test was adopted in spotting the source of significant difference in the groups. All hypotheses were tested at 0.05 level of significance.

CHAPTER FOUR

RESULTS AND DISCUSSION

The chapter dealt with the discussion of the results of this study. Findings of the study are presented in the sequence in which the hypotheses were arranged. Discussion of findings also followed accordingly. All the null hypotheses were tested at 0.05 level of significance.

4.1 Demographic Information

Table 4.1: Demographic Information of Students

Distribution of Students across the Groups

ILD	GRJIS	CS
83	126	105

Distribution of Students according to Gender

Gender	No. of Students	Frequency
Male	148	47.1%
Female	166	52.9%
Total	**314**	**100%**

Distribution of Students according to Level of Commitment

Level of Commitment	No. of Students	Frequency
Low	172	54.8%
High	142	45.2%
Total	**314**	**100%**

A total of 314 students took part in the study out of which 83 are in the ILD group, 126 in GRJIS group, while the Control group (CG) comprised of 105 students. One hundred and forty eight students representing 47.1% of the total participants are male, while 166, an equivalent of 52.9% of the participants are females. Of the total participants in the study, 172 (54.8%) had low level commitment, while 142 (45.2%) had high commitment.

4.2 Testing of Null Hypotheses

4.2.1 Hypotheses 1a: There was no significant main effect of treatment on students' achievement in concepts of light in physics.

To test this hypothesis, the data obtained from the post-test achievement test was subjected to Analysis of Covariance (ANCOVA) and the result obtained is presented in Table 4.2.

Table 4.2: Analysis of Covariance (ANCOVA) of Post-Achievement by Treatment, Commitment and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1564.621	12	130.385	22.444	0.000	0.472
Intercept	983.936	1	983.936	169.373	0.000	0.360
PreAchievement	1029.824	1	1029.824	177.272	0.000	0.371
Treatment	626.849	2	313.424	53.952	0.000*	0.264
Commitment	37.969	1	37.969	6.536	0.011*	0.021
Gender	0.277	1	0.277	0.048	0.827	0.000
Treatment x Commitment	1.428	2	0.714	0.123	0.884	0.001
Treatment x Gender	24.681	2	12.341	2.124	0.121	0.014
Commitment x Gender	1.378	1	1.378	0.237	0.627	0.001
Treatment x Commitment x Gender	8.110	2	4.055	0.698	0.498	0.005
Error	1748.592	301	5.809			
Total	39075.000	314				
Corrected Total	3313.213	313				

$R^2 = 0.47$ (Adjusted $R^2 = 0.45$) * denotes significant $p<0.05$

Results in Table 4.2 revealed that there was a significant main effect of treatment on students' achievement in physics ($F_{(2, 312)} = 54.95$; $p<0.05$, partial $\eta^2 = 0.26$). The table revealed the effect size of 26.0%, implying that 26.0% of the total 47.0% variation observed (Adjusted $R^2 = 0.45$) in students' post-achievement scores in physics in the ANCOVA model was due to the significant main effect of the treatment. Thus, hypothesis 1a was rejected. This implies that physics post-test achievement mean score of students exposed to ILD and GRJIS is significantly better than that of those exposed to control/conventional instructional strategy. In order to explore the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups was carried out and the result is presented in Table 4.3.

Table 4.3: Estimated Marginal Means for Post-Achievement by Treatment and Control group

			95% Confidence Interval	
Treatment	Mean	Std. Error	Lower Bound	Upper Bound
Experimental Group 1 (ILD)	11.89	0.29	11.31	12.46
Experimental Group 2 (GRJIS)	11.82	0.22	11.38	12.26
Conventional Strategy (CS)	8.55	0.26	8.05	9.06

Results in Table 4.3 revealed that students in the treatment group 1 had the highest adjusted mean score in their post-achievement in physics which is (11.89), followed by those in the treatment group 2 (11.82), while the Conventional Strategy (CS) control group has the least adjusted post-achievement score of (8.55). This order is represented ILD > GRJIS > CS.

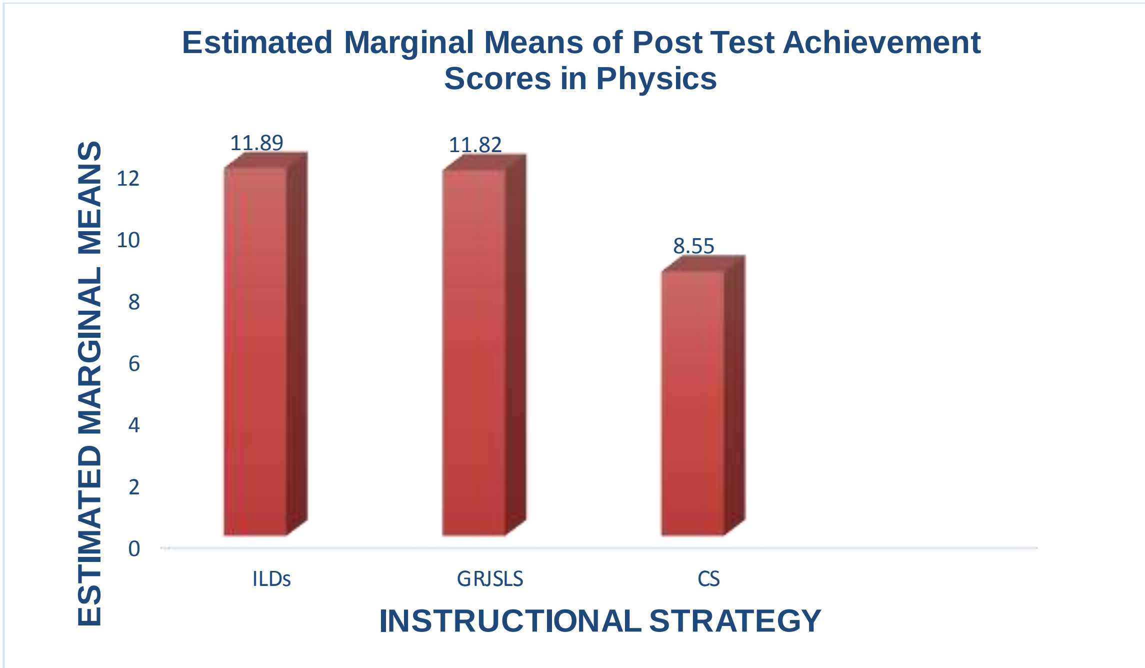


Fig. 4.1: The Estimated Marginal Means of Post-Test Achievement Scores in Physics

Fig 4.1 shows the bar chat of the Estimated Marginal Means of Posttest achievement scores of students in Physics. It could be deduced that students in the treatment ILDs and GRJIS groups had a mean score of 11.89 and 11.82, respectively while the students in the conventional group had a mean score of 8.55. The implication of this finding is that students in the ILD group attained the highest mean score, trailed by those in GRJIS with mean post achievement score of 11.82, while those in the CS had the least score of 8.55.

To further show that students in the interactive lecture demonstrations and guided reversed jigsaw instructional strategy achieved better than those in the Conventional (control) group. The estimated Marginal Means of the groups is illustrated thus with line graph in Figure 4.2.

Fig 4.2: Line Graph of the EMM of Post-test Achievement Scores in Physics

In order to determine which of the groups caused this significant main effect of treatment on students’ achievement in physics, the Bonferroni post-hoc test was carried out across the groups, while the result is presented in Table 4.4

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

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Sig.
Experimental Group 1 (ILD)	Experimental Group 2 (RJSLS)	.067	1.000
	Conventional Strategy (CS)	3.336	.000*
Experimental Group 2 (GRJIS)	Experimental Group 1 (ILD)	-.067	1.000
	Conventional Strategy (CS)	3.268	.000*
Conventional Strategy (CS)	Experimental Group 1 (ILD)	-3.336	.000*
	Experimental Group 2 (GRJSLS)	-3.268	.000*

* denotes significant $p<0.05$

Table 4.4 showed that the post-achievement mean score of students in physics in the experimental group 1 was not significantly different from those in the experimental group 2 but significantly different from those taught with the conventional strategy. Also, the difference in the post-achievement mean-scores of students exposed to experimental group 2 and those in the conventional strategy was significant. This means that the significant difference in the post-achievement mean scores in physics observed in the ANCOVA result was not due to the difference between the treatment groups (interactive-lecture-demonstrations and guided-reverse jigsaw groups) but between the treatment groups and the control group. For instance, the difference in the post-achievement scores between the treatment groups (ILD and GRJIS) is $\pm$ 0.067 which is considered not significant, while for the treatment and control groups, the mean difference is $\pm$ 3.336 or $\pm$ 3.268. This is too high and considered significant

This is further illustrated with the line graph in Fig 4.3 and bar chat in Fig 4.4.

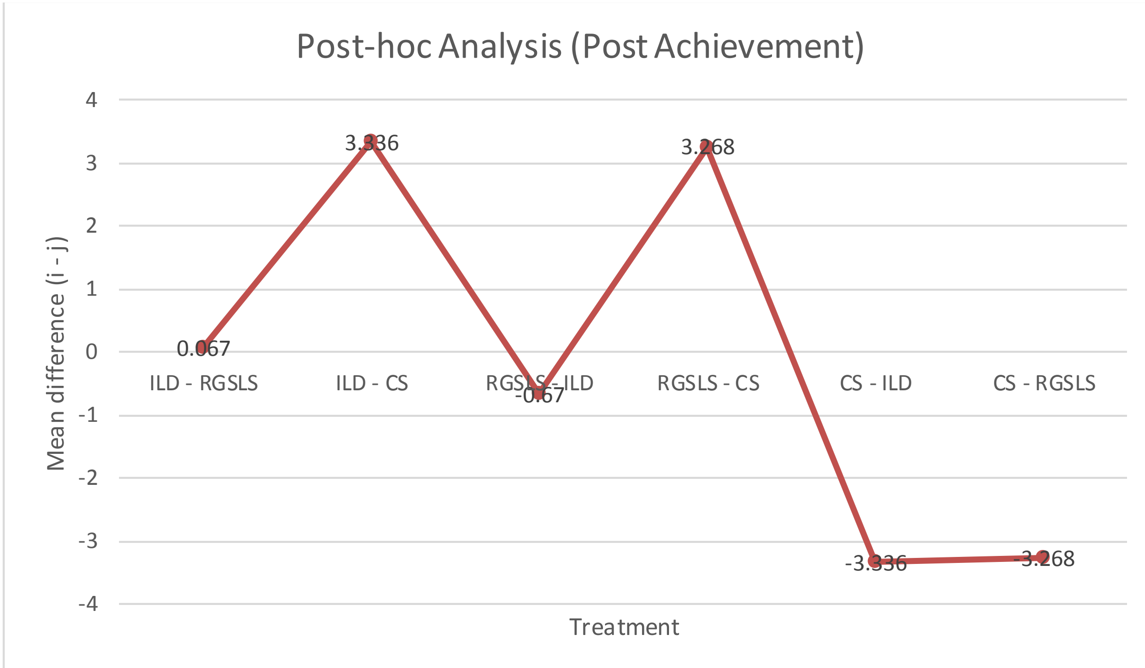
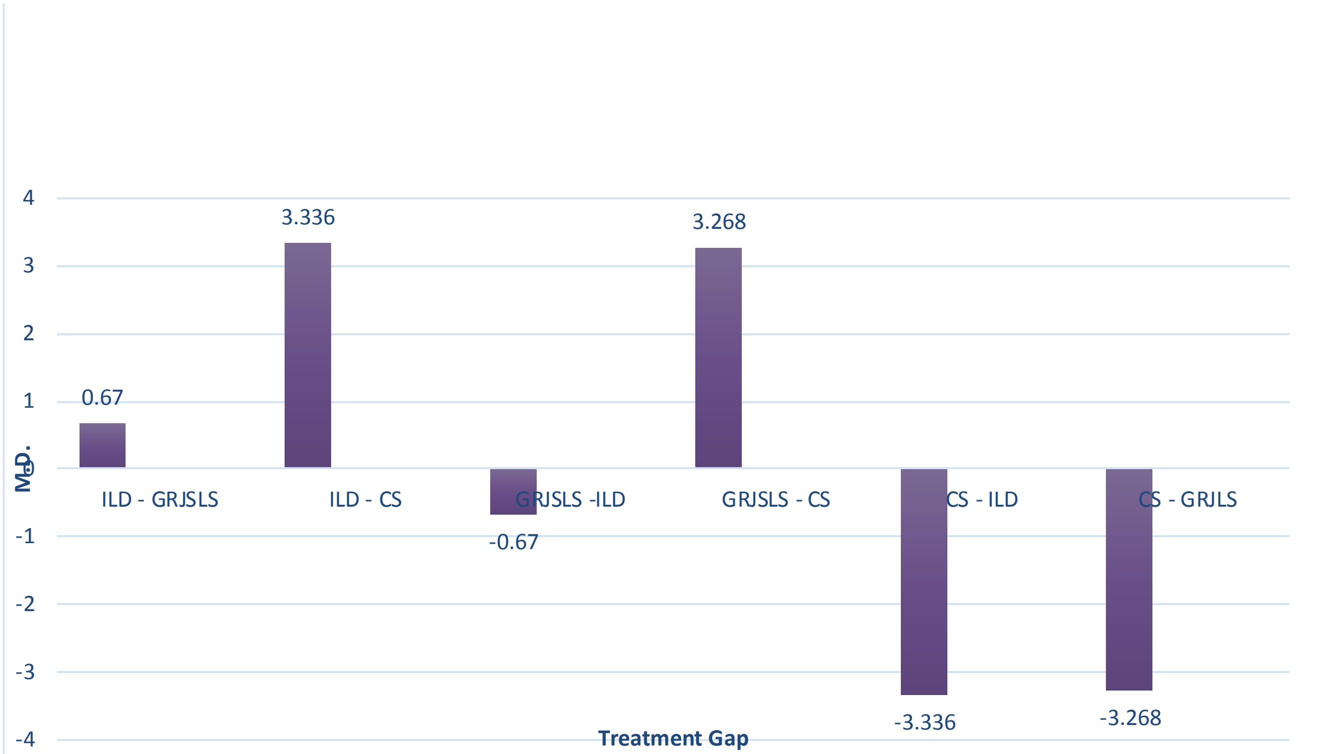


Fig 4.3: Line Graph of Post-hoc Analysis of Post-Achievement by Treatment and Control Groups



M.D.= Mean Difference

Fig 4.4: Bar- Chat of Post-hoc Analysis of Post Achievement Scores

It is very obvious from the figures that the difference in the means scores between the two experimental groups is so negligible compared to the one between every experimental and the control groups.

Hypotheses 1b: There was no significant main effect of treatment on students' attitude towards learning of concepts of light in physics.

In order to test the hypothesis, the data obtained from the use Physics' Students Attitude Questionnaire (PSAQ) was subjected to Analysis of Covariance (ANCOVA) with the results obtained presented in Table 4.5 below.

Table 4.5: Analysis of Covariance (ANCOVA) of Post-Attitude by Treatment, Commitment and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3621.192	12	301.766	9.453	0.000	0.274
Intercept	8619.190	1	8619.190	270.004	0.000	0.473
PreAttitude	2.323	1	2.323	0.073	0.788	0.000
Treatment	2827.035	2	1413.517	44.280	0.000	0.227
Commitment	0.002	1	0.002	0.000	0.993	0.000
Gender	51.118	1	51.118	1.601	0.207	0.005
Treatment x Commitment	8.220	2	4.110	0.129	0.879	0.001
Treatment x Gender	6.655	2	3.328	0.104	0.901	0.001
Commitment x Gender	73.259	1	73.259	2.295	0.131	0.008
Treatment x Commitment x Gender	23.952	2	11.976	0.375	0.687	0.002
Error	9608.668	301	31.922			
Total	669034.000	314				
Corrected Total	13229.860	313				

R^2 = 0.27 (Adjusted R^2 = 0.25) * denotes significant $p<0.05$

In Table 4.5, it was revealed that there was a significant main effect of treatment on students' attitude to physics ($F_{(2, 312)}$ = 44.28; $p<0.05$, partial η^2 = 0.23). Table 4.5 revealed the effect size of 23.0%. This means that 23.0% of the total 27.0% variation observed (Adjusted R^2 = 0.25) in students' post-attitude scores in physics was due to the significant main effect of the treatment. Hence, hypothesis 1b was rejected. This implies that the main effect of the treatment on students' attitude towards physics is significant with an effect size of 23%.

To further show that those exposed to ILD and GRJSLS exhibited a better attitude to the concepts of light in physics, the estimated marginal means of the treatment groups was carried out and the result obtained is presented in Table 4.6.

Table 4.6: Estimated Marginal Means for Post-Attitude by Treatment and Control group

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental Group 1 (ILD)	50.70	0.69	49.35	52.05
Experimental Group 2 (GRJIS)	45.12	0.53	44.08	46.16
Conventional Strategy (CS)	42.30	0.58	41.15	43.44

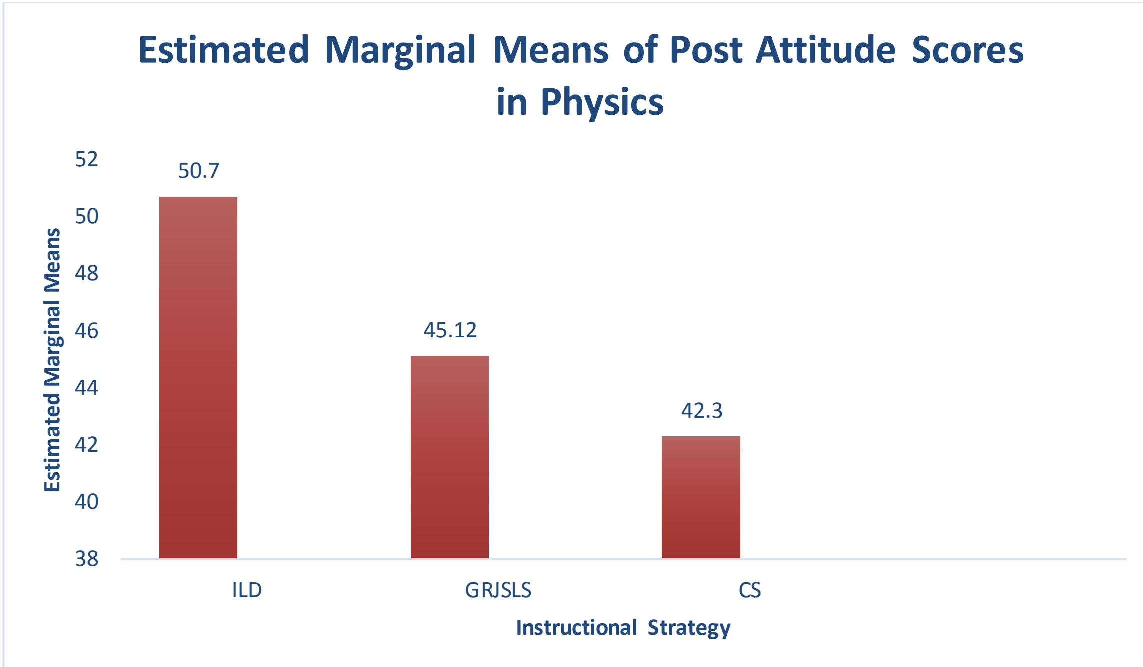


Fig. 4.5: The Estimated Marginal Means of Post Attitude Scores in Physics

The above result revealed that students in the treatment group 1 (interactive lecture demonstrations group) had highest adjusted mean score in their post-attitude to physics (50.70) followed by those in the treatment group 2 (reverse-jigsaw teaching strategy group) (45.12) and the Conventional Strategy (CS) control group has (42.30). This order is represented ILD > GRJSLS > CS. This is further illustrated with line graph as in Figure 4.6.

Fig 4.6: Line Graph of Estimated Marginal Means of Post Attitude Scores of Physics Students

To determine which of the groups caused this significant main effect of treatment on students' attitude to physics, the Bonferroni post-hoc test was carried out across the groups, while the result is presented in Table 4.7

Table 4.7: Bonferroni Post-hoc Analysis of Post-Attitude by Treatment and Control Group

(I) treatment	(J) Treatment	Mean Difference (I-J)	Sig.
Experimental Group 1 (ILD)	Experimental Group 2 (RJSLS)	5.581*	0.000
	Conventional Strategy (CS)	8.404*	0.000
Experimental Group 2 (GRJSLS)	Experimental Group 1 (ILD)	-5.581*	0.000
	Conventional Strategy (CS)	2.823*	0.001
Conventional Strategy (CS)	Experimental Group 1 (ILD)	-8.404*	0.000
	Experimental Group 2 (GRJSLS)	-2.823*	0.001

* denotes significant $p<0.05$

Table 4.7 indicated a significant difference in the post-attitude mean scores of physics students in the experimental groups in favor of interactive lecture demonstrations. Also, the difference in the post-attitude mean-scores of students in experimental group 1 and those in the conventional strategy was significant. This indicates that the significant difference observed in the ANCOVA result was due to the difference between the treatment groups (experimental groups 1 and 2) and also between the treatment groups and the control group as students' post-attitude scores to physics is concerned. This finding is further pictorialised with bar chart and line graph as in Figures 4.7 and 4.8.

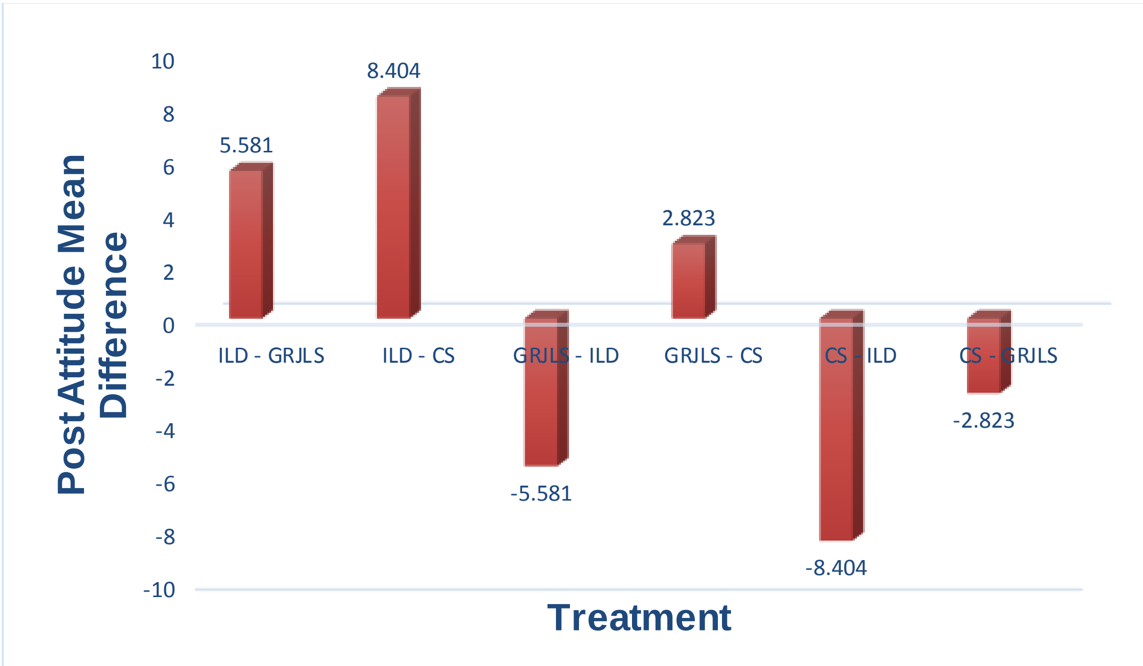


Fig. 4.7: Bar Chart of the Post-hoc Analysis of Post Attitude Scores of Physics Students

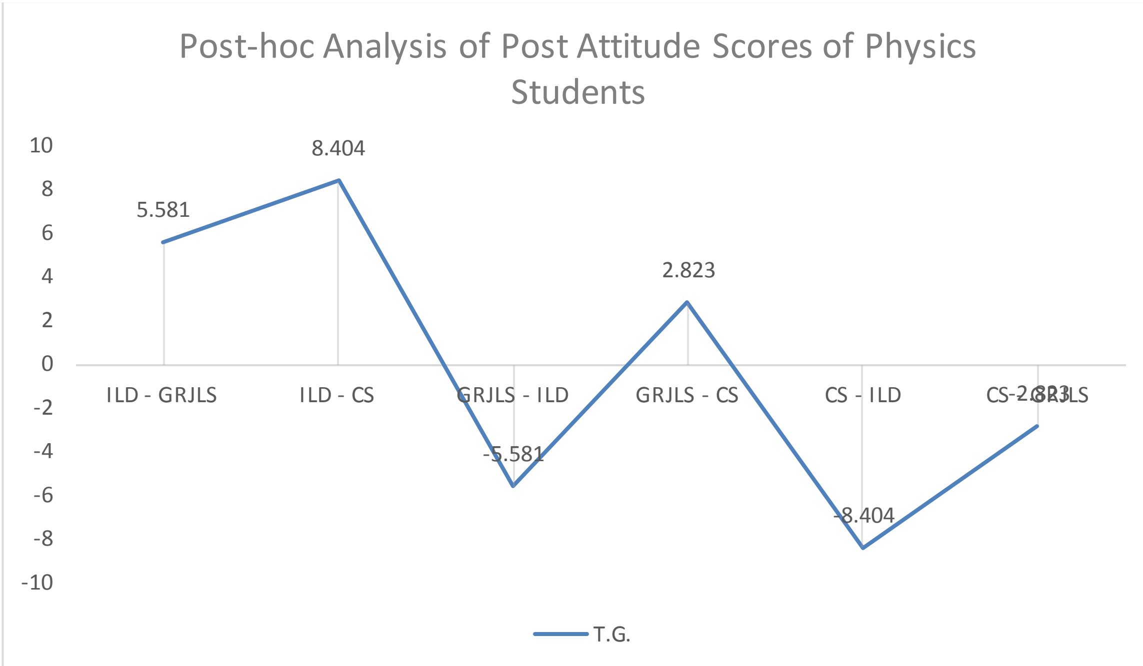


Fig. 4.8: Line Graph of the Post-hoc Analysis of Post Attitude Scores of Physics Students

Analysis of the two figures indicated high mean difference between the two experimental groups as well as the one between each of the experimental groups and the control group. This implies that the change in attitude is due to the difference between the treatment groups (ILD and GRJIS) and between the treatment groups and the conventional group.

Hypotheses 2a: There was no significant main effect of students' commitment to learning on their achievement in concepts of light in physics

Results in Table 4.2 showed that there was a significant main effect of students' level of commitment on students' achievement in physics ($F_{(1; 313)} = 6.54$; $p<0.05$, partial $\eta^2 = 0.02$). Table 4.2 revealed the effect size of 2.0%, implying that 2.0% of the total 45.0% variation observed (Adjusted $R^2 = 0.45$) in students' post-achievement scores in physics in this ANCOVA model was due to the significant main effect of level of commitment. Thus, hypothesis 2a was rejected. In order to explore the magnitude of the significant main effect across commitment groups, the estimated marginal means of the groups was carried out and the result is presented in Table 4.8.

Table 4.8: Estimated Marginal Means for Post-Achievement by Commitment

				95% Confidence Interval	
Treatment	N	Mean	Std. Error	Lower Bound	Upper Bound
Low	172	10.38	0.21	9.96	10.79
High	142	11.13	0.21	10.72	11.54

Results in Table 4.8 indicated that students with high level of commitment to physics had the higher adjusted mean score in their post-achievement in physics (11.13), followed by their counterparts with low commitment in physics (10.38). For clarification and better understanding, the bar-chart in Figure 4.9 displays a picture of the effect of students' level of commitment on their academic achievement in physics.

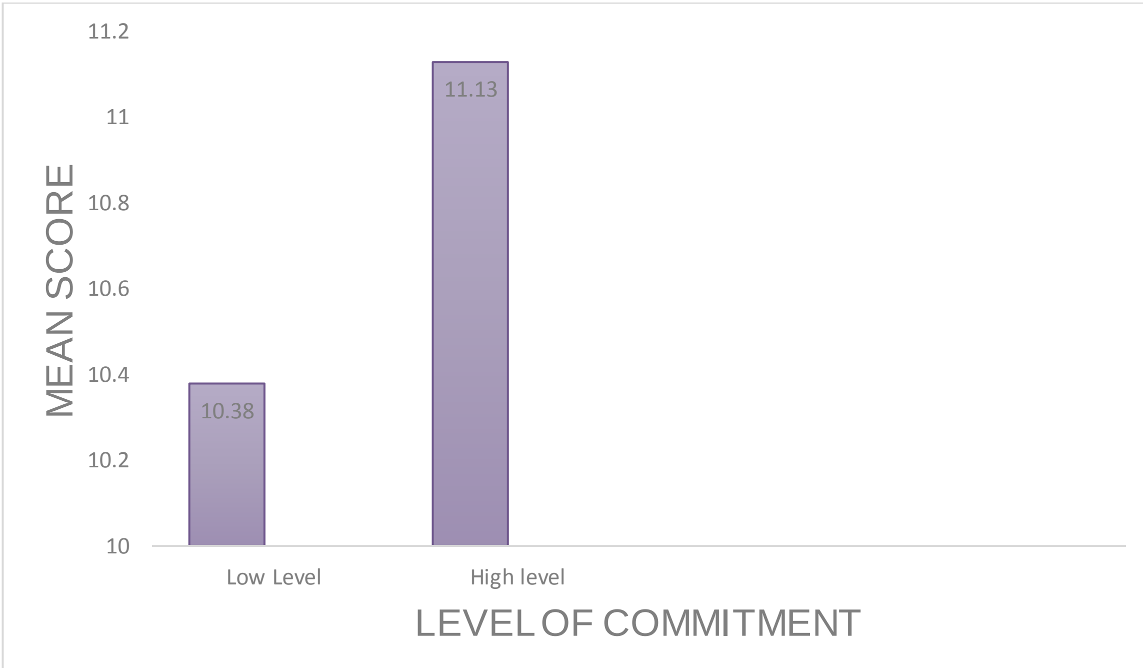


Fig. 4.9: Bar-Chart Showing the Effect of Commitment on Academic Achievement in Physics

Hypotheses 2b: There was no significant main effect of level of commitment on students' attitude towards learning concepts of light in physics

Table 4.5 showed that the main effect of level of commitment on students' attitude to physics ($F_{(1, 313)} = 0.00$; $p>0.05$, partial $\eta^2 = 0.00$) was not significant. Therefore, hypothesis 2b was not rejected. This implies that students' level of commitment to concepts of light in physics had no effect on their attitude to physics.

