EFFECTS OF GLENCOE'S AND RUSBULT'S PROBLEM-SOLVING INSTRUCTIONAL STRATEGIES ON STUDENTS' ACHIEVEMENT AND INTEREST IN ELECTRICAL INSTALLATION AND MAINTENANCE WORK IN NORTH-CENTRAL, NIGERIA

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ABSTRACT

The study determined the Effects of Glencoe's and Rusbult's Problem-Solving Instructional Strategies on Students' Achievement and Interest in Electrical Installation and Maintenance Work in North-Central, Nigeria. Six research questions were raised and answered as well as six null hypotheses were formulated and tested at 0.05 level of significance. The study adopted a factorial research design using pretest, posttest, non-equivalent control group design. The study was conducted in the North-central geo-political zone of Nigeria. The population for this study comprised of 1013 NTC II student of EIMW in the 29 technical colleges in North-central geo-political zone of Nigeria. A two-stage simple random sampling technique and purposive sampling technique was used in the study. The instruments used for data collection consisted of Electrical Installation Work Cognitive Achievement Test (EIWCAT), Electrical Installation Work Psychomotor Achievement Test (EIWPAT) and Electrical Installation Work Interest Inventory (EIWII). The instruments were validated by three experts. The reliability coefficient of: EIWCAT was determined as 0.80 using Kuder-Richardson formula 20 (K-R 20), EIWPAT was determined as 0.82 using Pearson's Product Moment Correlation (PPMC) and EIWII was determined as 0.70 using Cronbach's Alpha statistical technique. Data were collected through physical administration of the research instruments and analyzed using mean and standard deviation to answer all the research questions and Analysis of Covariance to test all the null hypotheses formulated. Findings from the study revealed that students taught EIMW using Rusbult's problem-solving strategy had higher mean skill achievement and interest scores than students taught using Glencoe's problem-solving strategy, students taught EIMW using Glencoe's problem-solving strategy had higher mean cognitive achievement scores than students taught using Rusbult's problem-solving strategy and there was significance difference between students' cognitive and skill achievements, and interest mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies. The study shows that the mean gained between the pre-test and post-test skill achievement scores of the students taught EIMW using Glencoe's problem-solving strategy was 52.14 using Rusbult's problem-solving strategy had pre-test mean skill achievement score of 20.60 with standard deviation of 2.84 and post-test score of 78.89 with standard deviation of 1.97 and pre-test mean cognitive achievement score of 13.57 with standard deviation of 4.50 and post-test score of 78.43 with standard deviation of 1.89. The mean gained between the pre-test and post-test mean cognitive achievement scores of the students taught EIMW using Glencoe's problem-solving strategy was 64.86. Based on the findings from the study, the study recommended among others that, Electrical Installation and Maintenance Works teachers should adopt the use of: Rusbult's problem-solving strategy to enhance students' skill achievement and interest; and Glencoe's problem-solving strategy to enhance students' cognitive achievement, Electrical Installation and Maintenance Works teachers should adopt the use of Glencoe's and Rusbult's problem-solving strategies in order to enhance students' cognitive and skill achievements as well as stimulate their interest and to enhance students' cognitive and skill achievements as well as stimulate their interest.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Technical colleges are established with the aim of producing craftsmen in various disciplines. Their existence is to stimulate technological and industrial growth by developing and utilizing technologies for industrial and economic advancement. Technical college is an integral part of the total educational system in Nigeria. It contributes towards the development of good citizenship by developing the physical, social, civic, cultural and economic competencies of the individual (Sanni, 2012). The goals of technical college, as stated in Federal Republic of Nigeria (FRN, 2013) are to: provide trained manpower in the applied sciences, technology and business, particularly at craft, advanced craft and technician levels; provide the technical knowledge and vocational skills necessary for agricultural, commercial and economic development; and give training and impart the requisite skills to individuals who shall be self-reliant economically and in tune with latest technology. In technical colleges, students are trained to acquire relevant knowledge and skills in different occupations for employment in the world of work (NBTE, 2018). The courses offered at these technical colleges includes general subjects which are offered by all students they are mathematics, English languages, social studies, civic education, physics, chemistry and religion. While trade areas among others which are optional are Carpentry and Joinery, Motor Vehicle Mechanics (MVM), Blocklaying and Concreting, Computer Craft Studies (CCS) and Electrical Installation and Maintenance Work (EIMW).