Hypotheses 3a: There is no significant main effect of gender on students' achievement in concepts of light in physics

Results in Table 4.2 indicated that there was no significant main effect of gender on students' achievement in light concepts in physics ($F_{(1, 313)} = 0.05$; $p>0.05$, partial $\eta^2 = 0.00$). Hence, hypothesis 3a was not rejected. This means that gender had no effect on students' achievement in physics.

Hypotheses 3b: There is no significant main effect of gender on students' attitude towards learning light concepts in physics

Results in Table 4.5 revealed that gender does not have any significant main effect on attitude of students to learning concepts of light in physics ($F_{(1, 313)} = 1.16$; $p>0.05$, partial $\eta^2 = 0.01$). Hence, hypothesis 3b was not rejected. This implies that gender had no effect on students' attitude to physics.

Hypotheses 4a: There is no significant interaction effect of treatment and students' level of commitment on students' achievement in light concepts in physics.

Table 4.2 indicated that there was no significant interaction effect of treatment and level of commitment on students' achievement in light concepts in physics ($F_{(2; 312)} = 0.12$; $p>0.05$, partial $\eta^2 = 0.00$). Thus, hypothesis 4a was not rejected. This indicates that treatment and commitment combined had no effect on students' achievement in physics.

Hypotheses 4b: There is no significant interaction effect of treatment and level of commitment on students' attitude towards learning light concepts in physics.

Table 4.2 indicated that treatment and commitment did not have a significant interaction effect on attitude of students to concepts of light in physics ($F_{(2; 312)} = 0.13$; $p>0.05$, partial $\eta^2 = 0.00$). Thus, hypothesis 4b was not rejected. This indicates that the treatment and commitment had no effect on students' attitude to physics.

Hypotheses 5a: There is no significant interaction effect of treatment and gender on students' achievement in light concepts in physics.

Results in Table 4.2 indicated that there was no significant interaction effect of treatment and gender on students' achievement in light concepts in physics ($F_{(2; 312)} = 0.12$; $p>0.05$, partial $\eta^2 = 0.01$). Hence, hypothesis 5a was not rejected. This means that treatment and gender had no effect on students' achievement in concepts of light in physics.

Hypotheses 5b: There is no significant interaction effect of treatment and gender on students' attitude towards learning concepts of light physics.

Results in Table 4.5 showed that the interaction effect of treatment and gender on students' attitude to light concepts in physics ($F_{(2; 312)} = 0.10$; $p>0.05$, partial $\eta^2 = 0.00$) was not significant. Thus, hypothesis 5b was not rejected. This implies that interaction effect of treatment and gender on students' attitude to physics (light concepts) is not significant.

Hypotheses 6a: There is no significant interaction effect of level of commitment and gender on students' achievement in light concepts in physics.

Results in Table 4.2 revealed that the interaction effect of level of commitment and gender on students' achievement in light concepts in physics ($F_{(1; 313)} = 0.24$; $p>0.05$, partial $\eta^2 = 0.00$) was not significant. Therefore, hypothesis 6a was not rejected. This implies that students' level of commitment and gender had no effect on students' achievement in light concepts in physics.

Hypotheses 6b: The interaction effect students' commitment and gender on attitude of students to learning light concepts in physics is not significant.

Table 4.5 above is a confirmation that the interaction effect of students' level of commitment and gender on students' attitude to learning light concepts in physics ($F_{(2; 312)}$ = 2.30; p>0.05, partial η^2 = 0.01) was not significant. Thus, hypothesis 6b was not rejected. This implies that level of commitment and gender had no effect on students' attitude to physics (light concepts).

Hypotheses 7a: There is no significant interaction effect of treatment, students' level of commitment and gender on students' achievement in light concepts in physics.

Results in Table 4.2 revealed that there was no significant interaction effect of treatment, level of commitment and gender on students' achievement in physics (light concepts) ($F_{(2, 312)}$ = 0.70; p>0.05, partial η^2 = 0.01). Therefore, hypothesis 7a was not rejected. This indicates that treatment, level of commitment and gender had no effect on students' achievement in concepts of light in physics.

Hypotheses 7b: There is no significant interaction effect of treatment, students' level of commitment and gender on students' attitude towards concepts of light in physics.

Table 4.5 indicated that the interaction effect of treatment, level of commitment and gender on students' attitude to physics ($F_{(2; 312)}$ = 0.38; p>0.05, partial η^2 = 0.00) was not significant. This, hypothesis 7b was not rejected. This indicates that treatment, and students' level of commitment and gender had no effect on students' attitude to concepts of light in physics.

4.3 Summary of Findings

1. There were significant main effects of treatment on students' achievement in and attitude to concepts of light in physics.
2. Students' level of commitment was significantly related to achievement in light concepts in physics but not to attitude of students to light concepts in physics.
3. There were no significant main effects of gender on students' achievement in and attitude to the concepts of light in physics.

4. There were no significant interaction effects of treatment and students' level commitment on the achievement of students in and attitude of students to the concepts of light in physics.
5. Treatment and gender had no significant interaction effect on achievement of students in and attitude to concepts of light in physics.
6. Students' level of commitment and gender had no significant interaction effects on the achievement of students in and attitude to concepts of light in physics.
7. Treatment, students' level of commitment and gender had no significant interaction effects on achievement of students in and attitude to concepts of light in physics.

4.4 Discussion of Findings

Results obtained from the study are discussed according to the hypotheses postulated in chapter one.

4.4.1a Effects of Treatment on Students' Achievement of Students in Physics (Light)

It is obvious from the study that physics students recorded significant gains and achievement after exposure to treatment (interactive lecture demonstrations, guided-reverse jigsaw instructional strategy and conventional strategy). Students taught with ILDs had the highest adjusted post-achievement mean score in the Physics Achievement Test (PAT), trailed by GRJIS group, while CS group recorded the lowest post-achievement mean score.

The effectiveness of the ILDs as shown by their better mean score can be attributed to the nature of the strategy which involves students interacting with the teachers, their peers and materials thereby improving on their engagement in or commitment to learning light concepts in physics. This in turn had a positive impact on their achievement in physics. In addition, active participation of the students as a result of the nature of the strategy implied that students were carried along in the learning process as there were demonstrations of the concepts learnt to further show their understanding. In consequence, there is an improvement in their practical skills as well as their academic achievement. As an activity-based strategy, it arose students' interest in the abstract light concepts taught by demonstrating this to the students in class which in turn improved on their achievement. The strategy emphasises on students' involvement in the various activities in class such thinking, demonstrating and teaching. The strategy recognises the fact that students come into the classroom with preconceived notion about the workings of the physical world around which could block their understanding of the light concepts in physics. Those notions were knocked off by the various steps in the strategy. This in turn improved on their achievement as reflected in their mean achievement score which was the best among the treatment.

Guided reverse jigsaw instructional strategy (GRJIS) on the other side was better than the conventional strategy as the second best. This is attributable to the cooperative and collaborative nature of the strategy which enables students to rely on one another in the task of learning a concept. Students are engaged as every student in a group is saddled with the responsibility of getting something unique to contribute to the group's task. Accomplishing this requires that no two students in a group should be allowed to do the same task. This makes the students to become eager to demonstrate their innate abilities in carrying out any task given to them, as no student would want to be seen as being lazy. It further enables them to work harder and go extra miles to get things done by taking charge of their individual responsibilities thereby, improving their academic achievement as shown by the mean score.

Findings of the study corroborate Lawrence, (2018) who carried out a study on the relative effectiveness of enriched demonstration and enriched lecture instructional strategies on senior secondary school students' achievement in chemistry and whose results revealed a significant difference in the achievement of students exposed to enriched-demonstration strategy compared to their counterparts taught with enriched lecture strategy. Similarly, Slekiene and Raguliene (2010) carried out a study that dealt with the application of interactive lecture demonstrations tagged (IALD) during lectures of general physics phenomenon. The result showed that students taught with IALD performed better.

Moreover, the study agrees with Agu and Samuel (2018), whose investigation on the effect of reversed jigsaw, team –assisted instruction and guided discovery instructional strategies on the interest and achievement of basic science and technology students showed that there were significant differences in the interest and achievement of students which favoured the reversed jigsaw instructional strategy. Saribaglou et al (2019), investigated the effect of reversed jigsaw method on university students' academic performance and anxiety in statistics course and their finding indicated that reversed jigsaw strategy has a positive effect on students' performance among others. Isa and Muhammad, (2019) also observed a statistically significant difference in students' academic performance in chemistry among secondary schools' students when taught with jigsaw instructional strategy.

Contrarily, Komang and Basori (2019)'s study on the efficacy of jigsaw IV and reverse jigsaw instructional model on participation and performance (cognitive abilities) of students favoured jigsaw IV strategy over reverse jigsaw cooperative learning model. In addition, Samuel, (2018) investigation on the effect of jigsaw IV, group investigation and reverse jigsaw cooperative instructional strategies on achievement and retention of basic science students revealed that reverse jigsaw strategy recorded the lowest post achievement score of the three groups.

4.4.1b Effects of Treatment on Students' Attitude to Concepts of Light in Physics

Results indicated a significant main effect of treatment on attitude of students to the concepts of light in physics. In other words, there was a significant difference in the post attitude scores after exposure to treatment (ILDs, GRJIS and CS). The interactive lecture demonstration recorded the greatest post attitude mean score in physics light concepts, inferring that ILDs was the best strategy among the treatment. The outstanding improvement in attitude to physics recorded by those in ILDs group could be attributed to the nature of the strategy that enables the students to utilise several senses while learning. Students can see, hear and possibly experience an actual event. Such method according to Muhammad et al., (2016) when adopted in teaching, will stimulate students' interest, assists in presenting ideas and concepts more clearly, provide direct experiences and reinforce learning. This is in agreement with the submission of Adekunle, (2021) that teacher's use of exciting instructional packages make learning of science and mathematics fun and fascinating for the students thereby, leading to positive attitude towards learning among secondary school students

The implication of this finding is that students will develop positive attitude to classroom activities when they are given the opportunity to take part in the learning process. The result of this study buttressed the findings of Inuwa, Abdullah and Hassan, (2018) which submitted that a demonstration method will enable students to actively participate throughout the lesson period as they would be encouraged to ask questions at each step of the lesson and at the end of the lesson, students are asked to practice some exercises similar to what they learned during the lesson. In addition, students are afforded the opportunities to study on their own. The finding is however in contrast to Moll and Milner-Bolotin (2009) research on computer-based Interactive Lecture Experiments (ILEs) in a large introductory physics course on students' academic achievement and attitudes towards physics which showed that it was insufficient in improving students' attitude to physics.

The post-attitude mean score of students in the guided-reverse-jigsaw instructional strategy group was also good. This is however attributed to the nature of the strategy that enable students to work with one another, getting help from each other, discussing and sharing information with others and enjoying jigsaw context. This submission is consistent with that of Ajitoni and Salako, (2014) that indicated treatment (jigsaw technique) had substantial key influence on learners' attitude. This was further corroborated by Amosa and Mudasiru, (2017) who posited that jigsaw II and other computer-supported cooperative learning strategies had a positive effect on students' attitude towards physics. The findings however contradicts Alghamdi, (2017)'s investigation on of the impact of cooperative learning instruction, specifically by using the Jigsaw instructional strategy on science achievement and attitudes towards science among 11th grade students and reported that Jigsaw as a cooperative learning strategy had no significant change on the students' attitudes towards science.

Generally, findings of this study buttressed the position of the constructivist theory which hammered more on students' active involvement in class activities as displayed by both ILDs and GRJIS. The results further confirms the position of Awandia, (2021) on the investigation of how teacher's teaching methods can change students' negative attitudes towards physics to positive.

4.4.2a Effects of Students' Level of Commitment on Achievement in Physics (Light)

It could be deduced from the study that there is a significant main effect of level of commitment to learning on students' academic achievement in physics (light concepts). Evidence to support this could be found in Table 4.8 which indicated that students with high commitment to physics learning had a higher adjusted mean score in their post-achievement in physics, followed by their counterparts with low commitment in physics. However, the effect size is just 2% which when compared to the effect size of treatment could mean that though level of commitment had an effect on achievement, the effect is overshadowed by that of treatment. The implication is that students with low level of commitment in the treatment group can as well be high achievers in physics. This is possible because the two strategies (ILDs and GRJIS) are full of activities that are capable of improving their commitment level. Such activities include personal research, team work, class activities demonstrations among others.

The higher adjusted mean score of students with high level of commitment could also be traced to such students' intrinsic motivation. For such individuals, the urge and zeal to learn physics arises from within them. They devote greater percentage of their time to class activities and any other assignment that may be given to them because they feel satisfied. This submission is in support of the findings of Agoro, (2002) that learners learn effectively when it originates from their own mind. This was further corroborated by Babajide, (2010) who identified learners' commitment to science as one of the factors in a learning process upon which achievement in science depends. Ogunleye and Babajide (2011) went further to submit that when commitment is improved upon, it could lead to greater urge and zeal towards the learning of Physics.

It further aligns with Muhammad and Ghulam, (2014) investigation to analyze commitment, engagement and locus of control as predictors of academic achievement at higher education level and result revealed significant positive impact of commitment, engagement and locus of control on academic achievement. In a similar study carried out by Akumu, (2019) to examine the relationship between active learning, student's commitment and academic achievement among secondary school students, it was revealed that there was a positive significant relationship between students' commitment and academic achievement. In a related study, Akpan et al., (2012) examined the influence of students' understanding and goal commitment on their academic achievement in Introductory Technology in secondary schools in Akwa Ibom State, Nigeria. 70 percent of the participants were found not to be committed to the pursuit of engineering/technology after the high school, while 30 percent were committed; Students who were committed to technology had higher achievement in Introductory Technology than those who were not. This is in alignment with the findings of RezeiGazki et al. (2019) who tested the pre-hypothesized model of the connection between active learning, students' commitment and academic performance. Results of a simple correlation between variables indicated a significant relationship between academic commitment and academic achievement. Conversely, in a study carried out by Ketula, (2019) to examine the relationship between active learning, student commitment and academic performance among secondary school students in Kawempe Division, a correlation research design was adopted. It was inferred that student's commitment documented no considerable correlation on learners' performance in schools.

4.4.2b Effects of Students' Commitment on Attitude towards Physics (Light)

It is obvious from this research work that commitment had no sizeable main impact on learners' attitude to physics which is ascribed to the fact that commitment is a subset of attitude. There are other indices that could be considered as far as attitude of students to learning is concerned. These include students' point of view towards the subject, the values attached to physics and level of assimilation. The no constraint or advantage of level of commitment on students' attitude to the learning of physics can also be a function of the strategies adopted by the teacher in teaching physics concepts. The finding aligns with Andrew, et al (2018) whose investigation on trust, growth mindset and student commitment to active learning in a college science course, revealed among others, that students' attitude such as students' lack of trust was associated with decreased commitment to (and engagement in) active learning. Students who do not trust their instructor may view active learning as a set of meaningless activities rather than an opportunity to learn. Findings of this study however negate those of earlier studies such as Sitotaw and Tadele, (2016) which found positive correlations between students' level of commitment and their attitude to an activity like learning. They submitted that undesirable attitude towards a subject always causes students to lose interest in participating in any activity-related to the subject, while a positive attitude to science leads to an encouraging commitment to the subject which can influence a all-time attention and learning in science.

4.4.3a Effects of Gender on Students' Achievement in Light Concepts in Physics

The study reported a no significant main effect of gender on the academic achievement of students in physics. This means that the two strategies used in this study are gender friendly as both male and female students showed improvement in the achievement scores during the posttest. This is ascribed to the nature of the items in the Physics Achievement Test (PAT) which may be gender sensitive thereby appealing differently to different sexes. In addition, influence of gender on students' academic achievement may not be a simple phenomenon that is sympathetic to one sex. It may rather have a complicated interaction with other factors such as understanding. This finding lends empirical evidence to that of Ingels and Dalton, (2008) that there is no significant gender difference in students' academic achievement and retention in various subjects. The same observation was made by Iloputaife (2001) who showed no significant relationship due to gender. However, the findings of this study contradict those of many other previous studies such as Okwo and Otubah, (2007); Adeoye, (2010) and Babajide, (2010) that boys do better than girls in physics essay test as well as other tests that are based on physics concepts that require learners of higher numerical ability.

4.4.3b Effects of Gender on Students' Attitude to Physics

Inference from the analysis indicated no sizable core influence of gender on the attitude of learners to physics especially, light concepts. This implies that gender is not key element affecting attitude of students to physics. This finding may be attributed to the fact that attitude according to Erdimer, (2009) is dependent on someone's experiences, knowledge, and skills acquired from other sources. In other words, students might have formed their attitude towards physics based only on the way they are trained.

Findings of this study align with the result obtained by Fatoba and Aladejana, (2014) that examined the effects of gender on students' attitude to physics in senior secondary schools in Oyo State and observed no major impact of gender on attitude of learners to physics. To Casmir, (2011) gender was also found not to exert any significant influence on the attitudes of students towards Biology.

4.4.4a Interaction Effect of Treatment and Level of Commitment on Students' Academic Achievement in Light Concepts in Physics

Result of this study revealed that treatment and commitment had no significant interaction effect on students' achievement in concepts of light in physics. This is evident from Table 4.2. The non-significant interaction effect of treatment and level of commitment showed that students' level of commitment seemed not to interact with instruction to produce results, meaning that the treatment conditions did not discriminate across levels of commitment in the study. This can be traced to the point that the treatment was good enough and would not require any interaction with students' level of commitment to boost the students' performance in physics. The two strategies used for this study do not only keep the students interested and motivated, they equally prevent them from losing their concentration beyond the average attention span of between 15 - 20 minutes. In line with the constructivist theory, students in the experimental groups benefitted immensely from the opportunities provided by the strategies for learners to participate actively, interact freely and collaborate with one another in a learning environment.

4.4.4b Interaction Effect of Treatment and Commitment on Students' Attitude to Physics

A cursory look at Table 4.2 revealed that treatment and commitment documented certainly not, any major interaction influence on attitude of students to physics. Import of this finding is that the extent of students' devotion towards physics notwithstanding, once the suitability of the strategies adopted is ascertained in terms of its emphasis on the relationship and interplay between the concepts that constitute the topics as well as its ability to enable students acquire the basic concepts of the topics, the treatment needs not any interaction with the commitment to effect positive changes in the attitude of the students towards physics learning. This finding disagrees with Georgiou, et al., (2007) who emphasised the role of teachers and schools in changing attitudes stating that academic achievement could be improved by, better teaching methods, more motivated teachers, and better course books among others. The finding is also at variance with that of Garden and Smith, (2001) and Alphine, (2015) who saw an encouraging association concerning attitude and personal efforts and willingness of students to learn which is tantamount to commitment.

4.4.5a Interaction Effect of Treatment and Gender on Students' Achievement in Physics

The result of the study indicated that there was no significant interaction effect of treatment and gender on students' achievement in physics. This means that gender does not interact with treatment offered to the students in the quest for improved academic performance in physics (light concepts). This implies that irrespective of gender, there is a difference between what a learner can achieve independently and what he/she can achieve with the help of more capable peers as preached by the two strategies adopted in this study. This finding agrees with that of Njoku, Nwagbo and Raimi, (2002) and Ugwuanyi (2020) who found no interaction effect of learning strategies and gender on students' achievement. This was further corroborated by Oludipe, (2003) that when a learner interacts and takes on more cognitive responsibility of executing a task in a social environment, he/she gradually internalizes the procedures involved and becomes progressively more learned in that task. Furthermore, Awofala et al, (2013) found no significant interaction effect of treatment and gender on students' learning. The study is however at variance with that of Eze and Obiekwe, (2017) who reported a significant difference in the mean performance in respect of gender when students are exposed to treatment (think-pair-share instructional strategy). The variation observed in the result of this study and that of Eze and Obiekwe (2017) might be due to difference in the choice of strategy adopted and academic subject examined, as Eze and Obiekwe (2017) examined students' performance in chemistry, while the current study examined performance in physics.

4.4.5b Interaction Effect of Treatment and Gender on Students' Attitude to Concepts of Light in Physics

It could be inferred from Table 4.5 that no significant interaction effect of treatment and gender on attitude of students to physics was documented. This implies that students' attitude to physics is not affected by the interaction of treatment and gender and this is attributable to the consistent effectiveness of instructional strategy across students' attitude scores. The result toes the line of Ezeudu and Gbendu, (2020) whose study revealed no significant interaction effect of instructional-method (flipped classroom strategy) and gender on attitude of students. The finding is however at variance with Jana and Patra (2017) who posited that, gender and treatment had significant interaction effect on students' attitude. Similarly, Charoula and Nicos, (2020) also posited that gender and treatment (scaffolding method) recorded a significant interaction effect on attitude of students to learning. The observed interaction effect of teaching method and gender in the previous works could be attributed to the type of instructional design/method utilised and the instructional procedure(s) applied in the classroom.

4.4.6a Interaction Effect of Students' Level of Commitment and Gender on Students' Achievement in Concepts of Light

It is evident from Table 4.2 that commitment and gender had no significant interaction effect on students' performance in light concepts in physics. This implies that the combined effect of students' level of commitment and gender is not sensitive to students' academic achievement in physics. The observed improvement about performance of students with high level of commitment either male or female, can be attributed to their greater involvement through hard work and devotion of larger percentage of their time and energy to the class activities. The findings toed the line of Agoro, (2002) and Gamze, (2010) who submitted that gender and commitment/attitude towards physics did not have any significant effect on academic success. Agoro went further to submit that for successful learning, learners should devote greater percentage of their time to scientific activities. No mention of gender was made in her submission as a prerequisite for successful learning in sciences.

4.4.6b Interaction Effect of Commitment and Gender on Students' Attitude to Physics

Analysis of Table 4.5 presented no significant interaction effect of commitment level of students and gender on attitude of students to light concepts in physics. The import of this is that students' post attitude scores in this study were not in any way sensitive to the students' gender and level of commitment to their studies. The observed positive change in students' attitude if any, may be due to the relevance of the topics in class to the students' daily life and the society in which they operate. This seems to be in line with the submission of Holbrook, (2005) that students fail to connect different facts and concepts with their practical applications when the content contains low levels of orientation towards issues relevant to their everyday life and the society. The change in attitude is therefore not a function of gender or students' level of commitment or their interaction.

4.4.7a Interaction Effect of Treatment, Commitment Level and Gender on Students' Achievement in Physics

It is evident from Table 4.2 that there was no significant interaction effect of treatment, students' level of commitment and gender on students' achievement in physics. This implies that students' academic achievement was not enhanced by the interaction effects of commitment and gender after all, gender has not been reported in this study to have any significant effect on students' academic achievement in physics, while the effect of commitment on academic achievement could not be said to be all that significant considering the post achievement score of students with high level commitment to those with low level commitment. This result therefore gives credence to the superiority of the instructional strategies (ILDs and GRJIS) adopted for this study. In other words, the strategies boosted students' academic achievement in physics irrespective of the combined effect of students' level of commitment and gender. The aftermath of this research work substantiated Bandura in Saul (2016) who emphasized that social learning theory advocates the use of collaborative and cooperative strategies which requires student's full participation, collaboration among students and the coaching role of the teacher in teaching.

4.4.7b Interaction Effect of Treatment, Students' Level of Commitment and Gender on Students' Attitude to Physics

Table 4.5 indicated that treatment, commitment and gender are of no significant three-way interaction effect on students' attitude to concepts of light in physics. This implies that students' attitude to physics is not dependent on the interaction effect of commitment and gender but the nature of treatment used for the study. This is in agreement with the submission of Adodo and Gbore (2012) who concluded that the solution to changes in student's attitude is dependent on teachers. Teachers are thus implored to employ interesting teaching methods in the teaching of science, as this will not only bring about an improvement in students' performance in science but will also bring about lasting and permanent positive attitude towards science.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary, conclusions and recommendations of the study.

5.1 Summary

The study was carried out to determine the effects of interactive demonstrations and guided-reverse jigsaw learning strategies on secondary school students' achievement and attitude to concepts of light in physics in Oyo State, Nigeria. Also, the moderating effects of students' gender and their level of commitment to light concepts in physics were also investigated. John Dewey's constructivist theory of interaction and albert Bandura's social cognitive theory provided the theoretical backing for the study. Seven null hypotheses were raised and tested at 0.05 level of significance. The study adopted the pretest-posttest control group quasi experimental design. Seven research instruments comprising of four stimulus and three response were developed and validated with reported reliability indices, while inferential statistics of Analysis of covariance was used to analyse the data. The results of the study revealed that physics students recorded significant gains in terms of achievement to and attitude to light concepts in physics when taught with interactive demonstrations and guided-reverse jigsaw learning strategies. The study also submitted that the strategies have potentials to stimulate interest, present ideas and concepts more clearly, provide direct experiences and reinforce learning.

5.2 Conclusion

The crux of this study was to come up with ways to improve physics students' academic performance in as well as their attitude to concepts of light in schools. Through the investigation, an attempt was made to determine the effects of interactive lecture demonstrations and guided-reverse jigsaw learning strategies on students' academic achievement in and attitude to physics. The two strategies were found to be very effective. Interactive lecture demonstration was found to be more effective than the reverse-jigsaw learning strategy in reducing the problems of poor academic performance in; and negative disposition to physics. As a result, the study is of the opinion that the two strategies, interactive lecture demonstrations and guided-reverse jigsaw learning strategies could be used to enhance conceptual learning in physics regardless of students' gender and level of commitment to learning.

5.3 Educational Implications

The findings of this study have several significant implications. Specifically, the study has shown the importance of adopting innovative strategies that will be beneficial to students for classroom instruction. The two strategies viz-a-viz interactive lecture demonstrations and guided-reverse jigsaw learning strategies adopted in this study had been shown to be of significant impact on students achievement and attitude to physics. This is attributed to a very interesting nature of the strategies to connect different facts and concepts in classes with their practical applications. It thus makes the content relevant to the students' everyday life and the society in which they find themselves. Physics is a physical science that tries to explain the material world and the natural phenomena in our environment. Thus, it is practical in nature. The import of this is that in teaching physics, ideas and concepts must not only be presented more clearly but must be able to provide direct or real-life experiences and reinforce learning. By so doing, the teacher would have succeeded in debunking the erroneous impression of students that physics is difficult, abstract and meant for geniuses only. To achieve this, efforts should be made by physics teachers to source for instructional materials from the students' immediate environment and the in-class activities should be shifted from the teacher in front of the class to interactions among students.

5.4 Limitations to the Study

The study was confronted with many restraints amongst which are:

1. The two strategies are instructional materials intensive which are either lacking or inadequate in some schools thereby imposing extra cost on the researcher of either improvising or borrowing from the nearby schools. The materials include ray box, bent metal pipe, tainted glasses among others.
2. Time allotted for physics lesson is not adequate enough to accommodate effective use of the strategies in question.

5.5 Recommendations

Based on the findings from this research work, it is hereby recommended that:

1. Interactive lecture demonstrations or guided-reverse jigsaw learning strategy should be adopted by physics teachers so as to correct the preconceived notion of students about the concept (light).
2. Efforts should be made by teachers to ensure that students work together in group or engage in team work in order to inculcate in them the culture of doing things together cooperatively so as to promote the much talked about unity in diversity in our nation.
3. Students of physics irrespective of gender and level of commitment should be given equal opportunities in the learning process using interactive lecture demonstrations or jigsaw instructional strategy as the two strategies have been shown to be efficacious in addressing issues of differences in gender and level of commitment especially in science education.
4. Physics topics especially, abstract concepts should be taught by associating them with the daily life of the students using simple demonstrations, class activities, team work, and home-work among others.

5.6 Contributions to knowledge

The contributions of the study to knowledge include but not limited to the following.

1. One major contribution of this study to knowledge is the revelation that interactive lecture demonstrations and guided-reverse jigsaw learning strategy are suitable strategies for physics instructions at the post-primary school level.
2. Students' level of commitment and gender were equally found to have little or no influence on the achievement of students in and their attitude to physics.
3. It was equally established that the two strategies are capable of encouraging students' cooperation, collaboration and free interaction with one another.
4. The study was ascertain that both interactive lecture demonstrations and guided-reverse jigsaw learning strategies are capable of enabling students to integrate their daily life experiences into physics classrooms.

5.7 Suggestions for Further Study

For further studies:

1. Similar investigation may be possibly conducted in privately owned secondary schools and involving more local government areas/schools.
2. Other moderating variables aside gender and students' level of commitment should be used in future studies.
3. The study should be replicated on subjects other than physics in like manner by adopting the two instructional strategies as used in the study.

References

Abaidoo, A. 2018. Factors Contributing to Academic Performance of Students in a Junior High School, Munich, Grin Verlag B. Ed-Thesis University of Education, Winneba-Ghana *https://www.grin.com/document/450284*

Abdullah, A. and Filiz, B. 2017. The Effect of Jigsaw Technique on the Students' Laboratory Material Recognition and Usage Skills in General Physics Laboratory-I Course *Universal Journal of Educational Research,* 5.7: 1073-1082.

Abdullahi, Z. M, Kalejaiye-Matti, R.B, Garba, B and Balogun, R.B. 2007. Gender Stereotype in Nigeria Educational System: Teachers Moderating Role. *International Journal of Research in Education*, 4.1&2: 34 – 38.

Abdul Salam, J. M. A. 2009. The Level of Commitment and its Relation to Students' Achievement as Perceived by English Language Teachers in Public Schools in Tulkarm District. M.A Thesis-An-Najah National University, Nablus, Palestine

Abubakar, A. 2020. The Study of Gender Differences in the Attitude of Students toward Science Subjects in Gusau. NCE-Project of Federal College of Education, (Technical), Gusau

Adam, S. 2004. Using Learning Outcomes Accessed Online 12/08/2020 from http://www.aic.lv/bolona/Bologna/Bol_semin/Edinburgh/S_ADam_back_pap.pdf

Adejoh, I.S. 2015. Effects of Group Investigation and Jigsaw Instructional Techniques on Secondary Schools Students' Achievement and Transferability in Economics in Kogi, State, Nigeria. An Unpublished M.Ed Dissertation of the Department of Social Studies Education, University of Nigeria, Nsukka.

Adekoya, Y. M. and Olatoye, R. A. 2011. Effect of Demonstration, Peer-Tutoring, and Lecture Teaching Strategies on Senior Secondary School Students' Achievement in an Aspect of Agricultural Science. *Pacific Journal of Science and Technology,* 12.1: 320 - 332

Adekunle, A. 2021. Teachers' Instructional Packages and Students' Attitude towards Learning Mathematics in Public Secondary Schools. *International Journal of Social Sciences and Humanities Review (IJSSHR),* 11.1: 232 – 243.

Adeodatus, M. R. 2018. Preparedness and Implementation of Compulsory Science Curriculum in Public Secondary Schools in Bukoba District

Council, Tanzania. M.Sc- Thesis, Faculty of Education. The Catholic University of Eastern Africa

Adeoye, F. A. 2010. Impact of Systematic Assessment of Instruction on Secondary School Students' physics Achievement at Cognitive Level of knowledge. *Eurasian Journal of Physics and Chemistry Education*. 2.1: 44-52.

Aderibigbe, S.D. 2012. Using New Strategies to Improve Teaching and Learning of Physics. *Journal of Educational Research and technology,* 3.1: 99 – 111.

Aderonmu, T.S.B. and Obafemi, D.T.A. (2015). Ordeals of Physics Instruction in Nigerian Secondary Schools: Way Forward for the Attainment of Global Competitiveness *Journal of Education and Practice*. 6.20: 87-96.

Adesoji, F. A. 2008. Managing Students' Attitude towards Science Through Problem – Solving Instructional Strategy, *Anthropologist*, 10.1: 21-24.

Adeyemo, S.O. 2010. Teaching/Learning of Physics in Nigerian Secondary Schools: The Curriculum Transformation, Issues, Problems and Prospects. *International Journal of Educational Research and Technology*, 1.1: 99 - 111

Adigun, J. Onihunwa, J. Irunokhai, E. Sada, Y and Adesina O. 2015. Effect of Gender on Students' Academic Performance in Computer Studies in Secondary Schools in New Bussa, Borgu Local Government of Niger State. *Journal of Education and Practice*. 6.33: 1 - 7

Adodo, S. O. and Gbore, L. O. 2012. Prediction of attitude and interest of science students of different ability on their academic performance in basic science. *International Journal of Psychology and Counseling,* 4.6: 68-72.

Adolphus, T. 2016. Investigation of School-based Factors affecting the Enrolment and Attainment of Senior Secondary School Physics Students in Rivers State, Nigeria. PhD Thesis, University of York.

Adolphus, T. and Aderonmu, T.S.B. 2013. Difficulties Students Encounter in Reporting Physics Practical at Senior Secondary School Level, Nigeria. *Asian Journal of Education and e- learning,* 1.1: 29-33

Adunola, O. 2011. The Impact of Teachers' Teaching Methods on the Academic Performance of Primary School Pupils in Ijebu-Ode Local Government Area of Ogun State. Ego Booster Books, Ogun State, Nigeria.

Afari, E. 2015. Relationship of Students' Attitude toward Science and Achievement. Attitude Measurements in Science Education. Attitude Measurement in Education. *245 – 262*. Accessed Online from https://www.researchgate.net/publication.Relationship

Afuwape, M. O. and Oludipe, D.I. 2008. Gender Difference in Integrated Science Achievement among Pre-Service Teachers in Nigeria; *Educational Research and Review,* 3.7: 242-245

Ahmad, B. Muhammad, H; Naji, K. and Avi. H. 2017. Demonstrations for Enhancing Students' Understanding of and Attitudes to Learning Oxidation-Reduction Concept. *Eurasian Journal of Mathematics, Science and Technology Education* 13.3: 555 - 570

Agoro, A. A. 2002. Relative Effects of Instruction, Level of Commitment and Gender on Student's Learning Outcome in Integrated Science. M. Ed Thesis, University of Ibadan, Nigeria.

Agu, P. A. and Samuel, I. R. 2018. Effect of Reversed Jigsaw, TAI Cooperative and Guided Discovery Instructional Strategies on Basic Science and Technology Students' Interest and Achievement, I*nternational Journal of Innovative Education Research* 6.2:19-26

Aina, J. K. and Adedo, G. A. 2013. Perceived Causes of Students' Low Enrolment in Sciences in Secondary Schools in Nigeria *International Journal of Secondary Education,* 1.5: 18-22

Aina, J.K. and Akintunde, Z.T. 2013. Analysis of gender Performance in Physics in Colleges of Education, Nigeria *Journal of Education and Practice,* 4.6: 1 - 6

Ajitoni, S.O. and Salako, E.T. 2014. Effects of Jigsaw Technique and Gender on Students' Attitudes to Ethnic Integration and Sustainable Development in Nigeria. *World Journal of Education,* 4.3: 46 – 52

Akanbi, A.O. 2003. An Investigation into Students' Performance in Senior Secondary School Physics. *Journal of Teacher Education Trends,* 1.1: 58-64.

Akinbobola, A.O. 2015. Effects of Learning Styles and Instructional Strategies on Students Achievement in Nigerian Senior Secondary Schools' Physics. *International Knowledge sharing Platform*. 41: 20 -29

Akinbola, A. 2006. Effect of Jigsaw Strategy on Junior Secondary School Students' Interest and Achievement in Social Studies. MED-Project Ahmadu Bello University, Zaria.

Akpan, G. W. Mbaba, u. G. and Udofia, A. E. 2012. Influence of Students' Understanding and Goal Commitment on Academic Achievement in Introductory Technology in Akwa Ibom State, Nigeria. International Education Studies, 5.2: 44 – 52.

Akuche, E. and Okunola, M. 2017. Trends in the WASSCE performance of students in Physics in Oyo State Nigeria (2004-2010). *Journal of Capital Development in Behavioural Science*, 2.1: 16-21

Akumu, D. H. 2019. Active Learning, Student Commitment and Academic Achievement among Secondary School Students in Makindye Division. Undergraduate Dissertations Repository-Makerere University

Alghamdi, A. 2017. Impact of Jigsaw on the Achievement and Attitudes of Saudi Arabian Male High School Science Students. Ph.D-Thesis of the Graduste Faculty of the University of Akron

Ali, M. S. Bichi, S. S. Mari, J. S. and Lakpini, M. 2017. The Efficacy of Jigsaw-Learning Model on Academic Performance of Polytechnic Students with Varied Learning Abilities in Kano, Nigeria. *Iranian Journal of Comparative Education*, 1.2: 85-99

Alordia, C. O. Akpadaka, G. and Oviogbodu, C. O. 2015. The Influence of Gender, School Location and Socio-Economic Status on Students' Academic Achievement in Mathematics *Journal of Education and Practice*, 6.17: 130 – 136

Alphine, C. L. 2015. Students' Attitudes and their Effects on Learning and Achievement in Mathematics: A Case Study of Public Secondary Schools in Kiambu County, Kenya. An Unpublished M.Ed Thesis of Kenyatta University

Amadi, I. J. 2016. Demonstration and Project Based Methods of Teaching on Students' Achievement and Interest in some Graph Related Concepts in Economics. M. Ed-Thesis, University of Nigeria, Nsukka.

Ameh P. O. and Dantani, Y. S. 2012. Effects of Lecture and Demonstration Methods on the Achievement of Students in Chemistry in Nassarawa Locla Government Area of Kano State. *International Journal of Modern Social Sciences.* 1(1), 29 - 37

American Institute of Physics (AIP). 2003. Why Studying Physics at High Schools? http://www.aip.org/isns/reports/2002/034.html *retrieved*

Amin, S. 2014. Effectiveness of Jigsaw Technique and Reading Comprehension Ability of Nautical Students. *A Conference Paper presented at the International Maritime English Conference (IMEC)* 23, Constanta, Romania.

Amosa, I.G. and Mudasiru, O.Y.2017. Relative Effectiveness of Computer Supported Jigsaw II, STAD and TAI Cooperative Learning Strategies on Performance, Attitude, and Retention of Secondary School Students in Physics *Journal of Peer Learning* 10.6:76 – 94

Andrew J. Cavanagh, A. J. Chen, X. Bathgate, M. Frederick, J. Hanauer, D. I. and Graham, M. J. 2018. Trust, Growth Mindset and Student Commitment to Active Learning in a College Science Course. CBE- Life Science Education, 17.1:Ar 10

Anekwe, J. U. 2006. Effect of Constructivist Based Instructional Model on Students Interest and Academic Achievements in French Language in Anambra State. Ph.D Thesis University of Port Harcourt, Nigeria.

Anuradha, W. 2022. What is the Difference between Lesson Plan and Lesson Note? Retrieved Online from *https://pediaa.com/what-is-the-difference-between-lesson-plan-and-lesson-note/* 31/01/2022

Areelu, F. and Ladele, O. A. 2018. Adopting Jigsaw Instructional Strategy for Improving Students' Interest in Mathematics *International Journal of Education, Learning and Development,* 6.3: 53 – 67

Arigbabu, A.A. and Mji, A. 2004. Is Gender a Factor in Mathematics Performance among Nigeria Pre-Service Teachers? *Sex Role* 51.11 & 12: 749 – 753

Ariyo, A. O. 2006. School and Student Factor and Determination of Students' Achievement in Mathematics at the Senior Secondary School Level in Oyo state, Nigerian. Ph.D. Thesis-University of Ibadan

Aronson, E. 2005. The Jigsaw Classroom. http://www.jigsaw.org retrieved 27/3 2014

Arra, C. T., D'Antonio, M. D., and D'Antonio Jr., M. 2011. Students' Preferences for Cooperative Learning Instructional Approaches: Considerations for College Teachers. *Journal of Research in Education*, 21: 114 – 126

Ashkenazi, G. and Weaver, G.C. 2007. Using Lecture Demonstrations to promote the Refinement of Concepts: The Case of Teaching Solvent Miscibility in Chemistry. *Education Research and Practice. A Journal of the Royal Society of Chemistry*, 8.2: 186 - 196

Atsua, T.U. and Abdullahi, U. 2003. Effects of Demonstration and Lecture Methods in Teaching Economics at Senior Secondary Schools in Benue State, Nigeria. *Journal of Educational Research and Evaluation* 14.3: 68-76

Attah, R. F. And Ita, P. M. 2017. Gender as Predictor of Academic Achievement in English Among Senior Secondary School Two Students in Calabar Metropolis, Cross River State *Global Journal of Educational Research* 16: 149-153

Awandia, J. T. 2021. Impact of Teaching Methods on Students Negative Attitudes towards Physics. *Greener Journal of Educational Research (GJER)*, 11.1: 11 - 23

Awang, M.M. 2013. Students' Attitudes and Their Academic Performance in Nationhood Education. *International Education Studies,* 6.11: 21-28.

Awodun, A. O., Oni, S. A. and Oyeniyi, J. D. 2015. Influence of Teacher's Gender on Secondary School Students' Performance in Physics in Ekiti State, Nigeria *International Journal of Innovative Research and Development*, 41: 72 – 77.

Awofala, A.O.A., Arigbabu, A.A. and Awofala, A.A. 2013. Effects of Framing and Team Assisted Individualised Instructional Strategies on Senior Secondary School Students' Attitudes toward Mathematics, *Acta Didactica Napocensia*, 6.1: 1-22

Awolere, O.O. 2015. Differentiated and Scaffolding Instructional Strategies as Determinants of Senior Secondary Students' Learning Outcomes in English Reading Comprehension in Oyo State. A Post-field Seminar Paper Presented at the Joint Staff/Students Seminar Series, Department of Teacher Education, University of Ibadan 12/12/2015

Ayanniyi, M.C. 2009. Effects of Three Modes of Advance Organizers on Secondary School Students' Achievement in, and Attitude to Poetic Literature in Ibadan Metropolis, Ph.D. Thesis. University of Ibadan

Ayeni, A. J. 2011.Teachers' Professional Development and Quality Assurance in Nigerian Secondary Schools. *World Journal of Education*, 1.2: 143 - 149

Azmin, N.H. 2016. Effect of the Jigsaw-Based Cooperative Learning Method on Student Performance in the General Certificate of Education Advanced-Level Psychology: An Exploratory Brunei Case Study *International Education Studies.* 9.1: 91 - 106

Babalola, V. O. (2004). Resource Materials in the Implementation of Curriculum in 21st Century in Noah A.O.K. Shonibare, D.O. Ojo A.A and Olajuwon, T. (eds) Curriculum Implementation and Professional Teaching in Nigeria. Lagos: Central Educational Services.

Babajide, E. O. 2010. The Influence of Personal Factors on Workers' turnover Intention in Work Organizations in South-west Nigeria. *Journal of Diversity Management* 5.4: 1 - 7

Babajide, V. F. T. 2010. Generative and Predict-Observe-Explain Instructional Strategies as Determinants of Senior Secondary School Students' Achievement and Practical Skills in Physics Ph.D –Thesis University of Ibadan, Nigeria

Bain, C. D. and Rice, M. L. 2006.The Influence of Gender on Attitudes, Perceptions, and Uses of Technology. *Journal of Research on Technology in Education,* 39.2: 119–132

Bako, P. W. 2017. Effects of Project and Demonstration Teaching Methods on Acquisition of Brooding Skills in Poultry among Students in Colleges of Education in Plateau State, Nigeria. M.Sc.-Thesis Ahmadu Bello University Zaria

Bamidele, L. 2004. Students' Poor Performance in Physics. A Bane to Our Nation's Technological Development. *Nigerian Journal of Science Education and Practice,* 2.1: 174 – 179.

Bandura, A. 1977. Social Learning Theory. New York: General Learning Press.

Belias, D, Sdrolias, L. Kakkos, N.Koutiva, M. and Koustelios, A. 2013. Traditional Teaching Method Versus Teaching through the Application of ICTs *Accounting Field European Scientific Journal,* 9.25: 73 - 101

Bello, T.O. 2011. Effect of Group Instructional Strategy on Students' Performance in Selected Physics Concepts. *The African Symposium: An Online Journal of the African Educational Research Network,* 11.1: 71-79

Benildo, M. 2021. What are some Basic Assumptions about Social Cognitive Theory? Retrieved Online from *https://everythingwhat.com/what-are-some-basic-assumptions-about-social-cognitive-theory 02/02/2022*

Bilesanmi-Awoderu, J. B. 2006. Effect of Computer Assisted Instruction and Simulation/Games on the academic Achievement of secondary School Students in Biology *Sokoto Educational Review*, 8.1: 49 -61

Bollotin, M. Kotlicki, A. and Reiger, G. 2007. The Role and Place of Interactive Lecture Experiments in Large Introductury Science Courses. *http://citeseerx.ist.psu.edu/viewdoc retrieved 8/7/2018*

Bonwell, C.C. and Eison, J.I.1991. Active Learning https;//www.everettcc.edu retrieved 22/6/2018

Bonwell, C. C. 1997. Using active learning as assessment in the postsecondary classroom. *Clearing House* 71.2:73.

Brown, D. 2018. Top Seven Characteristics of Committed People. *https://top7business.com retrieved 30/6/2018*

Buabeng, I., Conner, L., and Winter, D. 2016. Physics Teachers' Views on their Initial Teacher Education. *Australian Journal of Teacher Education,* 41.7: 36 – 55

Buabeng, I. Ossei-Anto, T.A. and Ampiah, J.G. 2014. An Investigation into Physics Teaching in Senior High Schools, *World Journal of Education* 4.5: 40 - 50

Budianto, L. 2011: Students' Psychological Factors in Sla: A Dilemma for Teachers of English. *Lingual Jurnal Ilmu Bahasa Dan Sastra* 5.1 Doi:10.18860/Ling.V5i1.614

Business Dictionary, 2018. What is Attitude? Definition and Meaning. Accessed Online *www.businessdictionary.com/defini*

Casmir N. E. 2011. Influence of Gender on Students' Attitude Towards Biology in Enugu East Local Government Area of Enugu State. *Nigerian Journal of Research and Production* 18.1: 1-9

Carleton Science Education Resource Centre (CSERC), 2018. Why Use Interactive Lecture? Accessed Online 29/06/2018 from *https://serc.carleton.edu/introgeo/interactive/why.html*

Catapano, J. 2018. The Jigsaw Method Teaching Strategy *http://www.teachhub.com/jigsaw-method-teaching-strategy retrieved 12/4/2018*

Celep, C. 2000. Teachers' Organization Commitment in the Organization. *National Forum of Teachers Educational Journal,* 10.3: 1999 - 2000

Centre for Teaching, Support and Innovation, (CTSI, U of T), 2018. What are Learning Outcomes *http://teaching.utoronto.ca/teaching-support/course-design/ retrieved 29/6/2018*

Charoula, A and Nicos, V. 2020.Developing Young Children's Computational Thinking with Educational Robotics: An Interaction Effect between Gender and Scaffolding Strategy 105, (C) *https://doi.org/10.1016/j.chb.20189.03.018*

Church, H. 2012. Taking Forward the Jigsaw Classroom: the Development and Implementation of a Method of Collaborative Learning for First Year Philosophy Tutorials. *Discourse: Learning and Teaching in Philosophical and Religious Studies 11.2:*40 - 52

Cox, J. 2018. Professional Commitment in the Teaching Profession *http://www.teachhub.com retrieved 30/6/2018*

Craker, D. E. (2006). Attitudes Toward Science of Students Enrolled in Introductory Level Science Courses at UW-La Crosse, *UW-L Journal of Undergraduate Research, 9*:1-6.

Crone, T.S. and Portillo, M.C. 2013. Jigsaw Variations and Attitudes about Learning and the Self. *Cognitive Psychology Sage Journal*. 40.3: 246 -251

Crouch, C. H. Fagen, A. P. Callan, J. P. and Mazur, E. 2004. Classroom Demonstrations: Learning Tools or Entertainment? *American Journal of Physics*, 72.6: 835-838.

Crownson S. 2022. Optics Unit Plan-Department of Physics, Illinois State University Retrieved Online from *http://www2.phy.ilstu.edu*> 13/02/2022

Daramola, S. O. and Omosewo, E. O. 2012. An Appraisal of the New Nigerian Senior Secondary School Physics Curriculum. *Journal of Education and Practice,* 3.8: 191 - 194

Dennis, I. 2017. What is the Difference between Experimental Physics and Theoretical Physics *https://www.quora.com retrieved 10/7/2018*

Dilshadi, M. and Saeed, A. 2015. Teaching of Physics at Higher Secondary Level in the Perception of Students. *International Journal of AYER,* 2:491 - 496

Duffy, A. 2018. Interactive Lecture Demonstrations *http://buphy.bu.edu/~duffy/ILD.html retrieved 29/6/2018*

Eison, J. 2015. Using Active Learning Instructional Strategies to Create Excitement and Enhance Learning, Florida *https://www.cte.cornell.edu retrieved 10/10/2015*

Encyclopaedia Britannica, 2017. Physics Science *https://www.britannica.com retrieved 9/7/2017*

Erdemir, N. 2009. Determining Students' Attitude towards Physics through Problem-Solving Strategy. *Asian-Pacific Forum on Science Learning and Teaching*, 10.2:1 – 19

Eryilmaz, A., Yildiz, I. and Akin, S. 2011. "Investigating of Relationship between Attitudes towards Physics Laboratories and Motivation for the Class Engagement. *Eurasian Journal of Physics and Chemistry Education.* Special Issue: 59 - 64

Esan, A.O.(2002). Gender differences in Mathematics Problem Solving amongst Nigerian Students. *Teacher Education Today. Journal of the committee of Provost of Colleges of Education in Nigeria,* 2.(1&2): 56-61.

Etkina, E. 2010. Pedagogical Content Knowledge and Preparation of High School Physics Teachers. *Physical Review Special Topics - Physics Education Research*, 6.2: 020110-1-020110-26

Eze, G.N. and Obiekwe, P.C. 2017. *Effect of Think-Pair-Share Instructional Strategy on Students' Achievement in Chemistry*. The 60th Annual Conference Proceedings of Science Teachers Association of Nigeria, 284-290.

Ezeudu, S. A. and Gbendu, G. O. 2020. Effect of Flipped Classroom Strategy on Students' Attitude towards Secondary School Geography: Implications for Entrepreneurship Education in Nigeria. *International Journal of Studies in Education*, 16.2: 38-51.

Fabunmi, M. 2004. The Role of Gender on Secondary School Students' Academic Performance in Edo State, Nigeria. *West African Journal of Education*, 24.1:90-93.

Fatoba J. O and Aladejana A. L. 2014. Gender Differences and Achievement in Integrated Science among Junior Secondary School Students: A Nigerian Study. *European Scientific Journal* 10.7: 1857-7881

Federal Government of Nigeria (FGN) 2004. National Policy on Education 4th Edition. National Education, Research and Development Council, Yaba, Lagos

Felfe, J., Schyns, B., & Tymon, A. (2014). The Impact of University Students' Commitment on In- and Extra-role Performance. *Journal of Applied Research in Higher Education*, 6.1: 149 - 167

Feynman, R. P.; Leighton, R.B. and Sands, M. 2011. Six Easy Pieces: Essentials of Physics Explained by Its Most Brilliant Teacher Reading, Mass., Addison-Wesley

Fitriani, F. 2017. Student Commitment to Do Lecture Task Observed from Motivation to Achievement. Advances in Social Science, Education and Humanities Research (ASSEHR), 66:176 – 180

Fuglei, M. and Resilient Educator, 2022. How Reading for Pleasure Helps Students Develop Academically. Retrieved Online from *https://resilienteducator.com/classroom-resources/how-reading-for-pleasure-helps-students-develop-academically/* *02/02/2022*

Fulmer, G.W. Ma, H and Liliang, L.L. 2019. Middle School Student Attitudes towards Science, and their Relationships with Instructional Practices: A Survey of Chinese Students' Preferred Versus Actual Instruction. *Asia-Pacific Science Education*, 5.1: 1 - 21

Future Teachers World, 2022. Social Cognitive Theory retrieved Online from *https://www.google.com/search?q=albert+bandura+social+cognitive+learning+theory:+images* 31/01/2022

Gambari, I. A. Olumorin, C. O. and Yusuf, M. O. 2013. Effectiveness of Computer-supported Jigsaw II Cooperative Learning Strategy on the Performance of Senior Secondary School Students in Physics, *Global Media Journal*, 6.2: 1-13

Gamze, S. S. 2010. Correlation Study of Physics Achievement, Learning Strategy, Attitude and Gender in an Introductory Physics Course. *Asia-Pacific Forum on Science Learning and Teaching*, 11.2: Article 4

Garden, R. A. and Smith, T. A. 2001. TIMSS Test development. A Technical Report. Chestnut Hill. M.A Boston College

Geektonight, 2022. What is Attitude? Definition, Types, Components, Formation, Functions, Characteristics. Available at https://www.geektonight.com/what-is-attitude-

George, R. 2006. Measuring Change in Students' Attitude towards Science over Time: An Application of Latent Variable Modeling. *Journal of Science Education and Technology,* 9.3: 213 – 225

Georgiou, S., Stavrinides, P., and Kalavana, T. 2007. Is Victor better than Victoria at Mathematics? *Educational Psychology in Practice*, 4.23: 329-342.

Gifkins, J. 2015. What is "Active Learning and why is it Important? Accessed online 28/06/2018 from *https://www.e-ir.info*

Giridharan, K. and Raju, R. 2016. Impact of Teaching Strategies: Demonstration and Lecture Strategies and Impacts of Teacher Effect on Academic Achievement in Engineering Education. *International Journal of Education Sciences,* 14: 174-186

Godson, F. and Ngussa, B. M. 2020. Effect of School Environment on Students' Commitment toward Learning among Secondary Schools in Monduli District, Tanzania *East African Journal of Education and Social Sciences* (EAJESS), 1.3: 60-67.

Gok, T. and Sılay, I. 2008. Effects of Problem-Solving Strategies Teaching on The Problem-Solving Attitudes of Cooperative Learning Groups in Physics Education. *Journal of Theory and Practice in Education*, 4.2: 253-266.

Gomez, F. 2020. "Predicting Academic Performance: A Commitment Perspective" Electronic Theses and Dissertations. *https://scholarworks.sfasu.edu/etds/71*

Gonen, S. and Basaran, B. 2008. The New Method of Problem Solving in Physics Education by Using Scorm-compliant Content Package. *Turkish Online Journal of Distance Education-TOJDE,* 9.3: 112-120.

Gonsalez, J. 2015. Four Things You Don't Know about the Jigsaw Method. Retrieved Online from *https://www.cultofpedagogy.com/jigsaw-teaching-strategy/* 01/02/2022

Gonzuk, J.N. and Chagok, M. 2001. Factors that Discourage Girls from Taking Physics- A Case Study of Plateau State. *Proceedings of the 42nd Science Teachers'*

Association of Nigeria Conference held at Queen Elizabeth School, Ilorin, Kwara State. 352-355.

Gugliotta, K.F. 2010. Gender Differences in Attitude towards Math and Science among Elementary Students: An Exploration of Role of Teachers *https://trace.tennessee.edu retrieved 12/12/2018*

Guido, R. M. D. 2013. Attitude and Motivation towards Learning Physics. *International Journal of Engineering Research and Technology (IJERT,)* 2.11: 2087 -2094

Güner, P. & Erbay, H. N. 2021. Metacognitive Skills and Problem-Solving. *International Journal of Research in Education and Science* (IJRES), 7.3: 715-734.

Halliday, D., Resnick, R. and Walker, J. 2008. Fundamentals of Physics, 8th Edition. United States: John Wiley & Sons, Inc. and Von Hoffmann Press.

Hakkarainen, K. 2018. Jigsaw *http://mlab.taik.fi/polut retrieved 29/6/2018*

Hammer, T. R. 2011. Social Learning Theory in Goldsrein, S and Naglieri, J. A. (Eds.) *Encyclopedia of Child Behavior and Development*. San Francisco: Springer; Accessed Online from *https://www.verywellmind.com/social-learning-theory-2795074*.

Hanze, M. and Berger, R. 2007. Cooperative Learning, Motivation Effects, Students' Characteristics: An Experimental Study Comparing Cooperative Learning and Direct Instruction in 12th Grade Physics Classes. *Learning and Instruction*, 17.1: 29-41.

Hazari, A., Tai, R. H., and Sadler, P. M. 2007. Gender Differences in Introductory University Physics Performance: The Influence of High School Physics Preparation and Affective Factors. *Science Education*, 91.6: 847-877

Heeden, T. 2003. The Reverse Jigsaw: A Process of Cooperative Learning and Discussion. *Teaching Sociology*, 31.3: 325-332

Helmenstine, A. 2017. The Basics of Physics in Scientific Study *https://www.thoughtco.com retrieved 9/7/2017*

Holbrook, J. 2005. Making Chemistry Teaching Relevant. *Chemical Education International*, 6.1: 1 - 12

Hoover, W. A. 1996. The Practice Implications of Constructivist Theory *https://sedl.org/pubs/sedletter/v09n03/practice.html Retrieved 30/01/2022*

Hopkins, J. 2018. Gender Concepts and Definitions *https://gender.jhpiego.org retrieved 29/6/2018*

Huang, Y-M., Liao, Y.-W., Huang, S.-H., and Chen, H.-C. 2014. A Jigsaw-based cooperative Learning Approach to Improve Learning Outcomes for Mobile Situated Learning. *Educational Technology and Society, 1*7.1:128-140.

Human -Vogel, S. 2015. The Role of Identity in Self-regulation: When do students cope and When do they commit? *Journal of Psychology in Africa,* 18.1: 115−122.

Human-Vogel, S., and Rabe, P. 2015. Measuring Self-differentiation and Academic Commitment in University Students: A Case Study of Education and Engineering Students. *South African Journal of Psychology*, 45.1: 60−70.