EIMW as one of the engineering trades offered in Nigerian Technical colleges, it involves the application of scientific knowledge in the design, selection of materials, construction, operation and maintenance of Electrical equipment. The Federal Republic of Nigeria (FRN, 2013), indicates that the programme for EIMW in Nigeria Technical Colleges was designed to produce competent craftsmen that are expected to test, diagnose, service and completely repair any fault relating to electrical installation main units and systems to the manufacturers' specification as indicated in the Technical College curriculum for EIMW (NBTE, 2010). The curriculum of Electrical Installation Maintenance Work (EIMW) is structured in foundation and trade modules which consist of general education such as mathematics, English languages, social studies, civic education, physics, chemistry and religion, theory and related courses, workshop practice, industrial training components and small business management and entrepreneurial training. This curriculum if adequately implemented is expected to produce competent craftsmen in Electrical Installation Maintenance Work (EIMW) for industrial and technological development in Nigeria. The goal of the programme at the technical college level is to turn out graduates that will be enterprising and self-reliant, with skills in domestic and industrial installation, as well as having the ability to operate, maintain and repair electrical and electronic equipment, among others.

Electrical Installation Maintenance Work (EIMW) trade graduates do not have the full knowledge and experiences of what they claim to have studied, as most of them find it difficult to practice what they have learnt (Moroney, *et-al* 2018). Ogumah, *et al* (2019) noted that at graduation most of the students are deficient of employability skills, work place skills, and job generation competencies. Egwu (2019) asserted that because good craftmens are difficult to come by in Nigeria, expatriates working in the country bring in their manpower from abroad due to dearth of competent hands. The author further stated that the poor human resource situation is worse in the country, as it is difficult to get competent electricians. Bakare (2012) even confirmed that most graduates often cause damage to electrical installations and electronic gadgets contracted to them for repair or service. Apart from the matter of EIMW trade graduates, another unpleasant issue is the incessant poor achievement of students in the annual national examination conducted by the National Business and Technical Examination Board (NABTEB).

The recent result released by the registrar and chief executive of NABTEB on August, 26, 2019, showed that only 27.2% of candidates passed the EIMW in NABTEB examination held in May/June 2019 across the country. Also notable, is the fact that annual failure has been recorded in the electrical and electronic trades in the May/june NABTEB examinations, as revealed by NABTEB External Examiner Report of 2019 (Guardian, 2019). The Technological development in the Electrical and Electronic industries is also in a constant state of flux and change. The influence of technological developments in the industries has brought about changes and have rendered analogue method of work inadequate for work in the Electrical and Electronic (E/E) industries while creating the need for new and often sophisticated skills. Obviously, the E/E industries need the service of craftsmen who can adapt to the changes and challenges in technology in the industries. The need for preparing students for these change and challenges therefore has necessitated a shift from instructional strategies that are based on the behavioral learning theories to those rooted in cognitive psychological learning theories for which Glencoe and Rusbult's problem-solving strategies are one (Teman and Dauda, 2019).

Problem-solving plays a very important role in Education, as it is used to train students/learners to apply scientific knowledge and skills learned. Besides, problems are seen as a vehicle for developing student's general problem-solving capacity and for making lessons more pleasant and motivating. Wun and Sharifah (2016) asserted that problem solving is an important life skill in the 21st century. Schoenfeld (2008) therefore argued that programmes, courses, and methods of instruction and exposition are being modified, restructured, and reorganized all over the world to meet the challenging needs of the society and solve merging problems. Schoenfeld added that even with these methods of instruction, exposures and modifications, students of technical colleges still perform below expectation. With the low performance of EIMW student in this technical colleges have caused several challenges as most people enjoy the stimulating challenge of a good problem and the satisfaction of solving it. Some of the problems encountered by learners especially in EIMW can be solved through Rusbult learning strategy