Ibe, E. and Nwosu, A.A. 2003. Effect of Guided-inquiry and Demonstration on Science Process Skills' acquisition among secondary School Biology Students. *Journal of Science Teachers' Association of Nigeria,* 38.(1 & 2): 58-63

Ibeh, G.F. Onah, D. U. Umahi, A. E. Ugwuonah, F. C. Nnachi, N.O. and Ekpe, J. E. 2013. Strategies to Improve Attitude of Secondary School Students towards Physics for Sustainable Technological Development in Abakaliki L. G. A. Ebonyi-Nigeria. *Journal of Sustainable Development Studies,* 3.2: 127-135

Ibrahim, A.T. and Jamil, H.B. 2012. The Nature of Parental Involvement in the Schooling Process in Katsina State. *Journal of Education and Learning,* 1.2: 37-43.

Ige, S.A. 2011. An Assessment of Performance Trends in Integrated Science in Junior Secondary Schools in Obafemi-Owode Local Government, Ogun State. *Unpublished Research Project, Department of Integrated Science, Federal College of Education, Abeokuta, Nigeria*.

Iloputaife, E.C. 2001. Effects of Analogy and a Five-step Conceptual Change Instructional Models on Physics Concept Achievement of Secondary School Students. Unpublished Ph.D. Thesis of the University of Nigeria, Nsukka

Ingels, S. J. and Dalton, B. W. 2008. Trends among High School Seniors, 1972–2004 (NCES 2008-320). Washington, DC: National Center for Education Statistics, Institute for Education Sciences, U.S. Department of Education.

Inuwa, U., Abdullah, Z. and Hassan H. 2018. A Mixed-Method Study of the Effect of the Demonstration Method on Students' Achievement in Financial Accounting.

International Journal of Instruction, 11.4: 577-592.

Isa, I. M. and Muhammad B. A. 2019. Effects of Jigsaw IV Cooperative Learning Strategy on Students' Academic Performance in Organic Chemistry in Zaria Education Zone, Kaduna State. *Nigeria International Knowledge Sharing Platform*,11.9:18-23

Isiaka, A.G and Mudasiru, 2015. Effects of Three Cooperative Instructional Strategies on the Performance of Secondary School Students in Physics. *Bulgarian Journal of Science Education*, 23.3:1 - 23

Jana, A. K. and Patra, A. 2017. Attitude and Achievement in Geography: A study on Bengali Medium Students. *International Journal of Education and Psychological Research (IJEPR)*, 6.2: 75-77

Jatsho, S. and Rinchen, S. 2016. Strategies for Teaching Physics: An Action Research. *Educational Innovation and Practice - A biannual Journal of Samtse College of Education*, 1:53-66.

Jegede, S.A. and Adedayo, J. O. 2013. Enriching Physics Education in Nigeria towards Enhancing a Sustainable Technological Development. *Greener Journal of Educational Research*, 3.2: 80-84.

Jegede, S. A. and Awodun, A. O. 2015. Effects of Outdoor Activities on Students' Attitudes towards Physics in Secondary Schools. *International Journal for Innovation Education and Research*, 3.5: 126 - 131

Joel, A. and Aride, U. 2006. Social Interaction and Social Relationship in School Children. New York: Harcourt-brace and Jovanovich Inc.

Johansson, C. and Rönkkö, K. 2004. Using Commitment as the Underlying Principle for Learning, Proceedings of the 6th Joint Conference on Knowledge-Based Software Engineering, JCKBSE, Protvino, Russia, August 25-27, pp. 129-138,

John, S.D. 2009. Interactive Lecture Demonstrations *https://www.usma.edu/cfe retrieved 28/6/2018*

Johnson, D. W. and Johnson, F. 2009. Joining together: Group Theory and Group Skills (10th Ed.). Boston: Allyn & Bacon.

Jones, M. G. Howe, A and Rua, M. J. 1999. Gender Differences in Students'

Experiences, Interests, and Attitudes toward Science and Scientists *http://www.weizmann.ac.il retrieved 12/12/2018*

Josiah, M. M. 2013. Effects of Practical Physics Knowledge on Students' Academic Achievement: A Study of Pankshin Local Government Area of Plateau State, Nigeria. *World Education Forum*, 2.1: 210 – 218.

Kapucu, S. 2017. Predicting Physics Achievement: Attitude towards Physics, Self-Efficacy of Learning Physics, and Mathematics Achievement. *Asia-Pacific Forum on Science Learning and Teaching*, 18.1: 1 - 22

Karamustafaoglu, O. 2009. Active Learning Strategies in Physics Teaching in Energy Education Science and Technology Part B: *Social and Educational Studies*, 1.1: 27-50

Karamustafaoglu, O. 2015. Active Learning Strategies in Physics Teaching *https://www.files.eric.ed.gov/ retrieved 10/10/2015*

Ketula, A. 2019. Active Learning, Student Commitment and Academic Performance among Secondary School Students in Kawempe Division. Undergraduate Dissertations Repository- Makerere University

Kilic, A. 2008. The Gender Dimension of Social Policy Reform in Turkey: Towards Equal Citizenship? *Social Policy and Administration* 42.5:487 - 503

Kolawole, E. 2007. Effects of Competitive and Cooperative Learning Strategies on Academic Performance of Nigerian Students in Mathematics. *Educational Research and Design*, 3:33 - 37

Komang, T. P. S and Basori, B.A E. 2019. Comparison of Application of Jigsaw IV and Reverse Jigsaw Methods based on Students' Participation and Achievement. *Journal of Informatics and Vocational Education*, 2.2: 75-81

Korpershoek, H. 2016. Relationships among Motivation, Commitment, Cognitive Capacities, and Achievement in Secondary Education. *Frontline Learning Research*, 4.3: 28-43

Kuh, G. D. 2009. What Student Affairs Professionals Need to Know About Student Engagement. *Journal of College Student Development*, 50.6: 683-706.

Kumar, S., Agarwal, M and Agarwal, N. 2021. Defining and Measuring Academic Performance of Hei Students-A Critical Review. *Turkish Journal of Computer and Mathematics Education,* 12.6: 3091 - 3105

Lawrence, A. 2018. Effectiveness of Enriched Demonstration and Lecture Instructional Strategies on Senior Secondary School Students' Achievement in Chemistry. *Journal of Contemporary Educational Research.* 2.1: 1-9

Learning Spark 2018. Advantages and Disadvantages of Lectures Available at http://www.learningspark.com *retrieved 20/4/2018*

Leelakrishna, R. 2017. Gender Differences in Attitudes to learning Science in Grade 7 *African Journal of Research in Mathematics, Science and Technology Education*, 21.1: 180-192

Lesch, S. 1995. Learning Outcome Learning Achieved by the End of a Course or Program Knowledge-Skills-Attitude *http://liad.gbrownc.on.ca/program/InsAdult/currlo.htm retrieved 29/6/2018*

Ludigo, H. Mugimu, C. B. and Mugaga, A.M. 2019. Pedagogical Strategies and Academic Achievement of Students in Public Universities in Uganda. *African Journal of Education and Practice*, 3.1: 81-96

Machin, S. and Mcnally, S. 2006. Gender and Student Achievement in English Schools *Oxford Review of Economic Policy* available at *https://www.researchgate.net/publication/5216298*

Maden, S. 2011. Effect of Jigsaw I Technique on Achievement in Written Expression Skill *Educational Sciences: Theory and Practice*, 11.2: 911-917

Mapolelo, D. C. and Akinsola, M. K. 2015. Preparation of Mathematics Teachers: Lessons from Review of Literature on Teachers' Knowledge, Beliefs, and Teacher Education. *American Journal of Educational Research*. 2015; 3.4:505-513.

Mart, T. C., 2013. A Passionate Teacher: Teacher Commitment and Dedication to Student Learning. *International Journal of Academic Research in Progressive Education and Development*, 2.1: 226-348

Mazzolini, A.P., Daniel, S, and Edwards, T. 2012. Using Interactive Lecture Demonstrations to Improve Conceptual Understanding of Resonance in an Electronics Course *Australasian Journal of Engineering Education*, 18.1: 69 – 88

Mbacho, N.W. and Changeiywo, J.M. 2013. Effects of Jigsaw Cooperative Learning Strategy on Students' Achievement by Gender Differences in Secondary School Mathematics in Laikipia East District, Kenya. *Journal of Education and Practice*, 2.3: 177 – 188.

Mbamara, U.S. and Eya, P. E. 2015.Causes of Low Enrollment of Physics as a Subject of Study by Secondary School Students in Nigeria: A Descriptive Survey. *International Journal of Scientific Research in Education,* 8.4: 127-149

McDermott, C. L., and Shaffer, P. S. 2000: Preparing Teachers to Teach Physics and Physical Science by Inquiry. *Physics Education,* 35.6: 411-416.

McGraw-Hill. 1993. McGraw-Hill Encyclopedia of Science and Technology (5th ed.).

National Academy of Sciences, 2022. Harnessing Light: Optical Science and Engineering for the 21st Century. Retrieved Online from https://www.nap.edu/read/5954/chapter/3 13/02/2022

Merriam-Webster, 2022: Secondary School Retrieved Online from *htpps://www.merriam-webster.com/dictionary/secondary%20school 02/02/2022*

Milner-Bolotin, M. Kotlicki, A. and Rieger, G. 2007. Can Students Learn from Lecture Demonstrations? The Role and Place of Interactive Lecture Experiments in Large Introductory Science Courses. *Journal of College Science Teaching*, 36.4: 45-49

Mimrot, B. H. 2016. A Study of Academic Achievement Relation to Home Environment of Secondary School Students. *The International Journal of Indian Psychology,* 4.1: 30-40.

Mini, N. and Abdul, G. K. 2015. Instructional strategies in Teaching Physics: An Integrated Approach. *Guru Journal of Behavioural and Social Sciences,* 3.4: 457-472

Mkpa, M. A. (2005). Challenges of Implementing the School Curriculum in Nigeria. *Journal of Curriculum Studies,* 12.1: 9-17.

Moll, R.F. and Milner-Bolotin, M. 2009. The Effects of Interactive lecture Experiments on Students' Academic Achievement and Attitude towards Physics 87.8:917 - 924

Muhammad, A. U., Bala, D and Ladu, K. M. 2016. Effectiveness of Demonstration and Lecture Methods in Learning Concept in Economics among Secondary School Students in Borno State, Nigeria *Journal of Education and Practice.* 7.12: 51-59

Muhammad, S. and Ghulam, M. A. 2014. Students' Commitment, Engagement and Locus of Control as Predictor of Academic Achievement at Higher Education Level. *Current Issues in Education,* 17.3: 1- 10

Mustapha, B. and Sadiq, R. 2016. Lecturers' Commitment towards Students' academic Performance. A Regression Analysis *https://www.researchgate.net retrieved 30/6/2018*

Mvududu, N. and Thiel-Burgess, J. 2012. Constructivism in Practice: The Case for English Language Learners. *International Journal of Education*, 4.3: 109 - 118

Narad, A. and Abdullah, B. 2016. Academic Performance of Senior Secondary Students: Influence of Parental Encouragement and School Environment. *Rupkatha Journal on Interdisciplinary Studies and Humanities*, 8.2: 12 - 19

National Academy of Science, 2022. Optics and Photonics. Available online at http://www.nas.edu

National Association of Geoscience Teachers [NAGT], 2018. Teaching Methods. A Collection of Pedagogic Techniques and Example Activities *https://serc.carleton.edu 26/4/2018*

National Center for Education Statistics, 2022. Retrieved 29/01/2022 from https://nces.ed.gov/surveys/frss/publications/1999080/index.asp?sectionid=6

National Universities Commission, 2007. Benchmark Minimum Academic Standard for Undergraduate Programmes in Nigerian Universities Education. Abuja Nigeria. 275.

Ndukwe, P.N. and Timayi, J. 2018. Impact of Jigsaw IV Cooperative Learning Strategy (J4cls) on Computer Anxiety and Achievement of Federal Colleges of Education Students in STEM Practical Sessions *ATBU Journal of Science, Technology and Education*, 6.2:151 - 159

Neil, J. 2005. 500 Word Summary of Dewey's Experienced and Education, Macmillan Accessed Online 24/4/2018 from *http://www.wilderdom.com/experiential/SummaryJohnDeweyExperienceEducation.ht*

NERDC 2009. Senior Secondary Education Curriculum, Physics for Senior Secondary Schools 1-3. Abuja: NERD

Njoku, M. I. A., Nwagbo, C. R. and Ugwuanyi, C. S. 2020. Effect of Peer Tutoring and Peer-led Team Learning on Students' Achievement in Biology. *International Journal of Database Theory and Application,* 13.1: 1-10.

Nkwo, N. I., Akinbobola, A. O. and Edinyang, S. D. 2008. Effect of Prior Knowledge of Instructional Objectives on Students in Selected Difficult Concepts in Senior Secondary School Physics. *Journal of Science Teachers' Association of Nigeria*.43 .(1&2): 62 -71

Nnamani, S. C. and Oyibe, A. O. 2016. Gender and Academic Achievement of Secondary School Students in Social Studies in Abakaliki Urban of Ebonyi State, Nigeria. *British Journal of Education,* 4.8: 72 - 83

Noah, M. 2019. Factors Influencing Physics Performance among Students in Tile Selected Secondary Schools. A Case Study of Buyengo Sub-Country. B. Ed-Thesis of the College of Education, Kampala International University.

Norezan, I. Mohd, A.A.Z. and Siti, M.D. 2019. Attitude in Learning Physics among form Four Students. *Social and Management Research Journal,* 16.2: 19 – 40.

Nunan, D. 2001. Second Language Teaching and Learning. Boston: Heinle and Heinle Publication: 69

Nwangwu, N.A. 2000. Management, Structure and Financing of Education UNESCO (Ed.) The State of Education in Nigeria *www.unesdoc.unesco.org retrieved 23/4/2018*

Nwankwo, M. U. and Okigbo, E. C. 2021. Effect of Jigsaw Teaching Strategy on Academic Achievement and Retention of Anambra State Secondary School Students in Chemistry. *Unizik Journal of Educational Research and Policy Studies (*UNIJERPS*)* 7: 375 - 386

Nwiigi, J. W. 2014. The Impact of Gender Differences on Student's Academic Performance in Secondary Schools in Ndumberi Division, Kiambu County, Kenya in Science Subjects and Languages. PGDE Thesis-University of Nairobi, Kenya

Nwona, H. A., and Akogun, N. A. 2015. Breaking Gender Barrier in Science, Technology and Mathematics Education. *Nigeria Journal of Research in Education,* 8: 98-108.

Nwosu, A.A. and Nwachuckwu, 2007. Effects of Demonstration Method on Different Levels of Students' Cognitive Achievement in Secondary School Biology. *Journal of Science Teachers' Association of Nigeria* 42.(1 & 2):50-59

Nwoye, A. N. and Okafor, A. E. 2019. Nigerian's Nascent Secondary School Physics Curriculum and its Implementation. Problems *Scientific Research Journal, (SCIRJ),* 7.6: 62-69

Obafemi, D. T. A. 2015. Bridging Gender Gap in the Physics Classroom: *The Instructional Method Perspective in Journal of Education and Practice.* 6.20:14 - 23

Obafemi, D.T.A and Onwioduokit, F. A. 2013. Identification of Difficult Concepts in Senior Secondary School Two (SS2) Physics Curriculum in Rivers State, Nigeria. *Asian Journal of Education and e-Learning* 1.5: 317 - 322

Odagboyi, I. A. 2015. Effect of Gender on Academic Competence of Primary Education Students of College of Education, Akwanga. *Advances in Social Sciences Research Journal,* 2.10: 199 - 203

Odiaka, S.I. 2002. Effects of Holistic and Sub- skill Instructional Approaches and Content Area Reading Comprehension among some Junior Secondary School Students in Ibadan Metropolis, Ph.D Thesis, University of Ibadan

Ogunleye, B. O. 2002. Evaluation of the Environmental Aspect of the Senior Secondary School Chemistry Curriculum in Ibadan, Nigeria. Ph.D Thesis, University of Ibadan

Ogunleye, B. O. 2011. Trends and Patterns of Nigerian Students' WASSCE Entry and Performance in Physics, Chemistry and Biology (2000-2009). *African Journal of Historical Sciences in Education*, 7.2:331 - 344

Ogunleye, A., Awofala, A. O. and Adekoya, E. A. 2014. Effect of Students' Background Knowledge of Mathematics on Senior Secondary School Students' Achievement in Physics. *Bulgarian Journal of Science Education, 23.6:863 - 880*

Ogunleye B. O. and Babajide, V. F. T. 2011. Commitment to Science and Gender as Determinants of Students Achievement and Practical Skills in Physics. *Journal of the Science Teachers Association of Nigeria*, 46.1: 125 - 135

Ogunleye, B.O. and Babajide, V.F.T. 2015. Generative Instructional Strategy Enhances Secondary School Students' Achievement in Physics *European Journal of Educational Studies.* 3.3:453- 461

Oguntade, H.O. 2000. Effects of Acculturation Programme on the Attitude of Learners of Second Nigerian Languages *African Journal of Education.* 6.182: 145 - 151

Ogunyinka, E.K. Okeke, T. I. and Adedoyin, R. C. 2015. Teacher Education and Development in Nigeria: An Analysis of Reforms, Challenges and Prospects. *Education Journal,* 4.3: 111-122

Ojediran, I. A. 2016. Philosophical Relevance of Physics Teacher Education Curricula in South-Western Nigerian Universities to Senior Secondary School Physics Curriculum *journal of Education and Social Policy,* 3.2: 128-134

Ojekwu, I. N. and Ogunleye, B. O. 2020. Effects of Jigsaw Learning Strategy on Science Students' Performance and Interest in Biology in selected Schools in Rivers State, Nigeria. *Sapientia Foundation Journal of Education, Sciences and Gender Studies,* 2.3: 325-334.

Okebukola, C. 2004. Quality Assurance in Teacher Selection among Private Secondary Schools in Owerri Municipal, Imo State for Effective Implementation of the UBE. *Journal of Curriculum Organization of Nigeria.* 37-44

Okeke, A. M. 2015.Effect of Jigsaw Instructional Strategy on Students' Achievement and Interest in Quadratic Equation in Nsukka Education Zone. M. Ed-Thesis University of Nigeria, Nsukka.

Okeke, E. A. C. 1986. Remedies for Students' Poor Performance in Science *Proceedings the 27th Annual Conference of the Science Teachers' Association of Nigeria 118 - 129.*

Okeke, U.K. 2019. Students' Achievement and Low Enrolment in Physics: The Place of Physics Teachers and other Necessary Resources *https://www.researchgate.net retrieved on 28/2/2021*

Okoth, B. K. Ogeta, N. O. Otieno, M. and John, A. O. 2019. Influence of Resources on Students' Academic Performance in Physics at Secondary Schools in Ugenya Sub-Country, Siaya Country, Kenya. *Greener Journal of Educational Research*, 8.5: 111 - 118

Okoroncha, U. A. and Adeoye, F. A. 2011. Evaluation of Nigerian Physics Curriculum Contents and Physics Textbooks, The Attainment of Goals of History and Philosophy of Science *Eurasian Journal of Physics and Chemistry Education*, 3.2: 75-83

Okwo, F. A. and Otubah, S. 2007. Influence of Gender Cognitive style on Students' Achievement in Physics Essay Test. *Journal of Science Teachers' Association of Nigeria*. 42.1&2: 85 – 88

Olaf, K. and Baumert, J. 2001. Does Interest Matter? The Relationship between Academic Interest and Achievement in Mathematics. *Journal for Research in mathematics Education,* 32.6: 448 - 470

Olarinmoye, R.D. 2000. Strategies for Effective Teaching of Modern Physics A keynote Address presented at the STAN Physics Panel Workshop held at Government College, Katsina State. 24th - 29th, April, 2000

Olatoye, R.A. and Adekoya, Y. M. 2010. Effect of Project-Based, Demonstration and Lecture Teaching Strategies on Senior Secondary Students' Achievement in an Aspect of Agricultural Science. *International Journal of Educational Research and Technology* 1.1: 20-29

Olayiwola, J. O. 2014. Problems of Teaching and Learning Science in Junior Secondary Schools in Nasarawa State, Nigeria *Journal of Education and Practice,* 5.34:109-118

Oludipe, B.M. 2003. Peer Tutoring-Assisted Instruction: An Intervention for Increasing Senior Secondary School Students' Performance in Physics. *African Journal of Educational Research* 9.1 & 2: 42 – 48.

Oluwatelure, T. A. 2015. Gender Difference in Achievement and Attitude of Public Secondary School Students towards Science. *Journal of Education and Practice,* 6.2: 87-92

Omosewo, E.O. 2009.Views of Physics Teachers on the Need to Train and Retrain Physics Teachers in Nigeria *African Research Review,* 3.1:314 - 325

Onah, D.U. and Ugwu, E.I. 2010. Factors which Predict Performance in Secondary School Physics in Ebonyi North Educational Zone of Ebonyi State, Nigeria. *Advances in Applied Science Research*, 1.3: 255 - 258

Onuaha, J. C. Eneogu, N.D. Asogwa, U. and Ngwuchukwu, M. 2016. Effect of Jigsaw on Students' Achievement in Junior Secondary School Social Studies in Nsuka, Nigeria. *The Social Science*, 11.14: 3484 – 3489

Onyeachu, E. 2000 Teachers Characteristics and School Curriculum Implementation in Nigeria secondary Schools: A Theoretical Review in *Journal of the Nigeria Academy of Education, Nigeria johaned*, 1:118-120

Oriakhi, U. and Ujiro, I. 2015. Influence of Gender on Students' Academic Achievement in Government Subject in Public Secondary Schools in Oredo Local Government Area of Edo State, Nigeria. *Journal of Educational and Social Research MCSER Publishing, Rome-Italy* 5.2:101 -109

Osborne, D.G. 2016. Why Teach Physics in Teaching School Physics Lewis, J. L. (Ed): A Publication of UNESCO *http://unesdoc.unesco.org retrieved 24/3/2018*

Osokoya, I. 2010. Teacher Education in Nigeria: Past, Present and Future Challenges. *Academic Leadership. The Online Journal* 8.4: Article 61

Owlcation, 2017. Physics: Definition and Branches *https://owlcation.com retrieved 22/6/2017*

Owolabi, T. 2004. A Diagnosis of Students' Difficulties in Physics. *Educ. Perspectives*, 7: 15-20

Oxford Living Dictionary, 2018. Commitment Oxford University Press. Accessed Online 29/7/2018 *https://en.oxforddictionaries.com*

Pelobillo, G. 2018. Jigsaw Technique in Learning Physics and Problem-Solving Dimensions of Senior High School Students *JPAIR Multidisciplinary Research* 32.1: 90 - 109

Physics Tutor, 2022. Topics for SSS 1 to SSS 3 based on Physics Scheme of Work Retrieved online from *http://basicallyphysics.blogspot.com/2014/08/topics-for-sss-1-to-sss-3-based-on-my.html* 15/02/2022

Prince M. 2004. Does active learning work? A Review of the research, J Eng Educ. 93: 223-231

Project Clue, 2021. The problem and Prospect of Teaching and Learning Physics in Secondary School Accessed Online from *https://researchtopics.xyz/education/project-*

ProjectClue, 2021. Undergraduate Project Topics, Research Works and Materials available at *https://www.projectclue.com/education/project-topics* *25/03/2021*

Raimi, S. M. 2002. Problem Solving Technique and Laboratory Skills as Supplements To Laboratory Teaching in Senior Secondary School Learning of Volumetric Analysis. Ph.D Thesis-Department of Teacher Education, University Of Ibadan,

Raimi, S.M. and Adeoye, F.A. 2002. Gender Difference among College Students as Determinant of Performance in Integrated Sciences *African Journal of Science Education.* 29.9: 1043-1059.

Rana, M. M. Farouque, M. G. Rahman, M. Z. 2020. Attitude of Common Interest Group Members towards National Agricultural Technology Programme (Phase-I) Interventions. *Journal of Bangladesh Agricultural University*, 18.1: 194–202.

RezeiGazki, P. Delavar, A. and Samavi, A. 2019. Does Academic Commitment Affect the Learners' Progress Through Academic Buoyancy? A Structural Equation Model. Ir*anian Evolutionary and Educational Psychology Journal*, 9:196-203

Riegle – Crumb, C and Moore, C. 2013. The Gender Gap in High School Physics: Considering the Context of Local Communities, *Social Science Quarterly*, 95.1: 253- 268

Saleh, S. 2014. Malaysian Students' Motivation towards Physics Learning. *European Journal of Science and Mathematics Education*, 2: 223 - 232

Samuel, R. I. 2018. Effect of Reversed Jigsaw Cooperative Instructional Strategy on Upper Basic II Basic Science Students' Interest, Attitude and Achievement in Thermal Energy *International Journal of Scientific and Education Research*, 2.5: 73 - 83

Saribaglou, J. A. Vahedi, S. Eskandar, F. A and Abidi, L. 2019. The Effect of Reversed Jigsaw Classroom on University Students' Academic Performance and Statistics Anxiety. *Educational Psychology* 15.52: 133 – 153

Saul, M. 2016. Albert Bandura's Social Cognitive Learning Theory in Simply Psychology retrieved December 28, 2021 at *https://www.simplypsychology.org/bandura.html*

Sayid, D.G. and Milad, K. 2011. Gender Differences in Factors Affecting Academic Performance of High School Students Elgevier, *Procedia Social and Behavioral Science.* 15:1040 – 1045

Sci-Tech Encyclopedia, 2012. Online International Encyclopedia of Science and Technology *http:/www.Ssci-tech.edu/physics-education/html*

SERC Carleton.Edu, 2021. What are Interactive Lecture Demonstrations? Retrieved Online from *https://serc.carleton.edu/introgeo/demonstrations/what.html* 01/02/2022

Sewwar, W.J. and Jewwet, A.S. 2004. Physics for Engineers (6th ed). New York: Thompson Brooks/Cole

Sharman, M.D; Johnston, J.D; Johston, H; Varvell,K; Robertson, G; Hopkins A; Stewart, C; and Thornton, R. 2010. Use of Interactive Lecture Demonstrations: A Ten Year Study in *Physical Review Special Topics-Physical Education Research 6*:020119-1 – 020119-9

Sheltering Wings, 2022. Commitment to Learning Retrieved Online from *https://shelteringwings.org/prevent-abuse/40-developmental-assets/commitment-to-learning/* 02/02/2022

Singh, S. P. Malik, S and Singh, P. 2016. Factors Affecting Academic Performance of Students. *Indian Journal of Research*, 5.4: 176 - 178

Sitotaw, B and Tadele, K. 2016. Students' Attitude towards Physics in Primary and Secondary Schools of Dire Dawa City Administration, Ethiopia. *World Journal of Educational Research and Reviews,* 2.2: 14 - 21

Slavin, R.E. 1996. Research on Cooperative Learning Achievement, What we know, What We Need to Know. Boston: Contemporary Educational Psychology

Šlekienė, V. and Ragulienė, L. 2010. The Learning Physics Impact of Interactive Lecture Demonstrations Problems of Education in the 21st Century *Scientia Educologica*, Lithuania, 24. 120 – 129

Social Psychology Network, 2019. The Jigsaw Classroom. Retrieved online from *https://www.jigsaw.org/* 16/07/2019

Sofiani, D. Maulida, A. S. Fadhillah, N. and Sihite, D.Y. 2017. Gender Differences in Students' Attitude towards Science *Journal of Physics: Conf. Series* 895: 1 - 7

Sokoloff, R. D. 2012. Active Learning of Introductory Optics: Strategies for the U.S. and the Developing World *https://www.osapublishing.org*

Sokoloff, R.D. and Thornton, R.K. 2006. Interactive Lecture Demonstrations, Active Learning in Introductory Physics *https://www.wiley.com retrieved 12/4/2018*

Sonsteng, O.; Ward, D; Bruce; and Petersen, M.2007. A Legal Education Renaissance: A Practical Approach for the Twenty-first Century. *William Mitchell Law Review*: 34.1: Article 7.

Spidalworks Digital. 2022. Physics- SS2- Retrieved Online from *https://classhall.com/subject/physics-ss2/* 13/02/2022

Strydom, J. F., Mentz, M., & Kuh, G. D. 2010. Enhancing Success in Higher Education by Measuring Student Engagement in South Africa. *Acta Academica*. 42.1: 259–278.

Suarez, C.H.A., Suarez, A.A.G and Suarez, O. J. 2021. Attitudes towards Physics: A Study with High School Students from the Colombian Context 1st International Conference on Physical Problems of Engineering (1st ICPPE) *Journal of Physics: Conference Series;1 - 6*

Taber, K. S. 2021. Physics Education *https://www.educ.cam.ac.uk retrieved 28/2/2021*

Tabotndip, J.E. 2021. Contributions of Secondary Education to National Development of Nigeria Accessed Online 02/03/2021 from https://globalacademicgroup.com

Tao, P.K. 1999. Peer Collaboration in Solving Qualitative Physics Problems: The Role of Collaborative Talk. *Research in Science Education*. 29.3: 365-383

TeacherVision, 2022. Tips for Achieving and Maintaining Discipline Retrieved online *https://www.teachervision.com/classroom-discipline/tips-achieving-maintaining-discipline 31/01/2022*

Teaching Certification.com, 2021. Physics Teacher Certification. Accessed Online 05/03/2021 from *www.teaching–certification.com*

Theodore, H. Jack, H. and Warren, H. 2009. Preparing High-School Physics Teachers *Physics Today* 62.2:40-45

Thompson, M., and Pledger, L. 1998. Cooperative Learning versus Traditional Lecture Format: A Preliminary Study. Paper presented at the Meeting of the National Communication Association, New York, NY.

Thornton, R. 2003. *Interactive Lecture Demonstrations.* Active Learning in Difficult Settings. *http://www.aapt.org retrieved 29/6/2018*

Timayi, J.M. Bolaji, C. and Kajuru, Y.K. 2016. Effects of Jigsaw IV Cooperative Learning Strategy (J4CLS) on Academic Performance of Secondary School Students in Geometry. *International Journal of Mathematics Trends and Technology*. 28.1: 12 - 18

Tingley, S. C. 2022. Homework, Reading, Teaching Techniques and Strategies: Should Students Have Homework? Retrieved Online from *https://www.wgu.edu/heyteach/article/should-students-have-homework1808.html 02/02/2022*

Tinto, V. 1975. Dropout from Higher Education: A Theoretical Synthesis of Recent Research. *Review of Educational Research*, 45:89–125.

Trumper R, 2006. Factors affecting Junior High School Students Interest in Biology, *Science Education International*. 17: 31-48

Tytler, R. and Osborne, J. 2012. Student Attitude and Aspirations towards Science in B.J.Fraser and C.J. Mcrobbie (Eds.), Second International Handbook of Science Education. 597 – 625. Dordrecht:Springer.

Udoh O. A. 2012. Refocusing Physics Education in Nigeria: Issues and Challenges in Teacher Education Okon Akpakpan Udoh. *Mediterranean Journal of Social Sciences*, 3.13: 11-19

Ugwanyi, C. S. Nwankwo, C. and Ugwoke, E. 2016. Assessment of the Efficacies of Power-Point Presentation and Demonstration Methods on the Interest and Achievement of Students in Physics. 57th Annual Conference Proceedings of Science Teachers Association of Nigeria Pp 487-493

UNESCO, 2000. Gender Equality and Equity. A Summary of UNESCO's Accomplishments of the Fourth World Conference on Women Beijing, 1995

Usman, I.S. and Abubakar, Y.B. 2019. Senior Secondary School Physics Curriculum Content Coverage and Student's Achievement in Katagum Educational Zone, Bauchi State, Nigeria. *International Journal of Scientific Research in Education*, 12.4: 489-499

Van, D.T. and Ramon, L. 2012. The Effects of Jigsaw Learning on Students' Attitudes in a Vietnamese Higher Education *International Journal of Higher Education*, 1.2: 9-20

Vanguard Newspaper, 2011. NECO Releases Results, records Another Mass Failure *https://www.vanguardngr.com*

Vasudevan, L. 2011. Interactive Lecture Demonstration, Active Learning and the ALOP Project. Proceedings of SPIE-The International Society for Optical Engineering DOI:10.1117/12.889508

Veloo, A., Nor, R., and Khalid, R. 2015. Attitude towards Physics and Additional Mathematics Achievement towards Physics Achievement *International Education Studies*, 8.3: 35-43.

Viljoen, B. 2015. The Relationship between Academic Commitment and Resilience for Education Students at the University of Pretoria. B.Ed Thesis Department of Educational Psychology Faculty of Education, University of Pretoria.

Vogel, F. R. and Human-Vogel, S. 2016. Academic Commitment and Self-Efficacy as Predictors of Academic Achievement in Additional Materials Science. *Higher Education Research and Development*, 35.6: 1298 - 1310

Wang, L. 2005. Using New Strategies to Improve Teaching and Learning in a Fundamental Physics Course in *The China Papers. http://science.uniserve.edu.au retrieved 26/4/2018*

Wattanakasiwich, P., Khamcharean, C. Taleab. P. and Sharma, M.D. 2012. Interactive Lecture Demonstration in Thermodynamics. *Latin American Journal of Physics Education*, 6.4: 08 – 514

Watson, P. 2002. The Role and Integration of Learning Outcomes into the Educational Process. 3.3: Available online at https://doi.org/10.1177/14697874023003002

Weiman, C. and Perkins, K. 2020. Transforming Physics Education Physics *Today* 58.1: A Publication of the American Institute of Physics (AIP)

Weltman, D. 2007. A Comparison of Traditional and Active Learning Methods: An Empirical Investigation Utilizing a Linear Mixed Model Ph.D Thesis Faculty of the Graduate School, University of Texas

West African Examinations Council. 2006. Chief Examiner's Report on Physics for May/June Senior Secondary School Certificate Examination. Accessed on 16/07/2006 from www.waeconline.org.ng

-- 2008. Chief Examiner's Report on Physics for May/June Senior Secondary School Certificate Examination. Accessed on 23/03/2019 from www.waeconline.org.ng

-- 2011. Chief Examiner's Report on Physics for May/June Senior Secondary School Certificate Examination. Accessed on 23/03/2019 from www.waeconline.org.ng

-- 2016. Chief Examiner's Report on Physics for May/June Senior Secondary School Certificate Examination. Accessed on 27/02/2021 from https://pasco360.com

-- 2017. Chief Examiner's Report on Physics for May/June Senior Secondary School Certificate Examination. Accessed on 23/03/2019 from https://waeconline.org.ng/e-learning/physics/phys222ms.html

-- 2018. Chief Examiner's Report on Physics for May/June Senior Secondary School Certificate Examination. Accessed on 23/03/2019 from https://waeconline.org.ng/e-learning/physics/phys223ms.html

-- 2020. About Us. *Retrieved 10/02/2022 from https://www.waecnigeria.org/about-us*

-- 2021. Chief Examiner's Report on Physics for May/June Senior Secondary School Certificate Examination. Accessed on 25/03/2021 from https://www.waeconline.org.ng/e-learning/Physics/phys228mc.html

Wikina, P. 2016. Effects of Two Essay Instructional Strategies on Students' Learning Outcomes in Descriptive and Expository Composition in Senior Secondary Schools in Abeokuta. A Post-field Seminar Paper, Department of Teacher Education, University of Ibadan 3/2/2016.

Wimer, J.W., Ridenour, K.T. and Place, A.W. 2001. Higher Order Teacher Questioning of Boys and Girls in Elementary Mathematics Classrooms. *The Journal of Educational Research,* 95.2: 84-92.

World Health Organization (WHO), 2018. Gender, Equity and Human Rights *http://www.who.int retrieved 29/6/2018*

Xavier, M. and Croix, S. J. 2016. Attitude of Physics Students towards Physics at College of Science and Technology– University of Rwanda. *The Rwandan Journal of Education*, 3.2: 1 – 10

Yara, P. (2009). Relationship between Teachers' Attitude and Students' Academic Achievement in Mathematics in some selected Senior Secondary Schools in South-Western Nigeria. *European Journal of Social Sciences*. 11.3: 364-369.

York, T. T.; Gibson, C.; and Rankin, S. 2015. "Defining and Measuring Academic Success," Practical Assessment, Research, and Evaluation: 20.5: https://doi.org/10.7275/hz5x-tx03 Available at: *https://scholarworks.umass.edu/pare/vol20/iss1/5*

Appendix I

Lesson Note on ILDs **Week 1**

Class: SS2

Duration: 45 minutes

Topic: Sources of Light and Classification of Objects

Instructional Materials: A lighted fluorescent tube/bulb, a wall, a cardboard paper, a plane glass, a mirror, a lighted touch, a carbon paper, clear water, oiled paper, tainted glass

Behavioral Objectives: At the end of the lesson, the students should be able to:

i. Identify the different types of objects on the basis of their ability to produce light or not.
ii. Classify objects into luminous and non-luminous groups.
iii. Identify objects that allow light to pass through them.
iv. Identify objects that do not allow light to pass through them.
v. Explain the concepts of transparent, translucent and opaque

Previous Knowledge: Students are aware that:

- light enables us to see things clearly
- not all objects produce light etc
- they are aware of darkness at night.

Introduction: The teacher asks the students how they feel when they have reason to go and bring something from a dark room or when they have course to walk around at night without a source of light.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher arranges and labels the different objects listed above as instructional materials.

Step 2: Teacher asks the students to go round and look at the objects to see if they are capable of producing light or not, enabling light to pass through them or not, allowing other objects to be seen through them or not etc

Step 3: Students are given time to make their predictions and write them on a prediction sheet.

Step 4: Students are requested to share their thoughts with their classmates. They could be allowed to change their answers if they so choose.

Step 5: The teacher picks each of the objects in turn, asks students questions on it and demonstrates before the whole class to arrive at its distinctive properties.

Step 6: Students are challenged to observe the demonstrations and record their observations.

Step 7: Students are required to note the disparity if any, between their predictions and the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

Step 9: The teacher leads the class in a discussion where he points out that:

- Objects e. g. lighted bulb and touch that produce light of their own are called luminous.
- Objects e. g. wall, mirror, cardboard paper that do not produce light are non-luminous.
- Objects e. g. clear water, plane glass that enable other objects to be seen through them are transparent objects. They also allow light to pass through them.
- Tainted glass and oiled paper which though allow light to pass through them but do not allow other objects to be seen are called translucent objects.
- Wall, mirror and cardboard paper are opaque etc

Evaluation: The teacher evaluates the lesson by asking students questions such as:

- Distinguish between luminous and non-luminous objects.
- State the similarity (ies) between transparent and translucent objects.

Summary: The teacher summarizes those important points listed above on the board so that students can copy into their note books.

Assignment:

- List 3 examples each of (i) luminous (ii) opaque (iii) transparent (iv) translucent objects.
- Classify the following objects under transparent, translucent and opaque: diamond; moon; stars; planets; palm oil; an oiled paper; nylon; a brass tray.

Week 2

Class: SS2

Duration: 45 minutes

Topic: Rectilinear Propagation of Light

Instructional Materials: One straight metal pipe, one bent metal pipe, a lighted candle, centrally punched cardboard pieces,

Behavioral Objectives: At the completion of the lesson, learners should be proficient to:

i. Explain the concept of rectilinear propagation of light.
ii. Demonstrate that light travels on a straight line.
iii. State the direct consequences of the rectilinear propagation of light.

Prior Knowledge: Students had earlier been aware of the concept of light, its effects and the associated terminologies.

Introduction: The teacher introduces the lesson by asking students questions on the previous topic and further asks them whether light from a lighted touch can travel round a corner.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher sets up the demonstration with a lighted candle place right before each of the two pipes (a straight and a bent pipe).

Step 2: Teacher asks the students to observe the set-up (demonstrations) and make a prediction on what happens when the arrangement is viewed from the other end of each pipe.

Step 3: Students are given time to make their predictions and write them on a prediction sheet.

Step 4: Students are to share their thoughts with their classmates. They could be allowed to change their answers if they so choose.

Step 5: The teacher joins the students in the observation of the demonstration (experiment) stressing the important observation he wants them to note.

Step 6: Students are challenged to observe the demonstrations again and record their observations.

Step 7: Students are required to note the disparity if any, between their predictions and the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

Step 9: The teacher leads the class in a discussion where he points out that:

- Light from a lighted candle placed before a straight pipe can be seen by the eye placed at the other end of the pipe.
- Light from a lighted candle placed before a bent pipe is cut off when viewed from the other end of the pipe.
- A similar effect is obtained when three cardboard pieces are arranged vertically so that holes at their centres are along a straight line, light from a candle in front of the first cardboard is seen by the eye placed at the back of the third cardboard.
- The teacher concludes by observe that light travels on a straight line, it doesn't negotiate corner. The phenomenon is called **rectilinear propagation of light.**
- It causes shadows and eclipses.

Evaluation: The teacher evaluates the lesson by asking students questions such as:

- How does light travel?

Summary: The teacher summarizes those important points listed above on the board so that students can copy in their note books.

Assignment:

- Explain the concept of rectilinear propagation of light.
- State the direct consequences of rectilinear propagation of light.

Week 3

Class: SS2

Duration: 45 minutes

Topic: Shadows and Eclipses

Instructional Materials: A point source of light e. g. a light tight box with a small needle hole at one end and a screen at the other end, an extended source of light like lighted candle, an opaque object e. g. ball

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Explain the terms shadows and eclipses.
- Distinguish between umbra and penumbra.
- State the different types of eclipse.
- Draw diagrams to illustrate formation of shadows.

Previous Knowledge: Students are aware that light travels on a straight line.

Introduction: The teacher introduces the lesson by asking students to state what will likely happen if light is obstructed by an opaque object.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher sets up the demonstration with a ball (an opaque object) positioned in the middle of torchlight and a screen in a dark room.

Step 2: Teacher asks the students to observe the set-up (demonstrations) and make a prediction on the likely effect of the arrangement on the screen.

Step 3: Students are given time to make their predictions and write them on a prediction sheet.

Step 4: Students share their thoughts with their classmates. They could be allowed to change their answers if they so choose.

Step 5: Teacher carries out the observation of the demonstration (experiment) stressing the important observation such as observation of an area of darkness on the screen.

Step 6: Students are challenged to observe the demonstrations again and record their observations.

Step 7: Students are required to note the disparity if any, between their predictions and the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

Step 9: The teacher leads the class in a discussion where he points out that:

- An area of darkness (shadow) is formed when light is obstructed by an opaque object.
- The torchlight sends out light in all directions but the portion of the light that strikes the ball is not let through by the ball, and so cannot reach the screen.
- The area of darkness is called shadow.
- With an extended source, the central part of the shadow is dark while the edges are partially dark.

- The centrally dark region is called umbra while the partially dark region is penumbra.
- Shadow formation on a large scale among the planets is called eclipse.

Evaluation: The teacher evaluates the lesson by asking students to:

- Distinguish between umbra and penumbra.
- Explain solar eclipse.

Summary: The teacher summarizes those important points listed above on the chalkboard for students to copy.

Assignment:

- Describe how shadow of a man changes as he walks away from a street lamp on a dark night.
- Draw a diagram to illustrate how lunar and annular eclipses are formed.

Week 4

Class: SS2

Duration: 45 minutes

Topic: Pin-hole Camera

Instructional Materials: A light tight box with a small needle hole at one end and a screen at the other end.

Behavioral Objectives: At the end of the lesson, the students should be able to:

- State the principle behind the workings of a pin-hole camera.
- Describe the features of a pin-hole camera.
- State the characteristics of images formed in a pin-hole camera.
- Explain the concept of magnification as it applies to a pin-hole camera.
- State the effects of increasing or decreasing the size of the hole of a pin-hole camera on the image size, image brightness and image sharpness.

Previous Knowledge: Students had earlier been taught shadows and eclipses. They are familiar with the principles behind the formation of shadows and eclipses.

Introduction: The teacher introduces the lesson by asking students what happens imagine they are in a dark room with a small opening made on the wall and someone holds a torchlight from the outside shadows and eclipses. He thereafter links their responses to the new topic.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher sets up the arrangement with a rectangular light proof box with a screen that is made of a translucent material at the back and a pin hole in front of the box.

Step 2: Teacher asks the students to observe the arrangement and make a prediction on what happens when an object is placed in front of the hole.

Step 3: Students are challenged to make their predictions and write them on a sheet of paper.

Step 4: Students are asked to share their thoughts with their classmates. They could be allowed to change their answers if they so choose.

Step 5: The teacher carries out the demonstration with the students and allow students to make observations.

Step 6: Students are required to record their observations.

Step 7: Students are asked to compare their predictions with the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

Step 9: The teacher leads the class in a discussion where he points out that:

- A pin-hole camera is a camera without lens.
- It's the simplest kind of camera.
- Image of an object in front of its front is real.
- The size of the image produced is comparatively smaller than that of the object.
- The image is inverted.
- The greater the object distances, the smaller the image.

Evaluation: The teacher evaluates the lesson by asking students to:

- Define the magnification of the image in a pin hole camera.
- What would you do to increase the size of the image on the screen of a pin-hole camera?

Summary: The teacher summarizes those important points listed above on the chalkboard for students to copy.

Assignment: Students are asked to:

- State the effect of increasing the number of pin holes on the brightness of the image.
- A man 1.5m tall stands 15cm away from a pin-hole camera. If the distance of the pin-hole from the screen is 15cm, find by drawing to scale the size of the image of the man on the screen

Week 5

Class: SS2

Duration: 45 minutes

Topic: Reflection of Light

Sub-topic: Rays and beams of Light; Regular and Irregular Reflections.

Instructional Materials: A small lamp, a ray box (a small box with a narrow slit), a free-standing lamp on a stand in a housing

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Describe a ray of light.
- Distinguish between rays and beams of light.
- Explain the terms parallel, convergent and divergent beams of light.
- Differentiate between regular and irregular reflections.

Previous Knowledge: Concepts of light and shadows formation are no longer new to students.

Introduction: The teacher introduces the lesson by asking questions on the previous topic of pin-hole camera and links it with day's lesson.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher sets up the demonstration with a free-standing lamp on a stand, shielded by a housing with a narrow slit through which light can escape to a screen in front of it. The hole may be made two, three or four in number later.

Step 2: Teacher asks the students to observe the arrangement and make a prediction on what happens when the lamp is lit.

Step 3: Students are challenged to make their predictions and write them on a sheet of paper.

Step 4: Students are asked to share their thoughts with their classmates. They could be allowed to change their answers if they so choose.

Step 5: The teacher carries out the demonstration with the students and allow students to make observations.

Step 6: Students are required to record their observations.

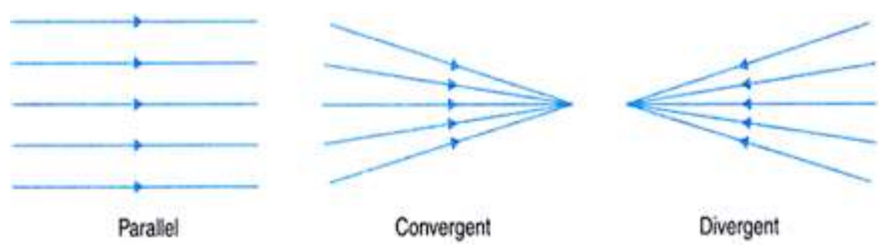
Step 7: Students are asked to compare their predictions with the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

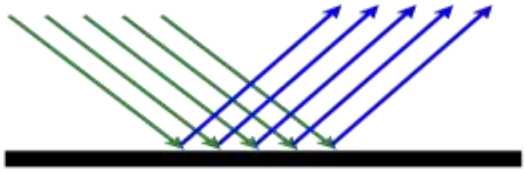
Step 9: The teacher leads the class in a discussion with emphasis on:

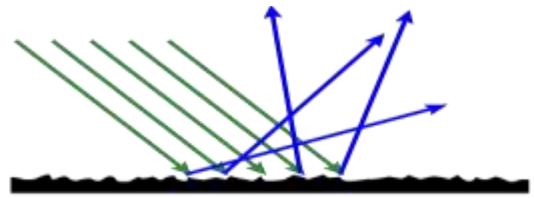
- Light ray as the direction along which light energy travels from the source.
- A beam of light is a group or collection of rays of light. It's usually denoted by a straight line with an arrow on it.
- A beam of light could be parallel as in the case of rays from a ray box or from a distant object.
- A divergence beam is produced from a source diffuse in different directions as in the case

  of light from lantern, torchlight etc
- A convergence beam is produced from a large source and come together to meet at a point.



- When a parallel beam strikes a smooth surface e. g. a plane mirror, rays are reflected in the one direction leading to regular reflection.
- When a parallel beam of light strikes a rough surface (a cardboard) , rays are scattered in different directions causing an irregular reflection.





Culled Online from [***https://www.google.com/search?q=regular-and-irregular-reflections***](https://www.google.com/search?q=regular-and-irregular-reflections)

Evaluation: The teacher evaluates the lesson by asking students to:

- State the conditions for (i) regular reflection; and (ii) irregular reflection to occur.
- When is a beam of light said to be parallel?

Summary: The teacher summarizes those important points listed above on the chalkboard for students to copy.

Assignment: Sketch the diagrams of (i) divergence beam; (ii) parallel beam (iii) convergent beam (iv) regular reflection and (v) irregular reflection. (illustrate with diagrams)

Week 6

Class: SS2

Duration: 45 minutes

Topic: Reflection on Plane Mirror

Instructional Materials: A mounted plane mirror, a ray apparatus, four optical pins and a paper.

Behavioral Objectives: Upon the completion of the lesson, students should be skilful enough to:

- Identify the incident rays, the reflected rays, the normal.
- Differentiate between angles of incidence and angles of reflection
- State the relationship between them.
- State both first and second laws of reflection.
- Use the relationship to solve simple mathematical problems.

Previous Knowledge: Students are familiar with the concept of reflection and its types.

Introduction: The teacher introduces the lesson by asking students to explain the term regular reflection. He thereafter links it with the topic for the day.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher sets up the demonstration by placing a mounted plane mirror on a paper and draw a slanting line to meet the mirror at a point say O. He thereafter sticks two pins vertically at a distance from each other on the line.

Step 2: Students are to draw a slanting line to meet the mirror at a point to be labeled. The students are also required to stick two pins on the line and observe the image of those pins from a specific direction.

Step 3: Students are challenged to make their predictions of what happens after removing the pins and joins the two lines. They are to write them on a sheet of paper.

Step 4: Students are asked to share their thoughts with their classmates. They could be allowed to change their answers if they so choose.

Step 5: The teacher carries out the demonstration with the students and allow students to make observations.

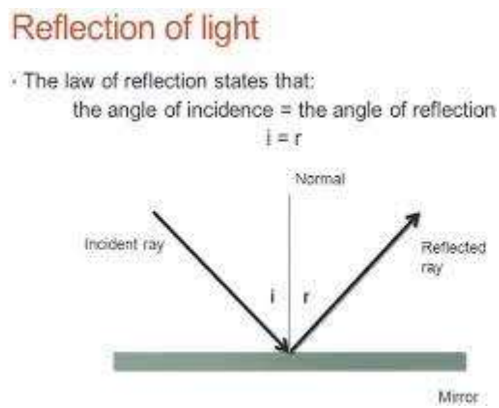
Step 6: Students are required to record their observations.

Step 7: Students are asked to compare their predictions with the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

Step 9: The teacher leads the class in a discussion with emphasis on:

- Incident ray: the ray that goes into the mirror.
- Reflected ray: the ray that is sent back by the mirror.
- Normal: a line perpendicular to the mirror.
- Angle of incidence: Angle that the incident ray makes with the normal.
- Angle of reflections: Angle between the reflected ray and the normal.
- Law I: Incident ray, reflected ray and normal are all on the same plane at the point of incidence.
- Law 1I of Reflection: Angle of incidence = angle of reflection.
-



Culled Online from

https://www.google.com/search?q=Laws+of+reflection&client=firefox

Evaluation: The teacher evaluates the lesson by asking students to:

- State the laws of reflection.
- A boy moves 2.4m towards a plane mirror. Through what distance has he moved nearer his image?

Summary: The teacher summarizes those important points listed above on the chalkboard for students to copy.

Assignment:

- Test the truth of the law of reflection by changing the angles of incidence and observing the corresponding angles of reflection.
- Draw a ray of light incident at 45^0 on plane mirror. Draw the normal and the reflected ray. What is the angle of deviation of the ray?

Week 7

Class: SS2

Duration: 45 minutes

Topic: Image Formation in a Plane Mirror

Instructional Materials: A mounted plane mirror, a ray apparatus, optical pins, sharp pencil and a paper.

Behavioral Objectives: By the close of the lesson, learners ought to be able to:

- Give details of how an image is formed by a plane mirror.
- Explain the concepts of real and virtual images.
- Distinguish between real and virtual images.

- Explain the concept of lateral inversion.
- State the characteristics of images formed by a plane mirror.

Previous Knowledge: Students are familiar with the concept of reflection and how to trace or locate the reflected rays.

Introduction: The teacher introduces the lesson by revising the last topic on reflection in a plane mirror and/or asking related questions.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher sets up the demonstration by placing a mounted plane mirror on a paper and placing a ray apparatus in front of it using a slit to produce a ray of light. The ray is made to strike a mirror.

Step 2: Teacher asks the students to erect a pin vertically somewhere inside the beam

Step 3: Students are challenged to observe a shadow of the pin going into the mirror and being reflected. They are asked to make predictions of what becomes of the pin as it appears in the mirror, in terms of distance from the mirror, its nature, height etc.

Step 4: Students are asked to share their jottings with their classmates. They could be allowed to change their answers if there is need for it.

Step 5: The teacher takes the students through the demonstration and allows them to make observations.

Step 6: Students are required to record their observations.

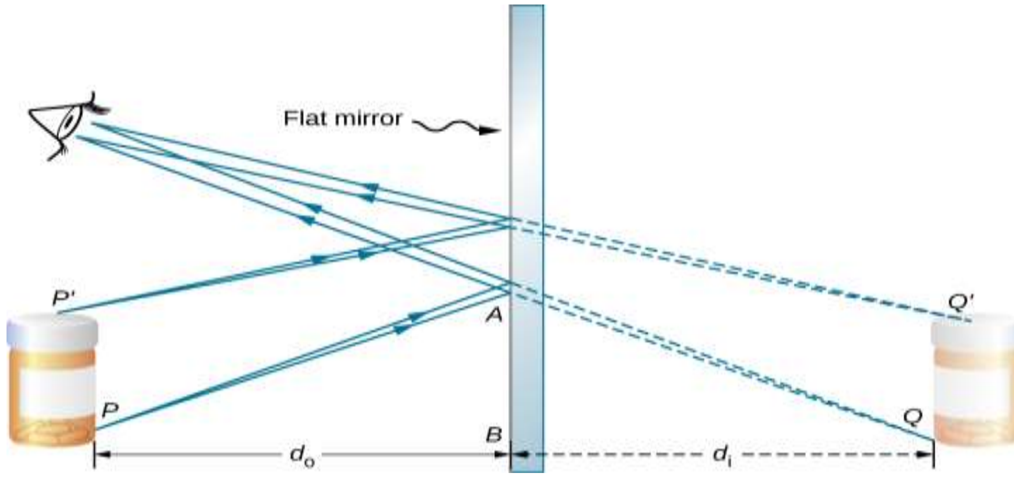
Step 7: Students are asked to compare their predictions with the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

Step 9: The teacher leads the class in a discussion stressing that image formed by a plane mirror is:

- Virtual i. e. cannot be formed on a screen.
- Upright or erect.
- Laterally inverted.
- Image size is the same as that of the object.

- Image distance = object distance.



Culled from University Physics Volume 3 available at https://opentextbc.ca/universityphysicsv3openstax/chapter/images-formed-by-plane mirrors/ 06/01/2022

Evaluation: The teacher evaluates the lesson by asking students to:

- State properties of images in a plane mirror.
- A boy moves 1.3m towards a plane mirror. Through what distance has he moved nearer his image.
- State the uses of a plane mirror.

Summary: The teacher summarizes those important points listed above on the chalkboard for students to copy.

Assignment:

- Explain the terms (i) real, (ii) virtual, (iii) lateral inversion and (iv) image distance
- If a word is written on a thin sheet of paper, explain how you would use a plane mirror to read the word from the back of the paper.

Week 8

Class: SS2

Duration: 45 minutes

Topic: Periscopes and Kaleidoscopes

Instructional Materials: 12" Pieces of PVC pipe, elbow joint pipes, plane small mirrors, putty,

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Describe the making of a periscope.
- State the uses of a periscope.
- State the numbers of images formed when two plane mirrors are inclined at a known angle to each other.
- Write out the formula for finding the number of images formed by inclined mirrors.

Previous Knowledge: Students are aware that several images are formed when two plane mirrors are set facing each other as in the case of mirrors in a barber's shop or at an angle from each other.

Introduction: The teacher introduces the lesson by asking the students to state their experience during a visit to a barbing (hair dressing) saloon having two mirrors set facing each other

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher sets up the demonstration by

- placing an object between two mirrors inclined at an angle to each other
- placing a curved elbow joint pipe over each end of the 12" each pipe facing opposite directions and fixing a mirror each into one end of the pipe with putty

Step 2: Students are asked to make predictions of their observations when they in turn use the arrangement to view objects at overhead positions.

Step 3: Students are asked to share their thoughts with their classmates. They could be allowed to change their answers if there is need for it.

Step 5: The teacher takes the students through the demonstration and allows them to make observations.

Step 6: Students are required to record their observations.

Step 7: Students are asked to compare their predictions with the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

Step 9: The teacher leads the class in a discussion stressing that:

- Two mirrors work together to make a periscope.
- The periscope captures the image of any overhead object for which it is used and reflect it back into the bottom mirror.

- Periscopes can also be used in trenches by military during war times.
- Useful in submarines to view object on the surface of water.
- Kaleidoscopes are formed when two mirrors are inclined at an angle to each other.
- An infinite number of images are formed when mirrors are arranged parallel to each other.
- For number "N" of images between two mirrors at an angle "x^o" to each other,

  $$\mathbf{N = \frac{360}{x^0} - 1}$$

Evaluation: The teacher evaluates the lesson by asking students to:

- State the uses of a periscope.
- How many images will be produced if the mirrors: (i) are inclined at 30^0; (ii) are parallel?

Summary: The teacher summarizes those important points listed above on the chalkboard for students to copy.

Assignment: Construct a periscope each for use in the class.

Week 9

Class: SS2

Duration: 45 minutes

Topic: Curved Spherical Mirrors

Instructional Materials: concave mirrors, convex mirrors, any reflecting surface that bulges outward, recesses inward

Behavioral Objectives: Upon the completion of the session, students become fit to:

- Distinguish between concave and convex mirrors.
- List and explain each of the terms associated with curved surfaces.
- State the principles behind the image formation in a plane mirror.
- State the characteristics of images formed by an object placed at different positions in front of the mirror.
- State the uses of the curved mirrors.