Rusbult believes that you get “oriented” by using all available information (words, pictures, and free information) to form a clear, complete mental picture of the problem situation (Rusbult, 1989). According to Rusbult you feel this satisfaction more when you master the tools of problem solving. By reading the problem statement carefully, you get accurate comprehension, the meaning of words and sentence structure in order to gather all the important facts. Most problems are written clearly, so use standard reading techniques to accurately interpret what is written. You may re-read a problem carefully for details, using the “successive refinements” methods. Occasionally, a problem contains useless information (a decoy), so you need to learn to recognize what information to be used and what should be ignored. The description of the four-step plan of the Rusbult problem-solving strategy include giving orientation on the problem; plan on how to solve the problem; take action by solving the problem, and also ensure whether the problem has been properly solved. In Rusbult problem solving, the teacher gives detail explanation to students at every stage of solving the problem and also provides the procedures for solving the problem where necessary. Apart from Rusbult problem-solving strategy, Glencoe’s is also another problem-solving strategy.

Glencoe's believed that some students don't spend time identifying the problem, which makes it more challenging for them to create, execute, and analyze the effectiveness of a solution plan (Glencoe's, 1989). Glencoe's therefore proposed four phases of problem solving (Exploration, planning, solving and examination). In exploration stage, students brainstorm and study the problem properly in order to understand it. In planning stage, the students identify the basic facts and materials needed for solving the problem. At this phase too, the students identify the parameters, formula or diagrams that are required for solving the problem. In solving stage, the students carry out the plan prepared and solve the problem identified. The last stage of the problem is examination where the students examine their answers carefully to see if it fits the facts given in the problem or the problem has been adequately solved (Teman & Dauda, 2019). In Glencoe problem solving, the teacher serves as guide or facilitator at every phase of the problem solving.

Teacher who serves as guides or facilitator of problem solving to students' academic achievement has also been identified as one of the factors why teacher adopt students-centered instructional strategies such as problem solving in vocational and technical education (Owodunni, 2011). Academic achievement connotes performance in school subject as symbolized by a score on an achievement test. Achievement is the outcome of education which involves the determination of the degree of attainment of the learner in tasks, courses or programmes to which the learner is sufficiently exposed (Atsumbe *et al.,* 2018). Achievement can therefore be inferred as the behavior which a student exhibits within a given time range or at the end of a given period of time. Academic achievement in EIMW is the quality and level of skills acquired and retained by students. According to Bamidele *et al*., (2019), performance of students in EIMW becomes poorer as the test items move from those requiring the ability to recall, to those involving some understanding and problem solving. They stressed that the essence of teaching EIMW is to enhance students thinking and problem solving capability. Ogbuanya and Akinduro (2017) recommends that EIMW instructors should use appropriate instructional materials, methods and strategies/techniques to render the teaching and learning of EIMW enjoyable, interesting and to improve achievement. However, achievement in EIMW study relates to accomplishment of learning by a student in both cognitive and psychomotor domain of learning. EIMW involved both cognitive and psychomotor skills.

Cognitive skills relate to knowledge and the development of mental and intellectual abilities. It involves thinking, reasoning and remembering (Hassan, 2010). While Psychomotor or skill achievement involves manipulative or practical skills. Okoro (2012) explained that skill achievement test involves the use of tools and equipment in a direct assessment of the amount of practical skills possessed by the student. Psychomotor deals with the development of muscular skills and coordination including the use of senses and the brain. Psychomotor emphasizes motor skill, manipulation of materials, objects or any performance task requiring neuromuscular coordination (Flavell, 2016). Psychomotor could be a performance task as simple as using a screwdriver to fasten a screw or as complex as using series of tools and instruments to detect and repair electric machine faults which require critical thinking. The psychomotor achievement of students is the translation of their performances in practical test into scores which indicates the skills they have acquired through training especially in electrical installation and maintenance work (Udofia, 2012).

Academic performances of students in EIMW are the measure of their achievement in both theory and practical. Students' academic achievement is determined by an achievement test which should cover the three domains of learning, namely: cognitive, psychomotor and affective. Student's level of academic achievement is usually influenced by many factors such as students' readiness, personality and ability level. Ability level enables students to understand and transfer understanding from one situation to another. Ability level is the characteristic mode of functioning that a student exhibits in intellectual activities in a highly consistent and persuasive way (Charles, *et al*, 2017). The students are placed into ability groups based on their academic strengths and weaknesses (Davidson, 2019). Ability grouping, also known as homogeneous grouping, is the educational method of placing students into groups in respect to their academic achievement level. Udofia (2012) observed that students' ability level is a significant factor in their academic achievement with the high-level students benefitting more from particular teaching methods than their low ability counterparts in Electrical/Electronics. This inconsistency on the extent to which students of different academic abilities benefit from particular teaching methods underscores the need for this study to explore the effect of problem-solving strategies on students ability in electrical installation and maintenance work.