Previous Knowledge: Students had earlier been taught how images are formed by plane surfaces.

Introduction: The teacher introduces the lesson with questions on the previous topic and establishment of a link between it and the new topic.

Presentation: The teacher presents the lesson as follows:

Step 1: The instructor sets up the demonstration and students:

- Feel the structures of both concave and convex mirrors.
- Observe images of an object at different positions from the mirror.

Step 2: Students are asked to make predictions of the features of the images formed by the mirrors on a sheet of paper.

Step 3: Students are asked to share their predictions with their classmates and change their answers if there is need for it.

Step 5: The teacher takes the students through the demonstration and allows them to make observations.

Step 6: Students are required to record their observations.

Step 7: Students are asked to compare their predictions with the correct observations.

Step 8: A student with correct predictions is asked to lead the class in a discussion.

Step 9: The teacher leads the class in a discussion stressing that:

- A concave mirror converges parallel rays to a point on the principal axis called the focus.
- A convex mirror diverges parallel rays from distant object to form an erect, virtual and diminished image behind the mirror at a point called the focus.
- Aperture refers to the width of the mirror
- Pole (P) refers to the central point on an aperture.
- Focal length (f) is distance between the pole and the focus.
- Radius of curvature (r) is distance between the pole and centre of curvature (C) and it is twice the focal length.
- Image and object distances in curved mirrors are related by $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$
- Where v = image distance; and u = object distance

Evaluation:

- Distinguish between a concave and a convex mirror by looking at their face in each.
- What advantages, as a driver's mirror, does a convex mirror over a plane mirror.

Summary: The teacher summarizes those important points listed above on the chalkboard for students to copy.

Assignment: Determine the position of the object and the image when a concave mirror of radius of curvature 30cm produced an inverted image 4 times the size of an object placed perpendicular to the axis.

Appendix II

Lesson Note on GRJIS

Week 1

Class: SS2

Duration: 45 minutes

Topic: Sources of Light and Classification of Objects

Instructional Materials: A lighted fluorescent tube/bulb, a wall, a cardboard paper, a plane glass, a mirror, a lighted touch, a carbon paper, clear water, oiled paper, tainted glass

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Identify the different types of objects on the basis of their ability to produce light or not.
- Classify objects into luminous and non-luminous groups.
- Identify objects that allow light to pass through them.
- Identify objects that decline passage of light.
- Explain the terms transparent, translucent and opaque

Previous Knowledge: Students are aware that:

- light enables us to see things clearly
- not all objects produce light etc
- they are aware of darkness at night.

Introduction: How do you feel when you have reason to go and bring something from a dark room or when have course to walk around at night without a source of light?

Presentation: The teacher presents the lesson as follows:

Step 1: Students are split into 5- person jigsaw sets.

Step 2: The teacher requests one of the students in each group to volunteer to be group leader.

Step 3: The group leader in conjunction with the teacher divides the day's lesson into 4 segments as follows:

- Identification of common properties of the given objects which include lighted torch, electric lamp, candle flame, lighted bulb
- Identification of the characteristic features of wood, cloth, cardboard paper, wall

- Identification of common features of plane glass, water, clear solutions.
- Identification of properties of oiled paper, butter paper, tainted glass

Step 4: A student from each group is selected to learn one of the segments.

Step 5: Students are given time to read over their segments to become familiar with it

Step 6: The teacher forms temporary "expert groups" by picking one student from each jigsaw group to join other students assigned to the same segment.

Step 7: The teacher or the students' leader brings the students back to their original jigsaw group to present his/her segment to the group.

Step 8: The teacher floats from group to group observing the process.

Step 9: Students are tested on the material for them to realize that the session is not for fun but really count. The following questions can serve as guides:

- What do the objects in each group do/have in common?
- Can any of them produce light of its own?
- Does any of them allow light to pass through it?
- Which of the objects would allow other objects to be seen through it?

Evaluation: The teacher evaluates the lesson by asking questions such as:

- Bring out those objects that can produce light of their own.
- To what class of objects does tainted glass belong?

Summary: The recap of the lesson includes:

- Objects that produce light of their own such as torch light, lighted candle etc are Luminous.
- Objects such as plane glass, clean water, clear solutions are called transparent objects because they allow light to pass through them and enable other objects to be seen through them,
- Tainted glass, nylon and oiled paper are said to be translucent because they only allow light to pass through them but do not allow other objects to be seen through them.
- No-luminous objects include cloth, wall, wood which do not produce light of their own.

Assignment: Students are asked to:

- List 3 other examples each (apart from the ones used in the class) of (i) luminous (ii) opaque (iii) transparent (iv) translucent objects.
- Classify the following objects under transparent, translucent and opaque: diamond; moon; stars; planets; palm oil; an oiled paper; nylon; a brass tray.

Week 2

Class: SS2

Duration: 45 minutes

Topic: Rectilinear Propagation of Light

Instructional Materials: One straight metal pipe, one bent metal pipe, a lighted candle, centrally punched cardboard pieces,

Behavioral Objectives: Upon the completion of the session, students are duty-bound to:

- Clarify the concept of rectilinear propagation of light.
- Demonstrate that light travels on a straight line.
- State the direct consequences of the rectilinear propagation of light.

Prior Knowledge: Students are familiar with light concepts, effects of light as well as the associated terminologies.

Introduction: The teacher introduces the lesson by asking students questions on the previous topic and further asks them whether light from a lighted touch can travel round a corner.

Presentation: The teacher presents the lesson as below:

Step 1: Students are assigned into 4- or 5- person groups.

Step 2: Teacher appoints a student from each group as a leader.

Step 3: Teacher split the day's lesson into 4 or 5 units viz-a-viz

- Placement of a light source before a straight pipe and recording of the observation when viewed from the other end.
- Placement of a light source before a bent pipe and recording of the observation when viewed from the other end.
- Arrangement of three pieces of centrally punched cardboard on a line and observation of a light source placed before the first one from the back of the 3RD cardboard when the cardboards are on a straight line.
- A repetition of the last segment but with cardboards not in straight line.

Step 4: A student from each group is picked to work on each of the segments listed above.

Step 5: The teacher gives students enough time to study well and read over their segments for proper mastery of the segment.

Step 6: The teacher forms temporary expert groups by selecting one student from each jigsaw group to join other students assigned to the same segment.

Step 7: He brings the students back to their initial jigsaw groups to present his/her segment to the group.

Step 8: The teacher floats from group to group observing the process while the class is in session.

Step 9: The teacher thereafter asks questions on the materials on which the class works. These include:

- What did you observe when viewed a lighted candle placed in front of a straight pipe from the other end?
- Is your observation the same when a straight pipe is replaced with a bent pipe?
- Report your observation when the pipe is replaced with three pieces of cardboard arranged in a straight line.

Evaluation: The teacher evaluates the lesson by asking students questions such as:

- How does light travel? On a straight line or round a corner?

Summary: The teacher summarizes the important points such as:

- Light travels on a straight line.
- The travelling of light on a straight line is termed rectilinear propagation of light.
- Rectilinear propagation is responsible for the formation of shadows.

Assignment: Students are asked to:

- Explain the concept of rectilinear propagation of light.
- State the direct consequences of rectilinear propagation of light.

Week 3

Class: SS2

Duration: 45 minutes

Topic: Shadows and Eclipses

Instructional Materials: A point source of light e. g. a light tight box with a small needle hole at one end and a screen at the other end or a torchlight from which the glass covering has been removed, an extended source of light like lighted candle, an opaque object e. g. ball

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Explain the terms shadows and eclipses.
- Distinguish between umbra and penumbra.
- State the different types of eclipse.
- Draw diagrams to illustrate formation of shadows.

Previous Knowledge: Students are aware that light travels on a straight line.

Introduction: The teacher introduces the lesson by asking students to state what will likely happen if light is obstructed by an opaque object.

Presentation: The teacher presents the lesson as below:

Step 1: The teacher distributes the students into 4- or 5- person jigsaw groups.

Step 2: Teacher nominates a student from each group as the leader.

Step 3: The teacher divides the day's activity into 4 or 5 sections such as:

- A study of propagation of light with a point source of light in a dark room i.e. placing an opaque object (ball) between a point source of light and a screen.
- A study of propagation of light with an extended source of light i. e. placing an opaque object (ball) between an extended source of light and a screen.
- Observation and description of individual's shadow outside the classroom.
- Reflection on similar occurrences among the planets i. e. sun, moon and earth.

Step 4: A student from each group is picked to work on each of the segments listed above.

Step 5: The teacher gives students enough time to study well and read over their segments for proper mastery of the segment.

Step 6: The teacher forms temporary expert groups by selecting one student from each jigsaw group to join other students assigned to the same segment.

Step 7: He brings the students back to their initial jigsaw groups to present his/her segment to the group

Step 8: The teacher floats from group to group observing the process while the class is in session.

Step 9: The teacher leads the class in a discussion where he points out that:

- An area of darkness (shadow) is formed when light is obstructed by an opaque object.
- The torchlight sends out light in all directions but the portion of the light that strikes the ball is not let through by the ball, and so cannot reach the screen.
- The area of darkness is called shadow.
- With an extended source, the central part of the shadow is dark while the edges are partially dark.
- The centrally dark region is called umbra while the partially dark region is penumbra.
- Shadow formation on a large scale among the planets is called eclipse.

Evaluation: The teacher evaluates the lesson by asking students to:

- Distinguish between umbra and penumbra.
- Explain solar eclipse.

Summary: The teacher summarizes those important points listed above on the chalkboard for students to copy.

Assignment: The teacher asks the students to

- Describe how boy's shadow changes as he walks away from a street lamp on a dark night.
- Draw a diagram to illustrate how a lunar and annular eclipses are formed.

Week 4

Class: SS2

Duration: 45 minutes

Topic: Pin-hole Camera

Instructional Materials: A light tight box with a small needle hole at one end and a screen at the other end.

Behavioral Objectives: At the end of the lesson, the students should be able to:

- State the principle behind the workings of a pin-hole camera.
- Describe the features of a pin-hole camera.
- State the characteristics of images formed in a pin-hole camera.

- Explain the concept of magnification as it applies to a pin-hole camera.
- State the effects of increasing or decreasing the size of the hole of a pin-hole camera on the image size, image brightness and image sharpness.

Previous Knowledge: Students had earlier been taught shadows and eclipses. They are familiar with the principles behind the formation of shadows and eclipses.

Introduction: The teacher introduces the lesson by asking students what happens imagine they are in a dark room with a small opening made on the wall and someone holds a torchlight from the outside shadows and eclipses. He thereafter links their responses to the new topic.

Presentation: The teacher presents the lesson as below:

Step 1: Students are split into 4- or 5- person jigsaw groups.

Step 2: The teacher divides the day's activity into 4 or 5 sections such as:

- Determining the nature of image produced on the screen whether real, virtual, upright, inverted, magnified or diminished etc.
- Examining the effects of change of object distance from the pin-hole on the resulting image.
- Investigating the effects of increasing the number of pinholes on the image produced.
- Determining the effect of increasing/decreasing the size of the pin hole on the image.

Step 3: A student from each group is picked to work on each segment.

Step 4: The teacher gives the students enough time to study well and read over their segments for proper mastery of the segment.

Step 5: The teacher forms temporary expert groups by selecting one student from each jigsaw group to join other students assigned to the same segment in other groups for brainstorming.

Step 6: He brings the students back to their initial jigsaw groups to present his/her segment to the group and to the whole class.

Step 7: The teacher moves from group to group observing the process while the class is in session.

Step 8: The teacher thereafter asks questions on the materials on which they work. These include:

- State the nature of image formed in a pin-hole camera.
- What is the effect of increasing the size of the hole of a pinhole camera on image size?
- What effect does increasing the number of holes have on the brightness of the image?

Evaluation: The teacher evaluates the lesson by asking students questions such as:

- What is the magnification of the image formed in a pin hole camera?
- State the principle upon which the working of a pin-hole camera is based.

Summary: The teacher summarizes those important points such as:

- For an object positioned in front of a pin hole, the image formed on the screen is upside down.
- The image formed is real as it can be seen on a screen.
- Increasing the distance of the object from the pin hole causes the object to be smaller.
- The more the number of holes, the more overlapping or blurred the image is.

Assignment: The teacher asks the students to:

- Explain the term magnification.
- What should be the length of a pin-hole camera if an object is placed 10cm in front of the pin-hole camera forms an image half its size on the screen?

Week 5

Class: SS2

Duration: 45 minutes

Topic: Reflection of Light

Sub-topic: Rays and beams of Light; Regular and Irregular Reflections.

Instructional Materials: A small lamp, a ray box (a small box with a narrow slit), a free-standing lamp on a stand in a housing, cardboard paper, plane mirror etc

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Describe a ray of light.

- Distinguish between rays and beams of light.
- Explain the terms parallel, convergent and divergent beams of light.
- Differentiate between regular and irregular reflections.

Previous Knowledge: Concepts of light and shadows formation are no longer new to students.

Introduction: The teacher introduces the lesson by asking questions on the previous topic of pin-hole camera and links it with day's lesson.

Presentation: The teacher presents the lesson as highlighted below:

Step 1: Students are allocated into 4- or 5- person jigsaw groups.

Step 2: The teacher divides the day's activity into 4 or 5 sections such as:

- Focusing light from (i) a one slit ray apparatus; and (ii) a many slits ray apparatus; on a screen and reporting the observations.
- Holding a plane mirror (or any smooth surface) in front of one's face and reporting the observation.
- Holding a cardboard (any rough surface) in front of one's face and reporting the observation.
- Turning the head of a torchlight round to focus light on a wall in a dark room and recording the observations.

Step 3: A student from each group is picked to work on each of the segments listed above.

Step 4: The teacher gives the students enough time to study well and read over their segments for proper mastery of the segment.

Step 5: The teacher forms temporary expert groups by selecting one student from each jigsaw group to join other students assigned to the same segment in other groups for brainstorming.

Step 6: He brings the students back to their initial jigsaw groups to present his/her segment to the group and to the whole class.

Step 7: The teacher moves from group to group observing the process while the class is in session.

Step 8: The teacher thereafter asks questions on the materials on which they work. These include:

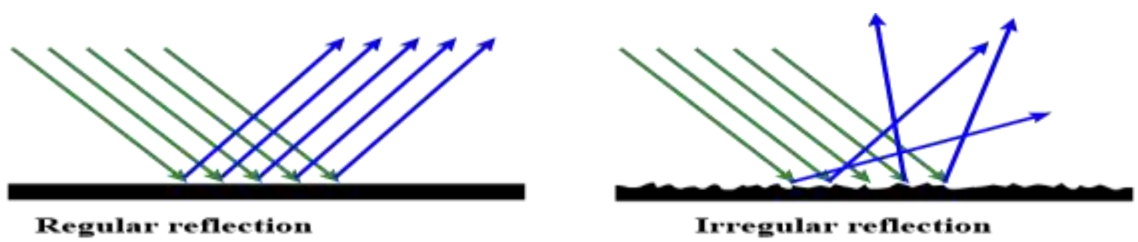
- What did you notice when you hold (i) a plane mirror and (ii) a cardboard in front of your face?
- Do you notice any difference in your observations when you focus light from (i) a single slit; and (ii) a many slits ray apparatus on a wall?

Evaluation: The teacher evaluates the lesson by asking students to:

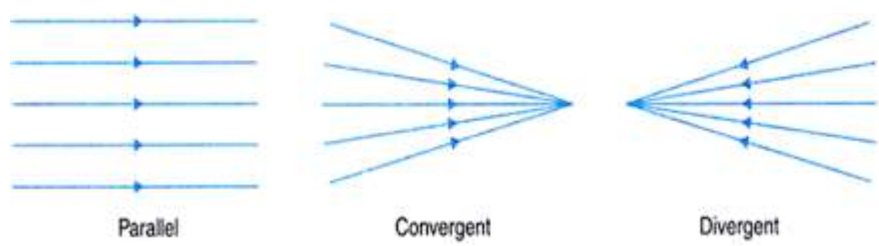
- Explain why the images of their faces appear when they hold a plane mirror in front of their face but do not appear when a plane mirror is replaced with a cardboard.

Summary: The teacher summarizes the lesson by stating that:

- A light ray refers to the direction taken by light energy while traveling (as in the case of light from a single slit ray apparatus) while a beam is a group of rays (as manifested when a many slits apparatus is used).
- Images of faces appear on a plane mirror because of regular reflection that occurs in it where a parallel beam is reflected in only one direction.
- The reverse is the case with a cardboard where the reflection is regular.
-



- A beam of light could be parallel, convergent or divergent as illustrated below



Culled Online from https://www.google.com/search?q=regular-and-irregular-reflections

Assignment: The teacher asks the students to sketch diagrams of (i) divergence beam; (ii) parallel beam (iii) convergent beam (iv) regular reflection and (v) irregular reflection. (illustrate with diagrams)

Week 6

Class: SS2

Duration: 45 minutes

Topic: Reflection on Plane Mirror

Instructional Materials: A mounted plane mirror, a ray apparatus, four optical pins and a paper.

Behavioral Objectives: By the close of the lesson, learners would be competent to:

- Identify the incident rays, the reflected rays, the normal.
- Differentiate between angles of incidence and angles of reflection
- State the relationship between them.
- State both first and second laws of reflection.
- Use the relationship to solve simple mathematical problems.

Previous Knowledge: Students are familiar with the concept of reflection and its types.

Introduction: The teacher introduces the lesson by asking students to explain the term regular reflection. He thereafter links it with the topic for the day.

Presentation: The teacher presents the lesson as below:

Step 1: Students are allotted into 4- or 5- person jigsaw groups.

Step 2: The teacher divides the day's activity into 4 or 5 sections such as:

- Identification of the incident rays, reflected rays and the normal for a ray of light that strikes a smooth reflecting surface.
- Studying the link connecting the angle of incidence to angle of reflection.
- Testing the truth of the laws of reflection.\

Step 3: A student from each group is picked to work on each of the segments listed above.

Step 4: The teacher gives the students enough time to study well and read over their segments for proper mastery of the segment.

Step 5: The teacher forms temporary expert groups by selecting one student from each jigsaw group to join other students assigned to the same segment in other groups for brainstorming.

Step 6: He brings the students back to their initial jigsaw groups to present his/her segment to the group and to the whole class.

Step 7: The teacher moves from group to group observing the process while the class is in session.

Step 8: The teacher thereafter asks questions on the materials on which they work. These include:

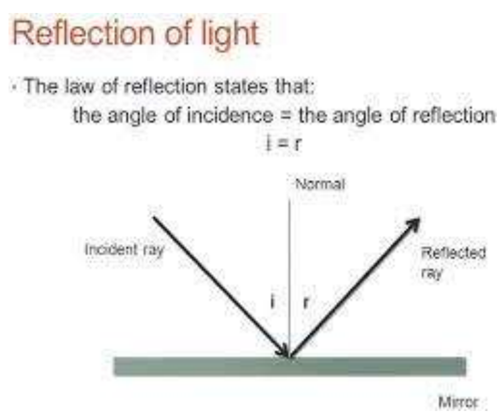
- Distinguish between the incident and the reflected rays?
- What is an angle of incidence? How is it related to the angle of reflection?

Evaluation: The evaluates the lesson by asking students to:

- State the laws of reflection.
- A boy moves 2.4m towards a plane mirror. Through what distance has he moved nearer his image?

Summary: This includes:

- Incident ray: the ray that goes into the mirror.
- Reflected ray: the ray that is sent back by the mirror.
- Normal: a line perpendicular to the mirror.
- Angle of incidence: Angle made by the incident ray with the normal.
- Angle of reflections: Angle between the reflected ray and the normal.
- Law I: Incident ray, reflected ray and normal are all on the same plane at the point of incidence.
- Law 1I of Reflection: Angle of incidence = angle of reflection.



Culled Online from https://www.google.com/search?q=Laws+of+reflection&client=firefox

Evaluation: The teacher evaluates the lesson by asking students to:

- State the laws of reflection.

- A boy moves 2.4m towards a plane mirror. Through what distance has he moved nearer his image?

Assignment:

- Test the truth of law of reflection by varying the angles of incidence and observing the corresponding angles of reflection.
- Draw a ray of light incident at 45^0 on plane mirror. Draw the normal and the reflected ray. What is the angle of deviation of the ray?

Week 7

Class: SS2

Duration: 45 minutes

Topic: Images in a Plane Mirror

Instructional Materials: A mounted plane mirror, a ray apparatus, optical pins, sharp pencil and a paper.

Behavioral Objectives: Upon the close of the session, students are duty-bound to:

- Describe concepts of real/virtual images.
- Distinguish between real and virtual images.
- Explain the concept of lateral inversion.
- State uses of a plane mirror.

Previous Knowledge: Students are familiar with the concept of reflection and how to trace or locate the reflected rays.

Introduction: The teacher introduces the lesson by revising the last topic on reflection in a plane mirror and/or asking related questions.

Presentation: The teacher presents the lesson as highlighted below:

Step 1: Students are distributed into 4- or 5- person jigsaw groups.

Step 2: The teacher divides the day's activity into 4 or 5 sections such as:

- Lateral inversion.
- Possibility of projecting the resulting image on a screen or not.
- Comparing the heights of the different images with those of the objects.
- Uprightness or inversion of the images.
- Usefulness of plane mirrors.

Step 3: A student from each group is picked to work on each of the segments listed above.

Step 4: The teacher gives the students enough time to study well and read over their segments for proper mastery of the segment.

Step 5: The teacher forms temporary expert groups by selecting one student from each jigsaw group to join other students assigned to the same segment in other groups for brainstorming.

Step 6: He brings the students back to their initial jigsaw groups to present his/her segment to the group and to the whole class.

Step 7: The teacher moves from group to group observing the process while the class is in session.

Step 8: The teacher thereafter asks questions on the materials on which they work. These include:

- How does your left hand appear in a plane mirror?
- Can the observed image be focused on a screen?

Evaluation: The teacher evaluates by requesting students to answer the following questions.

- How would the work "Abeokuta" appear when viewed in a plane mirror?
- What is the nature of the image height compared to the object height?

Summary: The teacher summarizes the day's lesson by stating the properties of images in a plane mirror. The image is:

- Virtual i. e. cannot be formed on a screen.
- Upright or erect.
- Laterally inverted.
- Of the same size as the object.
- Distance of the image from the mirror is the same as that of the object.
- Formed behind the mirror.

Assignment:

- State properties of images in a plane mirror.
- A boy moves 1.3m towards a plane mirror. Through what distance has he moved nearer his image.
- State the uses of a plane mirror.

Week 8

Class: SS2

Duration: 45 minutes

Topic: Periscopes and Kaleidoscopes

Instructional Materials: 12" Pieces of PVC pipe, elbow joint pipes, plane small mirrors, putty,

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Describe the making of a periscope.
- State the uses of a periscope.
- State the numbers of images formed when two plane mirrors are inclined at a known angle to each other.
- Write out the formula for finding the number of images formed by inclined mirrors.

Previous Knowledge: Students are aware that several images are formed when two plane mirrors are set facing each other as in the case of mirrors in a barber's shop or at an angle from each other.

Introduction: The teacher introduces the lesson by asking the students to state their experience during a visit to a barbing (hair dressing) saloon having two mirrors set facing each other

Presentation: The teacher presents the lesson as highlighted:

Step 1: Students are split into 4- or 5- person jigsaw groups.

Step 2: The teacher divides the day's activity into 4 or 5 sections such as:

- Images of object between two plane mirrors inclined at an angle to each other.
- Images of object between two plane mirrors placed parallel to each other.
- Working and uses of periscopes.
- Use of formula $\mathbf{N = \frac{360}{x^0} - 1}$ to calculate the number of images in inclined mirrors.

Step 3: A student from each group is picked to work on each of the segments listed above.

Step 4: The teacher gives the students enough time to study well and read over their segments for proper mastery of the segment.

Step 5: The teacher forms temporary expert groups by selecting one student from each jigsaw group to join other students assigned to the same segment in other groups for brainstorming.

Step 6: He brings the students back to their initial jigsaw groups to present his/her segment to the group and to the whole class.

Step 7: The teacher moves from group to group observing the process while the class is in session.

Step 8: The teacher thereafter asks questions on the materials on which they work. These include:

- Can you count the number of images formed when an object is placed between two plane mirrors placed parallel to each other?
- Of what use is periscope?

Evaluation: The teacher evaluates the lesson by asking students to:

- State the uses of a periscope.
- How many images will be produced if the mirrors: (i) are inclined at 30^0; (ii) are parallel?

Summary: The teacher summarizes the important points as follows:

- Two mirrors work together to make a periscope.
- The periscope captures the image of any overhead object for which it is used and reflect it back into the bottom mirror.
- Periscopes can also be used in trenches by military during war times.
- Useful in submarines to view object on the surface of water.
- Kaleidoscopes are formed when two mirrors are inclined at an angle to each other.
- An infinite number of images are formed when mirrors are arranged parallel to each other.
- For number "N" of images between two mirrors at an angle "x°" to each other,

$$\mathbf{N = \frac{360}{x^0} - 1}$$

Assignment: The teacher asks the students in groups to make a periscope each for use in the class.

Week 9

Class: SS2

Duration: 45 minutes

Topic: Curved Spherical Mirrors

Instructional Materials: concave mirrors, convex mirrors, any reflecting surface that bulges outward, recesses inward

Behavioral Objectives: Upon the close of the session, it is expected of students to:

- Differentiate concave from convex mirrors.
- Define each of the terms associated with curved surfaces.
- State the principles behind the image formation in a plane mirror.
- State the characteristics of images formed by an object placed at different positions in front of the mirror.
- State the uses of the curved mirrors.

Previous Knowledge: Students had earlier been taught how images are formed by plane surfaces.

Introduction: The teacher introduces the lesson with questions on the previous topic and establishment of a link between it and the new topic.

Presentation: The teacher presents the lesson thus:

Step 1: Students are split into 4- or 5- person jigsaw groups.

Step 2: The teacher divides the day's activity into 4 or 5 sections such as:

- Identification of the differences between concave and convex surfaces by holding each of them near one's face.
- Image formation in concave mirrors.
- Image formation in convex mirrors.
- Uses of curved spherical mirrors.

Step 3: A student from each group is picked to work on each of the segments listed above.

Step 4: The teacher gives the students enough time to study well and read over their segments for proper mastery of the segment.

Step 5: The teacher forms temporary expert groups by selecting one student from each jigsaw group to join other students assigned to the same segment in other groups for brainstorming.

Step 6: He brings the students back to their initial jigsaw groups to present his/her segment to the group and to the whole class.

Step 7: The teacher moves from group to group observing the process while the class is in session.

Step 8: The teacher thereafter asks questions on the materials on which they work. These include:

- How would you tell the differences between a concave and convex mirrors?
- Identify and define each of the terms associated with curved mirrors.

Evaluation:

- Sketch a diagram to show how the image of an object placed at C of a converging mirror is formed. Write out the properties of the image formed.
- What advantages, as a driver's mirror, does a convex mirror over a plane mirror.

Summary: The recap of the session comprised:

- A concave mirror converges parallel rays to a point on the principal axis called the focus.
- A convex mirror diverges parallel rays from distant object to form an erect, virtual and diminished image behind the mirror at a point called the focus.
- Aperture refers to the width of a mirror
- Pole (P) denotes the central point on an aperture.
- Focal length (f) is distance between the pole and the focus.
- Radius of curvature (r) is distance between the pole and centre of curvature (C) and it is twice the focal length.
- Image and object distances in curved mirrors are related by $\mathbf{\frac{1}{f} = \frac{1}{u} + \frac{1}{v}}$
- Where v = image distance; and u = object distance

Assignment: The teacher asks the students to determine the position of the object and the image when a concave mirror of radius of curvature 30cm produced an inverted image 4 times the size of an object placed perpendicular to the axis.

Appendix III

Lesson Note on CS

Week 1

Class: SS2

Duration: 45 minutes

Topic: Sources of Light and Classification of Objects

Instructional Materials: A lighted fluorescent tube/bulb, a wall, a cardboard paper, a plane glass, a mirror, a lighted touch, a carbon paper, clear water, oiled paper, tainted glass

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Identify the different types of objects on the basis of their ability to produce light or not.
- Classify objects into luminous and non-luminous groups.
- Identify objects that allow light to pass through them.
- Identify objects that light passage through them.
- Explain the terms transparent, translucent and opaque

Previous Knowledge: Students are aware that:

- light enables us to see things clearly
- not all objects produce light etc
- they are aware of darkness at night.

Introduction: How do you feel when you have reason to go and bring something from a dark room or when you have course to walk around at night without a source of light?

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher describes luminous objects as those objects that are capable of giving out light of their own. He observes that luminous objects can be classified into:

- Self-luminous of nature such as the sun, the stars etc
- Self-luminous of living creatures like fire-flies, glow-worms etc
- Self-luminous of man-made such as electric lamp, lighted candles, torchlight etc.

Step 2: The teacher explains that a non-luminous object does not produce light of its own, it could be a reflective surface which produces rays of light when light falls on it.

Examples include inner page of white writing paper, a mirror placed in the sun, a signboard placed by the side of the road etc

Step 3: The teacher states that non-luminous objects can be further classified into:

- Transparent objects
- Translucent objects
- Opaque objects.

Step 4: the teacher describes a transparent object as an object that allows light to pass through it as well as enabling other objects to be seen through it. He lists the examples to include white nylon, plane glass, clean water, clear solutions etc.

Step 5: The teacher states that translucent objects like their transparent counterparts allow light to pass through them but through them, other objects cannot be seen. He lists tinted glass, colored glass, oiled stained paper etc as the examples.

Step 6: The teacher describes an opaque object as any object that one cannot see through and light cannot pass through. He includes walls, human bodies, stone, wood, metals, moon etc in the examples.

Evaluation: The teacher evaluates the lesson by asking questions such as:

- Bring out those objects that can produce light of their own.
- To what class of objects does tainted glass belong?

Summary: The record of the important points of the session comprised of:

- Objects that produce light of their own such as torch light, lighted candle etc are luminous.
- Objects such as plane glass, clean water, clear solutions are called transparent objects because they allow light to pass through them and enable other objects to be seen through them,
- Tainted glass, nylon and oiled paper are said to be translucent because they only allow light to pass through them but do not allow other objects to be seen through them.
- Non-luminous objects include cloth, wall, wood which do not produce light of their own.

Assignment: Students are asked to:

- List 3 other examples each (apart from the ones used in the class) of (i) luminous (ii) opaque (iii) transparent (iv) translucent objects.
- Classify the following objects under transparent, translucent and opaque: diamond; moon; stars; planets; palm oil; an oiled paper; nylon; a brass tray.

Week 2

Class: SS2

Duration: 45 minutes

Topic: Rectilinear Propagation of Light

Instructional Materials: One straight metal pipe, one bent metal pipe, a lighted candle, centrally punched cardboard pieces,

Behavioral Objectives: By the completion of the session, students are expected to:

- State details of the term rectilinear propagation of light.
- Demonstrate that light travels on a straight line.
- State the direct consequences of the rectilinear propagation of light.

Prior Knowledge: Students are familiar with the concept of light, its effects as well as the associated terminologies.

Introduction: The teacher introduces the lesson by asking students questions on the previous topic and further asks them whether light from a lighted touch can travel round a corner.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher explains the concept of rectilinear propagation of light as a traveling of light along a straight line.

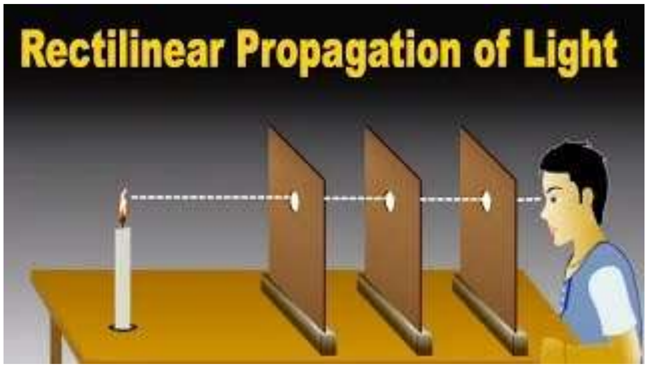
Step 2: Teacher backs his explanation with a demonstration by placing a torchlight in front of a straight metal pipe and asking students to look at it through the other end of the pipe. He asks to note down their observation(s).

Step 3: The teacher repeats the demonstration by replacing the straight metal pipe with a bent metal pipe and asks the students to report their observation when they look at it from the other end

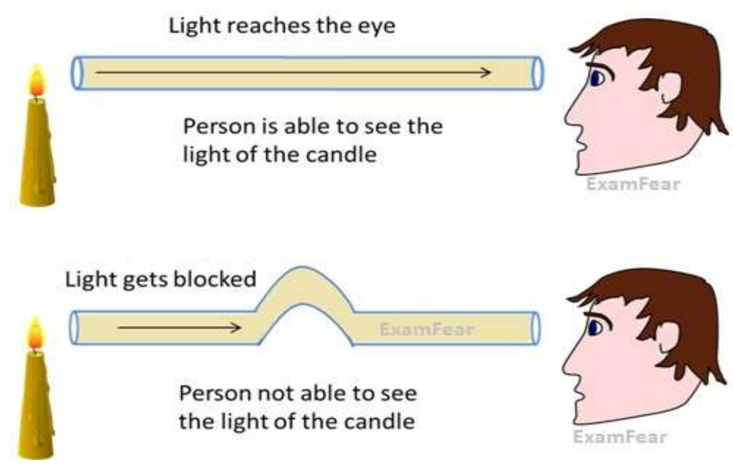
Step 4: The teacher describes an alternative way of carrying out the demonstration using three pieces of centrally punched cardboard paper and a lighted candle arranged firstly with the central holes on a straight line and thereafter, move a cardboard so that the holes are no longer in straight line.

Step 5: The teacher states that light will be cut off when the holes are not in straight line or when a bent metal pipe is used whereas the light from one end of a straight pipe can be seen when one looks through from the other end. The same result is obtained when the holes in cardboard papers are on a straight line.

Step 6: The teacher shows them the diagram that support his explanation in the class as follows.



A. Rectilinear Propagation of Light with Pieces of Cardboard Paper



B. Rectilinear Propagation of Light with Metal Pipes

Step 7: The teacher explains that the phenomenon of rectilinear propagation of light causes shadows and eclipses to be formed.

Evaluation: The teacher evaluates the lesson by asking students questions such as:

- How does light travel? On a straight line or round a corner?

Summary: The teacher summarizes the important points such as:

- Light travels on a straight line.
- The travelling of light on a straight line is termed rectilinear propagation of light.
- Rectilinear propagation is responsible for the formation of shadows.
- It equally causes eclipses

Assignment: Students are asked to:

- Explain the concept of rectilinear propagation of light.
- State the direct consequences of rectilinear propagation of light.

Week 3

Class: SS2

Duration: 45 minutes

Topic: Shadows and Eclipses

Instructional Materials: A point source of light e. g. a light tight box with a small needle hole at one end and a screen at the other end or a torchlight from which the glass covering has been removed, an extended source of light like lighted candle, an opaque object e. g. ball

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Explain the terms shadows and eclipses.
- Distinguish between umbra and penumbra.
- State the different types of eclipse.
- Draw diagrams to illustrate formation of shadows.

Previous Knowledge: Students are aware that light travels on a straight line.

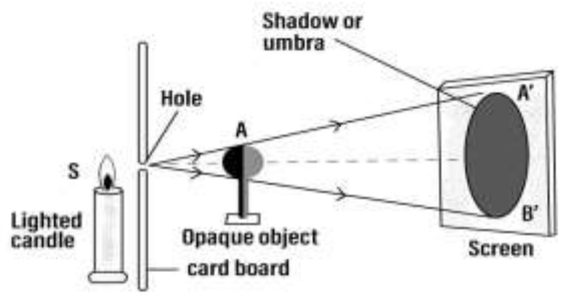
Introduction: The teacher introduces the lesson by asking students to state what will likely happen if light is obstructed by an opaque object.

Presentation: The teacher presents the lesson as below:

Step 1: That formation of shadows is a direct consequence of the rectilinear propagation of light.

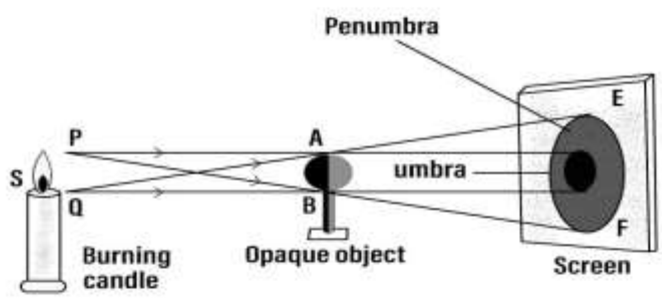
Step 2: The teacher describes shadows as an area of darkness formed when a path of light is obstructed by an opaque object i. e. when an opaque object is placed in front of a source of light.

Step 3: The teacher explains further that with a point source of light, the shadow formed is uniformly dark as in the diagram below.



3 **Shadow (or umbra) due to a point source**

But with an extended source of light, the shadow formed consists of central dark region called umbra, surrounded by a partial shadow called penumbra.



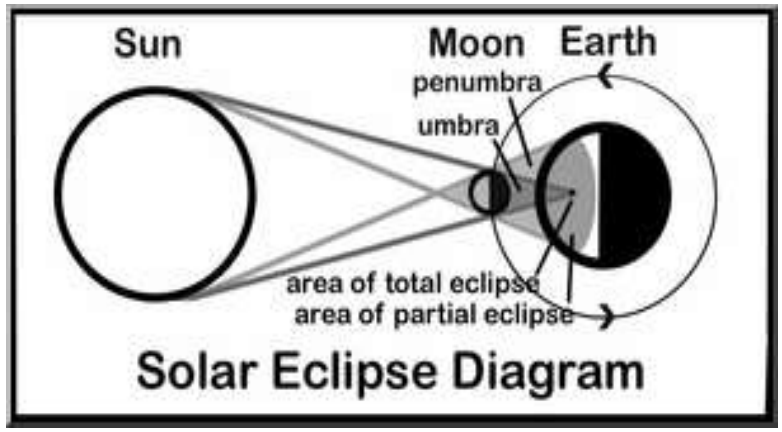
Shadow (umbra and penumbra both) due to an extended source of light

Step 4: The teacher explains that shadow can also occur on a much larger scale among the planets leading to the formation of what is called **eclipses**.

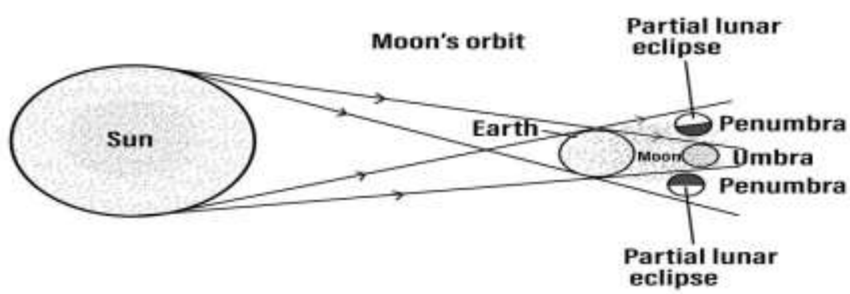
Step 5: The teacher explains that the **earth** (an opaque object) is a big planet moving round the **sun,** (a light source) while the **moon** is a much smaller satellite moving round the earth in its orbit. At any point in time, it is possible for the earth to cover the moon (i. e. casting a shadow on the moon) or for the moon to cover the earth, it is this covering that is termed eclipse.

Step 6: The teacher states further that the eclipse can be (a) solar eclipse, (b) lunar eclipse, and (c) annular eclipse.

- That Solar eclipse (eclipse of the sun) occurs when the moon passes between earth and the sun thereby, covering the view of the sun from the parts of the earth.

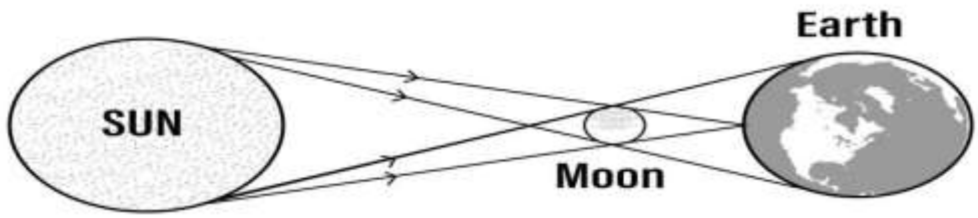


- With the earth getting between the sun and the moon, the shadow of the earth falls on the moon. This gives rise to lunar eclipse (eclipse of the moon).



Formation of lunar eclopse

- Annular eclipse is a form of solar eclipse that occurs when the umbra is too short to reach the earth.



Formation of annular solar esclpse

Evaluation: The teacher evaluates the lesson by asking students to:

- Distinguish between umbra and penumbra.
- Explain solar eclipse.

Summary: The teacher summarizes the important points as follows:

- An area of darkness (shadow) is formed when light is obstructed by an opaque object.
- The torchlight sends out light in all directions but the portion of the light that strikes the ball is not let through by the ball, and so cannot reach the screen.
- The area of darkness is called shadow.
- With an extended source, the central part of the shadow is dark while the edges are partially dark.
- The centrally dark region is called umbra while the partially dark region is penumbra.
- Shadow formation on a large scale among the planets is called eclipse.

Assignment: The teacher asks the students to

- Describe how shadow of a man changes as he walks away from a street lamp on a dark night.
- Draw a diagram to illustrate how a lunar and annular eclipses are formed.

Week 4

Class: SS2

Duration: 45 minutes

Topic: Pin-hole Camera

Instructional Materials: A light tight box with a small needle hole at one end and a screen at the other end.

Behavioral Objectives: At the end of the lesson, the students should be able to:

- State the principle behind the workings of a pin-hole camera.
- Describe the features of a pin-hole camera.
- State the characteristics of images formed in a pin-hole camera.
- Explain the concept of magnification as it applies to a pin-hole camera.
- State the effects of increasing or decreasing the size of the hole of a pin-hole camera on the image size, image brightness and image sharpness.

Previous Knowledge: Students had earlier been taught shadows and eclipses. They are familiar with the principles behind the formation of shadows and eclipses.

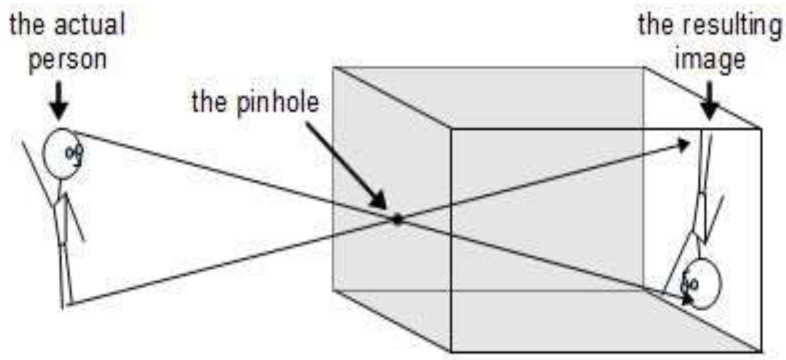
Introduction: The teacher introduces the lesson by asking students what happens imagine they are in a dark room with a small opening made on the wall and someone holds a torchlight from the outside shadows and eclipses. He thereafter links their responses to the new topic.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher describes a pin-hole camera as alight proof box with a screen made of a translucent material at the back and a pin- hole in front of the box.

Step 2: The teacher stresses that a pin-h ole camera works on the principle of rectilinear propagation of light.

Step 3: The teacher goes further to explain that for an object positioned in front of the pin hole, the image formed is upside down as illustrated below.



Step 4: The teacher gives properties of the image formed in a pin-hole camera as:

- The image formed can be focused on a screen and so it is a real image.
- The magnification (m) of the image is defined as
  $$\mathbf{m} = \frac{\text{image distance}}{\text{Object distance}} = \frac{\text{image height}}{\text{object height}}$$
- The image size decreases as the distance of the object from the pin hole increases.
- Increasing the number of pin holes results in the overlapping of a set of images to form a blurred image.
- The greater the size of the hole, the more blurred and brighter the image though, the size of the image remains the same.

Step 5: The teacher explains the use of magnification formula to solve some mathematical problems on a pinhole camera. The example goes thus:

Quiz: A pinhole camera is positioned 300m in front of a building forming an image on a screen 5cm from the pinhole. If the image is 2.5cm high, what is the height of the building?

Solution: Given: object distance, u = 300m; image distance, v = 5cm; image height V_h = 2.5; object height U_h = ?

- NB: Magnification $= \frac{\text{image distance}}{\text{Object distance}} = \frac{\text{image height}}{\text{object height}} \Rightarrow \frac{5}{300} = \frac{2.5}{x}$

  Therefore, $x = \frac{300 \times 2.5}{5} = \mathbf{150m}$

Evaluation: The teacher evaluates the lesson by asking students questions such as:

- What is the magnification of the image formed in a pin hole camera?
- State the principle upon which the working of a pin-hole camera is based.

Summary: The teacher summarizes those important points such as:

- A pin-hole camera produces an inverted image of an object positioned in its front on a screen.
- The image formed is real as it can be seen on a screen.
- Increasing the distance of the object from the pin hole causes the object to be smaller.
- The more the number of holes, the more overlapping or blurred the image is.

Assignment: The teacher asks the students to:

- Explain the term magnification.
- What should be the length of a pin-hole camera if an object is placed 10cm in front of the pin-hole camera forms an image half its size on the screen?

Week 5

Class: SS2

Duration: 45 minutes

Topic: Reflection of Light

Sub-topic: Rays and beams of Light; Regular and Irregular Reflections.

Instructional Materials: A small lamp, a ray box (a small box with a narrow slit), a free-standing lamp on a stand in a housing, cardboard paper, plane mirror etc

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Describe a ray of light.
- Distinguish between rays and beams of light.
- Explain the terms parallel, convergent and divergent beams of light.
- Differentiate between regular and irregular reflections.

Previous Knowledge: Concepts of light and shadows formation are no longer new to students.

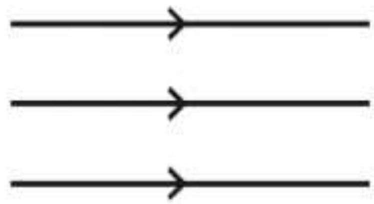
Introduction: The teacher introduces the lesson by asking questions on the previous topic of pin-hole camera and links it with the day's lesson.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher defines a light ray as a linear path along through which light energy travels. A ray of light is represented in diagrams by full straight line with an arrow on it indicating the direction in which light is propagated.

--------------->------------- **A ray of light.**

Step 2: The teacher describes a beam of light as a group of light rays, and is usually represented by a number of rays.

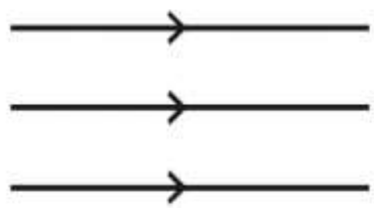


A Beam of Light

Step 3: The teacher lists the three types of beam of light as (a) parallel; (b) convergent; as well as (c) divergent beams of light

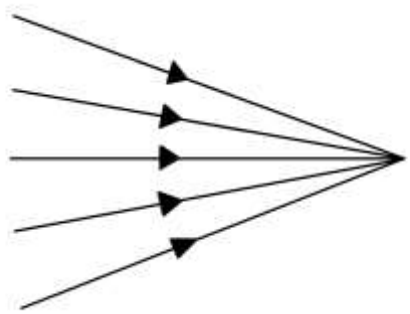
Step 4: Teacher describes each of the beams of light as follows:

A parallel beam: A group of rays of light that are parallel and equally spaced out from each other. Examples include rays of light from distant objects such as the ray from the sun, rays coming out from searchlight etc



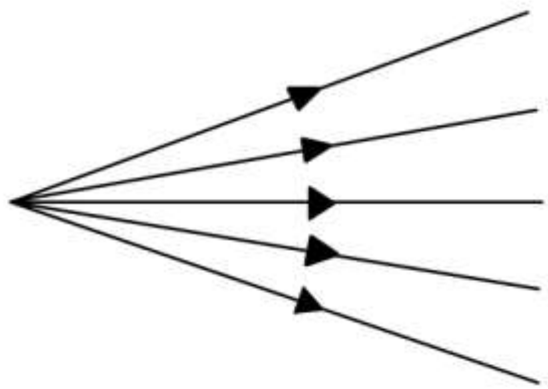
A parallel beam

A convergent beam: it is a group of light rays in which the rays meet at a point with the diameter of the rays going on decreasing in the direction of the rays. Beams produced by a convex lens when a parallel beam falls on it is convergent. Other examples are rays received by camera, the rays entering into our eyes converge on the retina etc.



Convergent beam

A divergent beam is a group of rays of light that spread outwards in different directions from a source. Examples include rays coming out from the car headlamp, rays coming out from the light bulb, rays from a burning candle etc

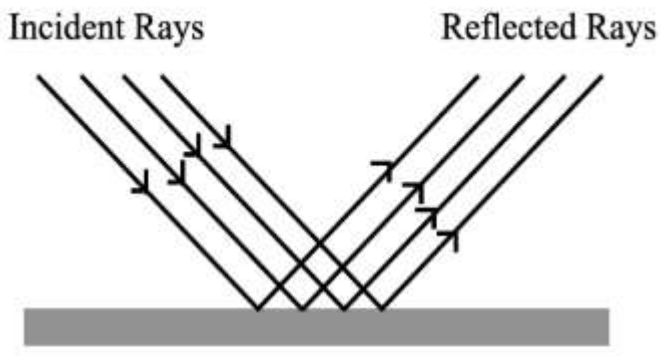


A divergent beam of light

Step 5: The teacher defines reflection of light as the throwing back of light rays from a medium without absorbing it. He maintains that all objects reflect light only that the different objects reflect different amount of light when light falls on them.

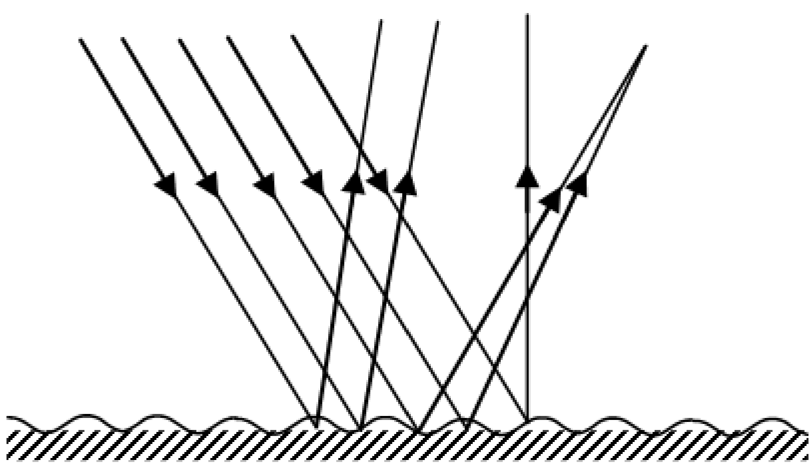
Step 6: The teacher identifies two types of reflection as (a) regular and (b) irregular reflection.

The teacher describes *regular reflection* as a reflection that occurs when a parallel beam of incident rays is reflected in only one definite direction, and it occurs when the reflecting surface is smooth or highly polished as in the case of a plane mirror. Such reflection leads to the formation of image in a plane mirror.



Regular Reflection

Step 7: The teacher describes irregular reflection as a form of reflection in which the rays from a parallel beam of light falling on a surface are scattered in different directions. They are not reflected in a definite direction. Such reflection is otherwise called a diffuse reflection and it occurs when light falls on a rough surface like cardboard. Irregular reflection does not form image of objects.



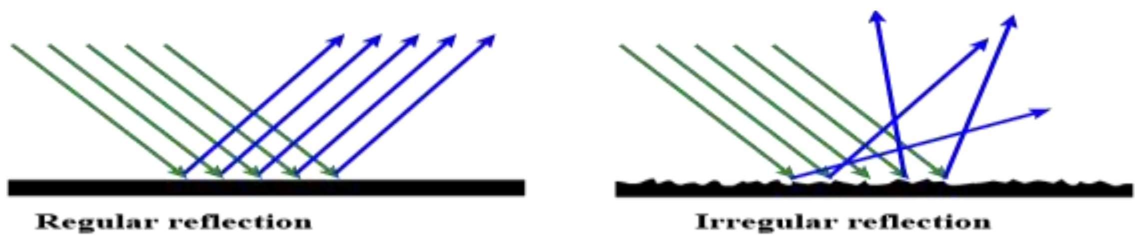
Irregular reflection

Evaluation: The teacher evaluates the lesson by asking students to:

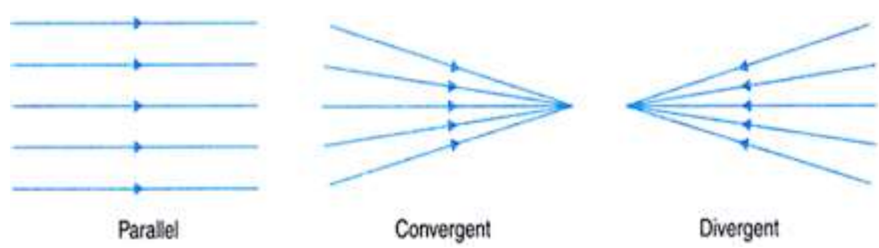
- Explain why the images of their faces appear when they hold a plane mirror in front of their face but do not appear when a plane mirror is replaced with a cardboard.

Summary: Emphasis is laid on the important points of the session such as:

- A light ray is the direction taken by light energy while traveling (as in the case of light from a single slit ray apparatus) while a beam is a group of rays (as manifested when a many slits apparatus is used).
- Images of faces appear on a plane mirror because of regular reflection that occurs in it where a parallel beam is reflected in only one direction.
- The reverse is the case with a cardboard where the reflection is irregular.
-



- A beam of light could be parallel, convergent or divergent as illustrated below



Culled Online from https://www.google.com/search?q=regular-and-irregular-reflections

Assignment: The teacher asks the students to sketch diagrams of (i) divergence beam; (ii) parallel beam (iii) convergent beam (iv) regular reflection and (v) irregular reflection. (illustrate with diagrams)

Week 6

Class: SS2

Duration: 45 minutes

Topic: Reflection on Plane Mirror

Instructional Materials: A mounted plane mirror, a ray apparatus, four optical pins and a paper.

Behavioral Objectives: By the close of the lesson, students should be competent to:

- Identify incident rays, reflected rays, normal.

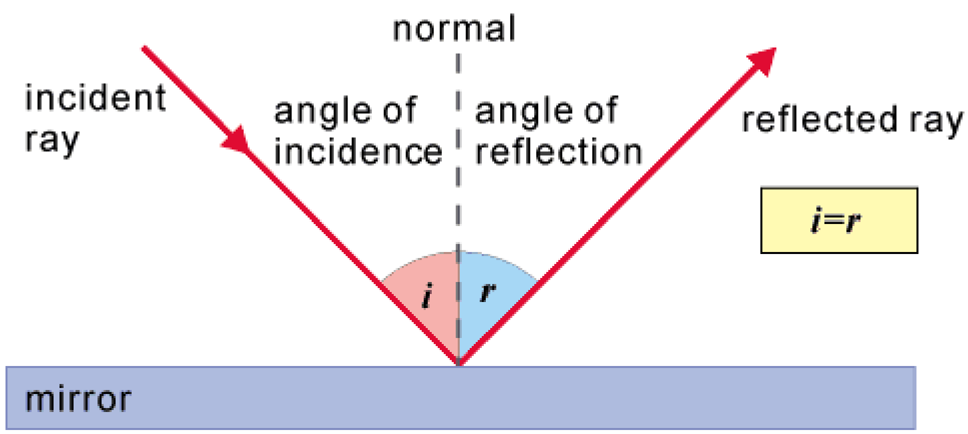
- Differentiate between angles of incidence and angles of reflection
- State the relationship between them.
- State both first and second laws of reflection.
- Use the relationship to solve simple mathematical problems.

Previous Knowledge: Students are familiar with the concept of reflection and its types.

Introduction: The teacher introduces the lesson by asking students to explain the term regular reflection. He thereafter links it with the topic for the day.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher illustrates the reflection of light on a plane surface with the diagram below.



Step 2: The teacher describes the basic terms associated with reflection as follows:

Incident ray: The ray from a light source that goes into the reflecting surface.

Reflected ray: The ray that is sent back by the mirror i. e. the reflecting surface.

Normal: A line that is perpendicular to the reflecting surface

Angle of incidence: Angle the incident ray makes with the normal.

Angle of reflection: Angle between the reflected ray and the normal.

Glancing angle: Angle between the reflected ray (or incident ray) and the mirror.

Angle of deviation: Angle between extrapolated incident ray and the reflected ray.

Step 3: The states the basic laws of reflection as follows:

First law: The incident ray, the reflected ray and the normal at the point of incidence, all lie on the same plane.

Second law: The angle of incidence (i) is equal to angle of reflection (r).

Step 4: The teacher states some useful mathematical relationships connected with reflection.

Angle of incidence = Angle of reflection. ($i = r$)

Glancing angle (g) = $90 - i$ or $90 - r$

Angle of deviation, d.= $2g = 2(90 - i) = 180 - 2i$.

Step 5: The teacher attempts a mathematical problem in the class for students to see.

A ray of light is incident on a plane mirror at an angle of 35^0. Calculate its (a) angle of reflection (b) glancing angle (c) angle of deviation and (d) angle between the incident and reflected rays.

Solution: Given: $r = 35^0$

(a) From 1st law of reflection, $i = r$. Therefore, $r = 35^0$.

(b) Glancing angle = $90 - i = 90 - 35^0 = 55^0$.

(c) Angle of deviation = $2g = 2 \times 55^0$. 110^0

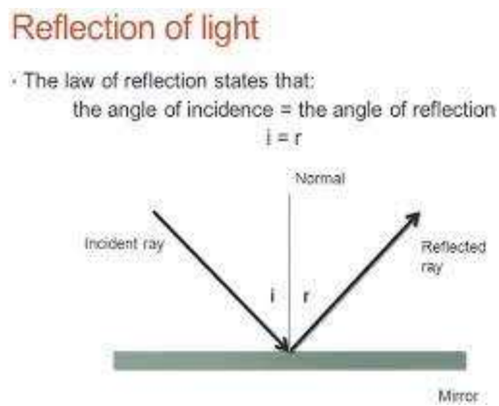
(d) Angle between incident and reflected rays $x^0 = i + r = 35^0 + 35^0 = 70^0$

Evaluation: The teacher evaluates the lesson by asking students to:

- State the laws of reflection.
- Distinguish between the incident and reflected rays.
- What is an angle of incidence? How is it related to the angle of reflection?
- A boy moves 2.4m towards a plane mirror. Through what distance has he moved nearer his image?