In electrical installation and maintenance works, students' assessment is based on both theory and practical abilities. That is, students who are classified as high academic achievers are those who demonstrated high level of cognitive and psychomotor skills. According to Wun and Sharifah, (2016), students whose performance scores are in the range of 75th percentile and above are considered as high academic achievers, students whose scores are in the range of 50^{th} to 69^{th} percentile are considered as medium academic achievers, whereas those whose scores are below 50th percentile are regarded as low academic achievers. It means that student could be classified as high, medium or low academic achievers by using frequency polygon graph. Such classifications usually show three categories of students: High academic achievers (75th percentile and above), medium academic achiever (50-74 percent) and low academic achievers (below 50 percent). Also, some authors classified students into high, medium and low academic achievers according to their average percentage scores in some selected subjects. This study will try to ascertain whether various ability levels could relatively achieve higher improved performance due to the new instructional processes and strategies.

The teaching strategy employed by the teacher could be a strong determinant of students' level of academic achievement and interest. Therefore, psychomotor achievement of students in electrical installation and maintenance work could depend on the teaching methodology and motivating factor (either intrinsic or extrinsic), ability and interest. Interest is an important factor in learning. It is viewed as the feeling that an individual has when he or she wants to know or learn more about something. This means that the student is bound to pay attention in that particular lesson. Chi, *et al* (2013) maintained that interest comes as a result or eagerness of curiosity to learn not by force. Interest is an important variable in learning because if a student has positive interest towards a particular subject he or she will not only enjoy studying the subject but would also derive satisfaction from the knowledge of the subject. Interest is perceived in relation to internal state of mind or reactions to external environment or predisposition to experience. This definition assumes that students' interest in EIMW implies the reactions, impressions and feelings the student has in EIMW and its related tasks most especially in topics like battery charging and electrical machines which students performs below expectation in their exams and even their final examinations. This therefore, implies that interest is also an important factor that can affect students' performance. Reviews have shown that problem solving strategies can enhance student academic achievement, ability level and interest (Abdulrahman *et al.*, 2016).

Student achievement and understanding are significantly improved when teachers are aware of how students construct knowledge with intuitive solution methods that students use when they solve problems. Structuring instruction around carefully chosen problems allowing students to interact when solving problems, and then providing opportunities for them to share their solution methods result in increased achievement on problem solving measures (Grouws & Cebulla, 2010). Based on the foregoing, it becomes necessary to investigate the efficiency of problem solving approach on students' achievement and interest in EIMW especially in teaching topics such as battery charging and electric machines. Abubakar and Danjuma (2012) opined that the dwindling nature of students' achievement in an important subject like EIMW, becomes pertinent for teachers and researchers to source for strategies that will sure-up students' achievement in the area of their weakness in battery charging and electric machines as a content or topic in EIMW and suggesting a way of improving the students performance in those areas. Aworanti (2012) also indicates that students-centered method such as problem-solving method could improve students' academic achievement better than teacher-centered method. This study will therefore ascertain whether Glencoe and Rusbult problem solving strategies will be better in enhancing students' cognitive and skill achievement and interest in Electrical Installation and Maintenance work trade at Technical Colleges.