Summary: The recap of the session includes:

- Incident ray: the ray that goes into the mirror.
- Reflected ray: the ray that is sent back by the mirror.
- Normal: a line perpendicular to the mirror.
- Angle of incidence: Angle between the incident ray and the normal.
- Angle of reflections: Angle between the reflected ray and the normal.
- Law I: Incident ray, reflected ray and normal are all on the same plane at the point of incidence.
- Law II: Angle of incidence = angle of reflection.



Culled Online from https://www.google.com/search?q=Laws+of+reflection&client=firefox

Week 7

Class: SS2

Duration: 45 minutes

Topic: Images in a Plane Mirror

Instructional Materials: A mounted plane mirror, a ray apparatus, optical pins, sharp pencil and a paper.

Behavioral Objectives: By the close of the session, students are expected to:

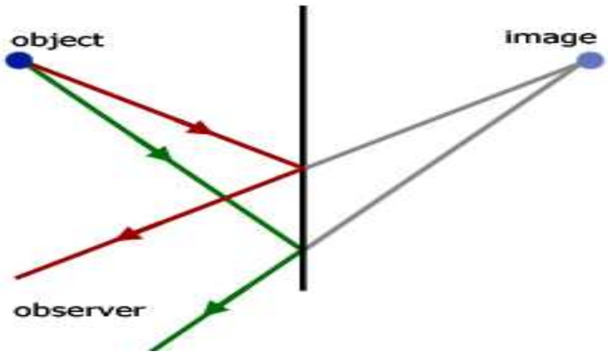
- State details of real and virtual images.
- Distinguish between real and virtual images.
- Explain the concept of lateral inversion.
- State uses of a plane mirror.

Previous Knowledge: Students are familiar with the concept of reflection and how to trace or locate the reflected rays.

Introduction: The teacher introduces the lesson by revising the last topic on reflection in a plane mirror and/or asking related questions.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher draws a diagram to illustrate how to locate image of an object using a plane mirror.



Step 2: Teacher explains the diagram thus:

Two distant pins on a ray that strikes a mirror are traced by erecting two pins to block the image of the ones as reflected by the mirror. The pins are removed and the points are joined together to a point at the back of the mirror where they appear to be coming from. That is the position of the image.

Step 3: The teacher states the properties of images in a plane mirror as:

The image is

- Virtual because it cannot be projected on a screen.
- Erect or upright.
- Formed as far behind the mirror as the object is in front. (image distance = object distance).
- Image is of the same size as the object.

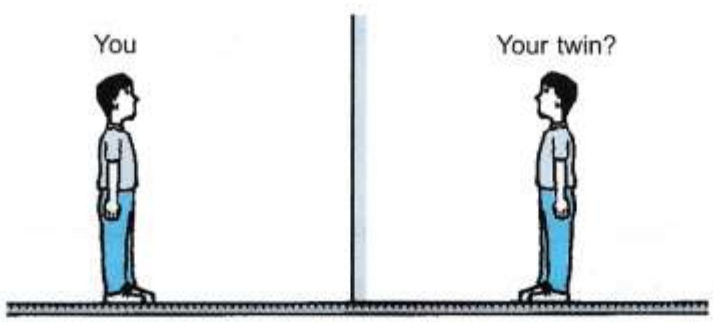
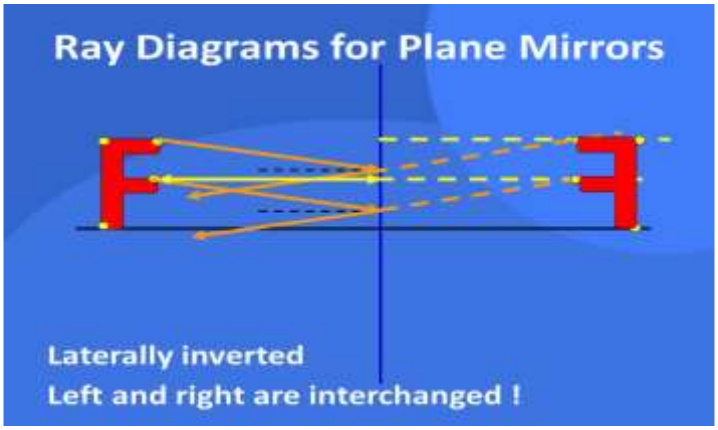


Figure *Your image and you are identical*

Step 4: The teacher describes the concept of lateral inversion as the sideways turning of the image obtained by reflection in a plane mirror.



Step 5: The teacher lists the following as the uses of plane mirrors.

- In making periscopes
- As looking glasses.
- To make kaleidoscopes.

Step 6: The teacher illustrates the use of the properties listed in step 3 above to solve some mathematical problems.

Quiz: A boy standing in front of a plane mirror walks 2m towards the mirror. What is the distance between the boy and his image?

Solution: 2m towards the mirror implies object distance of 5 – 2 = 3m

Recall: object distance = image distance

Thus: the distance between the boy and his image = 3m + 3m = 6m

Evaluation: The teacher evaluates the lesson by asking students questions:

- What are the properties of images in a plane mirror?
- State the relationship between the object height and the image height in a plane mirror.

Summary: The teacher gives a brief summary of the important points from the lesson for students to document in their notes. Such as for an object in a plane mirror, the image is:

- Virtual i. e. cannot be formed on a screen.
- Upright or erect.
- Laterally inverted.
- Of the same size as the object.
- Of the same distance as the object.

- Formed behind the mirror.

Assignment: Teacher asks the students to:

- State properties of images in a plane mirror.
- A boy moves 1.3m towards a plane mirror. Through what distance has he moved nearer his image.
- State the uses of a plane mirror.

Week 8

Class: SS2

Duration: 45 minutes

Topic: Periscopes and Kaleidoscopes

Instructional Materials: 12" Pieces of PVC pipe, elbow joint pipes, plane small mirrors, putty,

Behavioral Objectives: At the end of the lesson, the students should be able to:

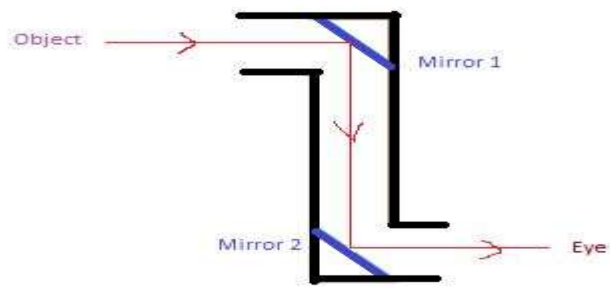
- Describe the making of a periscope.
- State the uses of a periscope.
- State the numbers of images formed when two plane mirrors are inclined at a known angle to each other.
- Write out the formula for finding the number of images formed by inclined mirrors.

Previous Knowledge: Students are aware that several images are formed when two plane mirrors are set facing each other as in the case of mirrors in a barber's shop or when they are inclined at an angle from each other.

Introduction: The teacher introduces the lesson by asking the students to state their experience during a visit to a barbing (hair dressing) saloon having two mirrors set facing each other

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher describes a periscope as a long tube with a mirror fitted at each end at an angle of 45^0 so that they can face each other.



A simple Periscope

In the periscope, light from the object hits the upper mirror i. e. mirror1 at 45^0 and reflects away at the same angle to the lower mirror, mirror 2. The reflected light which hits the second mirror is reflected again at 45^0 into the observer's eye thereby enabling the observer to see an overhead object.

Step 2: The teacher states the uses of periscopes to include:

- For viewing an overhead object.
- In a submarine to watch the happenings on the surface of the sea.
- In trenches during the war time to watch the movement of the enemies.

Step 3: The teacher describes the working of inclined mirrors otherwise called kaleidoscope.

He states further that when two mirrors are inclined to each other at an angle, they jointly form more than one image of an object placed between them.

Step 4: The teacher states the formula for finding the number N, of images produced by inclined mirrors at a known angle x, as

$$\mathbf{N = \frac{360}{x^0} - 1}$$

Step 5: Calculate the number of images formed when two mirrors are inclined at 60^0 to each other.

NB: $N = \frac{360}{x^0} - 1 \Rightarrow \frac{360}{60} - 1 \Rightarrow 6 - 1 \Rightarrow 5$ images

Step 6: For parallel mirrors, the angle is 00 therefore, the number of images formed is infinite.

Evaluation: The teacher evaluates the lesson by asking students to:

- State the uses of a periscope.

- How many images will be produced if the mirrors: (i) are inclined at 30^0; (ii) are parallel?

Summary: The teacher summarizes the important points as follows:

- Two mirrors work together to make a periscope.
- The periscope captures the image of any overhead object for which it is used and reflect it back into the bottom mirror.
- Periscopes can also be used in trenches by military during war times.
- Useful in submarines to view object on the surface of water.
- Kaleidoscopes are formed when two mirrors are inclined at an angle to each other.
- An infinite number of images are formed when mirrors are arranged parallel to each other.
- For number "N" of images between two mirrors at an angle "x^o" to each other,

  $$N = \frac{360}{x^0} - 1$$

Assignment: The teacher asks the students in groups to make a periscope each for use in the class.

Week 9

Class: SS2

Duration: 45 minutes

Topic: Curved Spherical Mirrors

Instructional Materials: concave mirrors, convex mirrors, any reflecting surface that bulges outward, recesses inward

Behavioral Objectives: By the close of the lesson, the students should be able to:

- Describe concave and convex mirrors.
- Describe each of the terms associated with curved surfaces.
- State the principles behind the image formation in a plane mirror.
- State the characteristics of images formed by an object placed at different positions in front of the mirror.
- State the uses of the curved mirrors.

Previous Knowledge: Students had earlier been taught how images are formed by plane surfaces.

Introduction: The teacher introduces the lesson with questions on the previous topic and establishes a link between it and the new topic.

Presentation: The teacher presents the lesson as follows:

Step 1: The teacher describes a curved mirror as a mirror whose reflecting surface is curved i. e. bulges outward or recesses inward. It could be taken to be part of sphere.

Step 2: Teacher informs the students of the two major types of spherical mirrors. The types are concave and convex mirrors.

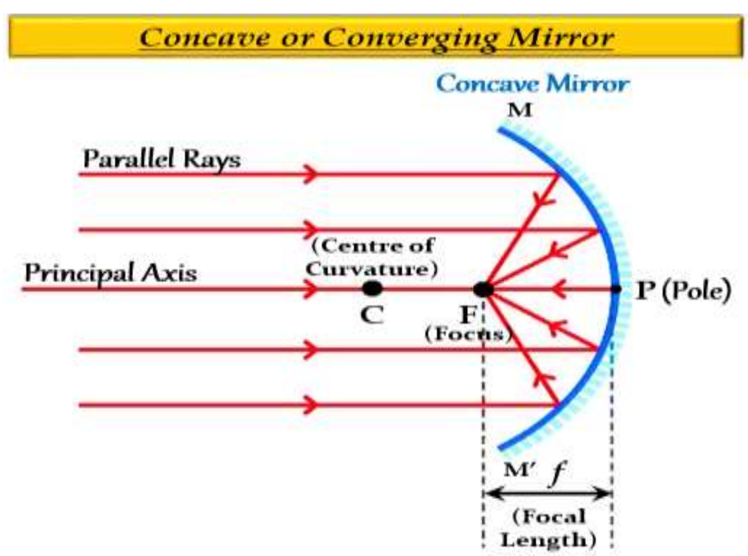
Step 3: The teacher describes each of the mirrors as:

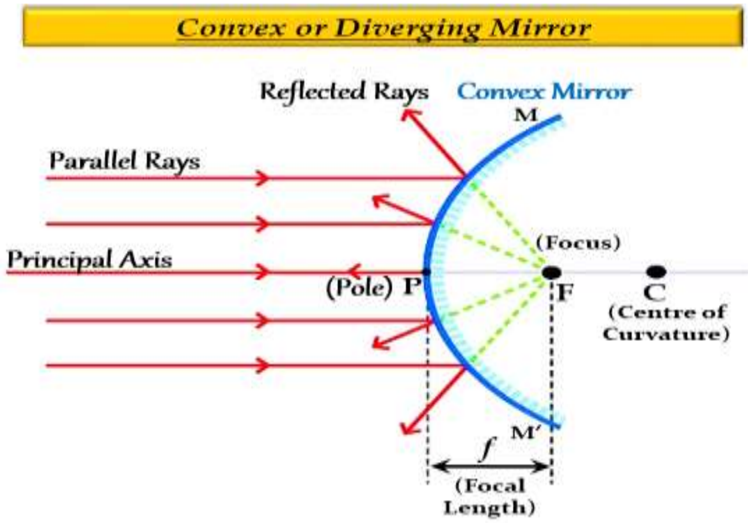
- A concave mirror is a mirror whose outer surface is silvered while the inner, hollow surface is the reflecting surface.
- A convex mirror is a mirror whose outer surface is the reflecting surface while the inner hollow surface is silvered.

Step 4: The teacher lists and explains each of the terms associated with curved mirrors. These are:

- Aperture is the width of the mirror.
- Pole (P) is the centre of the mirror.
- Centre of curvature, C: it is the centre of the sphere of which the mirror is a part.
- Principal axis: It is a line that joins the pole to the centre of curvature.
- Principal focus, F: for a concave mirror, it is a point at which all rays parallel and close to the principal axis converge at after reflection. It is real.
- Principal focus, F: For a convex mirror, it is a point at which all rays parallel and close to the principal axis appear to diverge from after reflection. It is virtual for a convex mirror.
- Focal length (f) is distance between the pole and the focus.
- Radius of curvature (r) is the radius of the sphere of which the mirror is a part. It is equivalent to the distance between the pole and centre of curvature (C) and it is twice the focal length. ($r = 2f$)

Step 5: The teacher draws diagrams to illustrate the points made in step 4 above.



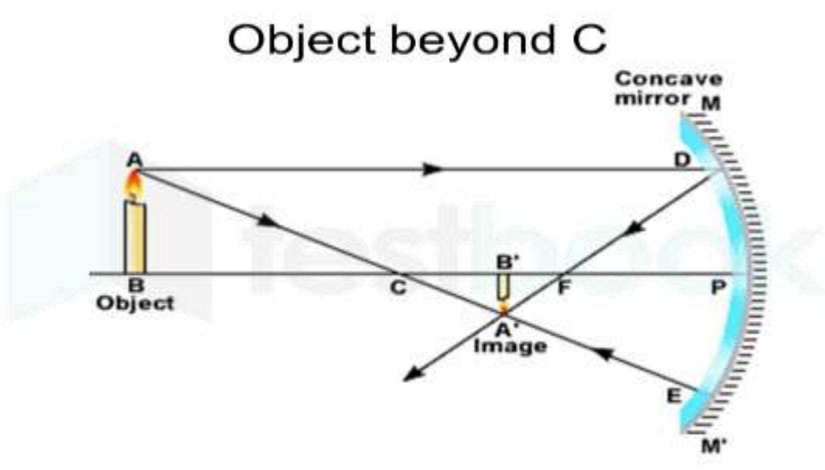


Step 6: The teacher describes how images are formed in curved mirrors using ray diagrams.

Step 7: The teacher states the three principles that must be adhered to when drawing ray diagrams as:

- Rays that are parallel to the principal axis are reflected through the principal focus, F.
- Rays through the principal focus, F are reflected parallel to the principal axis.
- Rays through the centre of curvature are reflected back through the same centre.

The teacher illustrates this further with an object placed beyond C as follows:



He writes out the properties of the image formed as:

- The image is formed between F and C.
- The image is real.

- The image is inverted.
- The image is diminished.

Evaluation:

- Sketch a diagram to show how the image of an object placed at the centre of curvature (C) of a concave mirror is formed. Write out the properties of the image formed.
- What advantages, as a driver's mirror, does a convex mirror over a plane mirror.

Summary: Key points of the session covered:

- A concave mirror converges parallel rays to a point on the principal axis called the focus.
- A convex mirror diverges parallel rays from distant object to form an erect, virtual and diminished image behind the mirror at a point called the focus.
- Aperture refers to the width of the mirror
- Pole (P) = central point on an aperture.
- Focal length (f) is distance between the pole and the focus.
- Radius of curvature (r) is distance between the pole and centre of curvature (C) and it is twice the focal length.

Assignment: The teacher asks the students to:

- Describe how a concave mirror can be used to burn a carbon paper.
- Describe how a concave mirror can be used to send out a parallel beam of light.

Week 10

Class: SS2

Duration: 45 minutes

Topic: Curved Spherical Mirrors and Mirror Formula

Instructional Materials: A chat showing diagrams of images of an object when placed at different positions from the pole of a mirror.

Behavioral Objectives: At the end of the lesson, the students should be able to:

- Establish a relationship between image distance V, object distance U and the focal length F.
- Use the relationship to some mathematical problems.

- State the uses of curved **spherical** mirrors.

Previous Knowledge: Students had earlier been taught how images are formed by plane surfaces.

Introduction: The teacher introduces the lesson with questions on the previous topic and establishes a link between it and the new topic.

Presentation: The teacher presents the lesson:

Step 1: Teacher states symbols used to denote each of the terms associated with the mirror formula as:

V = image distance;

U = object distance; and

f = focal length.

Step 2: The teacher writes out the formula and explains further: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

Step 3: The teacher goes further to state that for anything real, it is considered positive i. e. f = +ve, V = +ve while for virtual, f = -ve, v = -ve.

Step 4: the teacher demonstrates the use of the formula using the question below:

An object 40cm long is placed in front of a concave mirror of focal length, 15cm. calculate the linear position of the image and its linear magnification.

Solution: Given: f = 15cm; u = 40cm

Using $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ =

$\frac{1}{V} = \frac{1}{f} - \frac{1}{u} \quad => \frac{1}{15} - \frac{1}{40} = > \frac{40-15}{600} = \frac{25}{600}$

V = 600/25 = 24 cm

Magnification, M = V/U = 24/40 = 0.6

Evaluation: The teacher evaluates the lesson by asking students questions on the lesson of the day and takes time to listen and make corrections where necessary.

Assignment: Determine the position of the object and the image when a concave mirror of radius of curvature 30cm produced an inverted image 4-times the size of an object placed perpendicular to the axis.

Appendix IV

PHYSICS STUDENTS' ATTITUDE QESTIONNAIRE (PSAQ)

Gender: Male -------------------------------- Female: ------------------------------

Student's Number: ---

School: ---

Instruction: Each of the statements below expresses a feeling towards physics. Please rate each statement on the extent to which you agree. For each statement, you may choose (1) Strongly Disagree [SD]; (2) Disagree [D]; (3) Agree [A]; and (4) Strongly Agree [SA]. Please don't leave any scale blank.

S/n	Items	SA	A	D	SD
1	I do not get bored when studying/learning concepts of light in physics				
2	Light aspect of physics is one of the least important chapters to me.				
3	I usually get scared when light lesson is going on.				
4	I refrain from light related lessons in physics.				
5	I am not interested in news about optics related physics in newspapers and magazines.				
6	Concepts of light in physics are not the ones I am interested in.				
7	I do not like to participate in physics class activities.				
8	I do not like the light experiments that we do at school.				
9	I hate the calculations' aspects of optics only.				
10	I do not see any relevance of concepts of light to everyday life and society.				
11	I approach light lessons with a feeling of hesitation.				
12	It makes me nervous to even think about doing light experiment.				
13	I feel important when I work with light related physics tools.				
14	I do not get pleasure out of light lessons.				
15	Light is an aspect of physics that makes peoples' lives easier.				
16	I would like the number of hours assigned to light related concepts in physics lesson to be increased.				
17	Physics is a fun and it's fascinating.				
18	I do not get excited when I am doing optics (light) aspect of physics.				
19	I do my homework on optics aspect of physics without getting bored.				
20	I do light experiments cheerfully				

Appendix V

PHYSICS STUDENT'S ACADEMIC COMMITMENT SCALE (PSACS)

Gender: Male -------------------------------- Female: ------------------------------

Student's Number: ---

School: ---

Instruction: Please indicate how you feel about your physics studies. Read each statement carefully and decide to what extent you personally agree or disagree with it. Kindly, circle the option that corresponds with your opinion and make sure you tick an option for every statement.

s/n	Items	SA	A	D	SD
1.	I strongly wish to complete my light related physics studies successfully.				
2.	Studying concepts of light in physics is an important part of my life.				
3.	I am not prepared to give up studying optics aspect of physics				
4.	I want to continue with my studies on light related aspect of physics.				
5.	I do not believe in life-long learning of optics related aspect of physics.				
6.	Each of my classes on optics gives me a great deal of satisfaction.				
7.	I am not very happy studying light aspects of physics.				
8.	I feel contended with my studies on concept of light.				
9.	My classes on concepts of light fulfill my needs for intellectual stimulation and intellectual satisfaction.				
10.	I enjoy studying physics.				
11.	I do not do much (e. g. attend classes) to ensure success in my studies on concepts of light.				
12.	I spend a lot of time reading and studying light related concepts in physics.				
13.	Compared to others, I know I have not invested a great deal of time and effort in light aspects of physics.				
14.	I feel very involved in my physics like I have put a great deal.				
15.	Anything else would be better than having to study concepts of light in physics.				
16.	There are better concepts in physics than studying concepts of light.				
17.	If I had choice, I would rather learn something else (travel, socialize, work) than studying optics.				
18.	Studying light/optics lends meaning to my life.				
19.	My study of concepts of light contributes to shaping me as a person.				
20.	I am the kind of person that thrives on studying concepts of light.				

Appendix VI

PHYSICS ACHIEVEMENT TEST (PAT)

Gender: Male ------------------------------- Female: -----------------------------

Student's Number: ---

School: --

Group: --

Instruction: Circle the letter corresponding to the correct answer for each question.

Time Allowed: 1½ Hours

(1) A ray of light strikes a plane mirror at an angle of incidence Φ. Determine in terms of Φ the angle of deviation of the ray after reflection from the mirror.

(A) $90^0 – \Phi$ (B)$90^0 + \Phi$ (C) $180^0 - 2\Phi$ (D) 2Φ

(2) In a plot of *1/u* against *1/v* for a concave mirror, how can *f* be determined from the graph?

(A) *f* = the slope of the graph

(B) *f* = the intercept on the *1/u* axis

(C) *f* = the intercept on the *1/v* axis.

(D) *f* = the reciprocal of the intercept on either axis.

(3) A diverging mirror is used as a driving mirror because it

(A) has a wider field of view.

(B) produces a real image.

(C) has only one focus.

(D) produces an image the same size as the object.

(4) A boy moves 1.2m towards a plane mirror. Through what distance has he moved nearer his image?

(A) 3.6m

(B) 2.4m

(C) 1.2m

(D) 0.6m

(5) Which of these materials is translucent?

(A) Plane glass

(B) Clear water

(C) Butter Paper

(D) Wood

(6) Which of these mirrors is used for making periscopes?

(A) Concave mirror

(B) Convex mirror

(C) Parabolic mirror

(D) Plane mirror.

(7) A/an -------------- eclipse occurs when moon comes between sun and earth in a straight line.

(A) umbra

(B) solar

(C) lunar

(D) annular

(8) If the flame on the candle in front of a plane mirror is 2cm tall, how tall is its image?

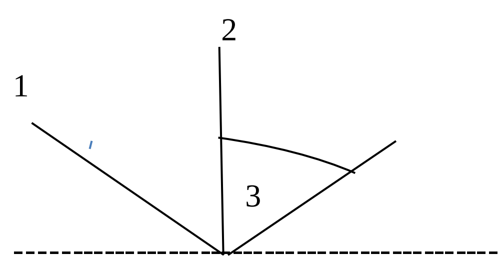
(A) 1cm

(B) 2cm

(C) 4cm

(D)8cm

(9) A light ray strikes a mirror as shown in the diagram.



Identify the numbered parts.

(A) 1 = incident ray 2 = normal 3 = angle of incidence

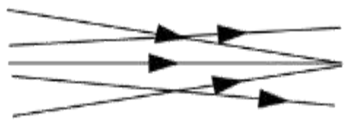
(B) 1 = reflected ray 2 = normal 3 = angle of reflection

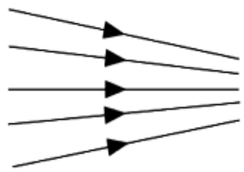
(C) 1 = normal 2 = incident ray 3 = reflected ray

(D) 1 = incident ray 2 = normal 3 = angle of reflection

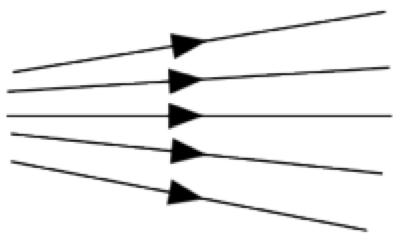
(10) Which one of the following represents a diverging beam of light?

A.

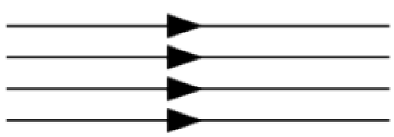




B.



C.



D.

(11) On most ambulances its name is written such that it can be read in the rear view mirror of the car in front. This phenomenon is known as

(A) Lateral inversion.

(B) Parallax

(C) Back to front

(D) A virtual image

(12) An eclipse of the moon occurs when

(A) there is a full moon

(B) the moon moves into the shadow of the earth.

(C) the sun is between the earth and the moon.

(D) the moon is directly between the sun and the earth.

(13) Which of the following best describes the image of a plane mirror?

(A) Virtual and magnification is one.

(B) Real and magnification is less than one.

(C) Virtual and magnification is greater than one.

(D) Real and magnification equal to one.

(14) When the image of an object is seen in a concave mirror, the image will -----------

(A) always be real.

(B) always be virtual.

(C) be either real/virtual.

(D) always be magnified.

(15) If a man's face is 30.0cm in front of a concave shaving mirror creating an upright image 1.50 times as large as the object, what is the mirror's focal length?

(A) 12.0cm

(B) 20.0cm

(C) 70.0cm

(D) 90.0cm

(16) We can see a non-luminous object when

(A) the object is near.

(B) light falling on it is transmitted.

(C) when light falling on it is reflected.

(D) the object is polished.

(17) Two plane mirrors are attached to form a dual mirror system with an adjustable angle. As the angle between the mirrors increases, the number of images -------------------

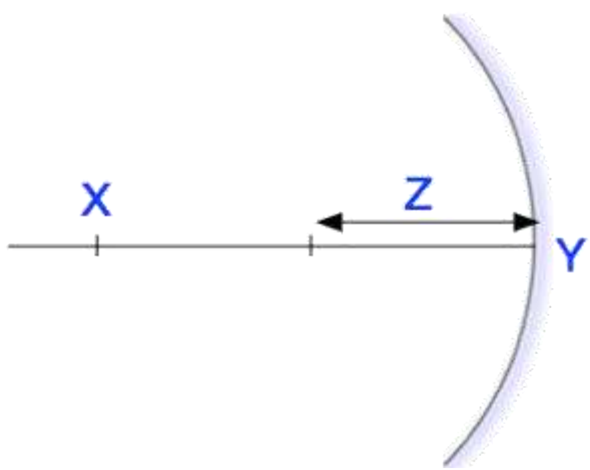
(A) increases.

(B) decreases

(C) remains the same.

(D) doubles.

(18) The diagram below shows a concave mirror.



Identify the labelled parts.

A. X = radius of curvature, Y = focus, Z = principal axis

B. X = centre of curvature, Y = pole, Z = focal length

C. X = focus, Y = principal axis, Z = focal length

D. X = centre of curvature, Y = pole, Z = focal length

(19) Which of the following is/are source(s) of artificial light?

(A) Electric bulb

(B) Candle

(C) Torch

(D) All of the above

(20) What condition is necessary for a real image in a concave mirror?

(A) object inside the focus.

(B) object bigger than its image

(C) object smaller than its image

(D) object outside the focus.

Appendix VII

RESEARCH ASSISTANT EVALUATION SCALE (RAERS)

The rating scale was used to evaluate the trained research assistants for effective use of the instructional guides. The rating scale requested for the name of the school, class, topic and type of group i. e. experimental or control. It contained items that monitored and measured teachers' knowledge and skill to conform to the identified steps for chosen instructional strategies. Each research assistant was evaluated by different raters.

Research Assistant Evaluation Scale

Name of School:

Class Taught:

Topic Taught:

Type of Group (Experimental or Control Group):

S/N	**Objective**	**5**	**4**	**3**	**2**	**1**
1	Extent of mastery of instructional strategy taught to effect conceptual change in the students.					
2	A display of reasonable understanding of the content of light concepts selected.					
3	Adherence to stated objectives.					
4	Coherence with steps in the instructional guide.					
5	Ability to make the lesson child-centered.					
6	Skillfulness to convey the specifics of the subject matter to the learners.					
7	Expertise to occupy all pupils in the class					
8	Adequacy of the knowledge of evaluation procedures					

Key: Excellence = 5; Good = 4; Fair = 3; Poor = 2; and Very poor = 1

School: --

Name of Rater: ---

Signature of Rater: --

Appendix VIII

ANSWERS TO PHYSICS ACHIEVEMENT TEST

1. C
2. D
3. A
4. B
5. C
6. D
7. B
8. B
9. D
10. C
11. A
12. D
13. A
14. C
15. D
16. C
17. B
18. D
19. D
20. D