1.2 Statement of the Research Problem

EIMW students upon graduation, are expected to possess skills among others in domestic and industrial installation, as well as having the ability to operate, maintain and repair electrical and electronics equipment (Bakare, 2012). It is hoped that these skills will boost their chances at enterprise and self-reliance. The realization of this objective rests hugely on the quality and strategies of instruction they receive from the teacher. EIMW students have been reported to perform poorly in EIMW related courses in their final college examinations for some years now. An analysis of National Business and Technical Examination Board (NABTEB) examinations conducted in May/June for electrical installation and maintenance work students in government technical colleges in North-Central Nigeria, from 2011 to 2018 revealed that in 2012, 7.35% passed with five credits including English and Mathematics. 13.25% in 2011, 4.28% in 2012, 8.06% in 2013, 2014 had a percentage of 2.85, 2015 had 5.66%, for 2016 it was 8.24%, in 2017 the percentage was 3.15 and 2018 had 8.18% (NABTEB, 2018). Sadly, EIMW graduates are deficient in employability skills, workplace skills and job generation competencies (Abubakar & Danjuma, 2012). This abysmal outing at final and college examinations could be linked to a few factors but most prominently the use of inappropriate and uninspiring teaching methods by the teachers. Akinsuroju (2012) revealed that most teachers adopt teaching methods that are easy to implement in the classroom, but most of the time inadequate and inappropriate for teaching trades like EIMW because the methods and strategies do not provide a link between the industry and classroom situation.

The problem of poor performance at final and college examinations, as well as the lack of adequate requisite skills for survival in the world of work, is worsened by the fact that the teaching methods adopted by the teachers might mostly be ‘talk-and-chalk’ based-methods and so are void of student participation in the learning process. Hence, the EIMW graduates produced by teachers who adopt these teaching methods might suffer from unemployment despite the existence of numerous opportunities, because of their capacity deficiency. This makes it paramount to seek strategies for teaching EIMW that aims at improving its understanding and performance by students both theoretically and practically. Some of the teaching methods that could be of great help to prepare

EIMW students for entry-level jobs, advancement in the workplace and higher-order thinking and problem-solving work skills are; Glencoe's and Rusbult's Problem-Solving Strategies. Studies have shown that Glencoe's and Rusbult's Problem-Solving Strategies are effective in teaching and learning of technical subjects (Nfon, 2013), but it is not certain if they could produce similar results when used to teaching trades like EIMW. Hence, the problem of this study is to examine the effects of Glencoe's and Rusbult's Problem-Solving Strategies on students' achievement and interest in EIMW in technical colleges.

1.3 Aim and Objectives of the Study

The aim of this study was to determine the effects of the Glencoe's problem-solving strategies (GPSS) and Rusbult's problem-solving strategies (RPSS) on achievement and interest of EIMW students in Technical Colleges in North-Central Nigeria. Specifically, the objectives of the study were to determine the effect of ;

1. Glencoe's and Rusbult's problem-solving strategies on students' skill achievement in electrical installation and maintenance work (EIMW) trade.
2. Glencoe's and Rusbult's problem-solving strategies on students' cognitive achievements in electrical installation and maintenance work (EIMW) trade.
3. Glencoe's and Rusbult's problem-solving strategies on students' interest in learning electrical installation and maintenance work (EIMW) trade.
4. Ability level on skills achievement of student taught EIMW with Glencoe's and Rusbult's problem-solving strategies.
5. Ability level on cognitive achievement of students' taught EIMW with Glencoe's and Rusbult's problem-solving strategies.
6. Ability level on interest of students' taught EIMW with Glencoe's and Rusbult's problem-solving strategies.

1.4 **Significance of the Study**

The finding of this study was significant because the study will be of great benefit to Ministries of Education, curriculum planners, principals, heads of department, teachers and students of the technical colleges, researchers and general public.

Ministries of Education will benefit from this research because the study would assist them in planning, in identifying those areas of weaknesses and strengths so as to improve the standard of training received in EIMW at the technical colleges. It could also assist them in the provision of quality of teachers who can teach the students both theoretical and practical aspects of EIWM, quality of students who can put this theoretical knowledge into practical use so that they can contribute to the development of the country state and society at large and it could also assist in the provision of facilities for teaching and learning of EIWM this will make easier for both the teachers and students and formulation of strategies for effective implementation of EIMW programme. It would also assist the ministry of education to know those areas were the teachers needs training and retraining on their job.

The curriculum planners would be able to identify those areas that need improvement and renovations mostly in areas that were identified students weakness and strength by the ministries so as to enable the aim and objectives set by Ministries of institution to be achieved and enable both the teachers and students meet up with demand of changing technological world.

The principals could be more enlightened on their responsibility such as monitoring and supervision of the training programme to ensure adequate compliance with the aims and objectives of the EIMW programme in technical colleges.

Heads of Department would also be more enlightened on their responsibility such as monitoring and supervision of the training programme to ensure adequate compliance with the aims and objectives of the EIMW programme. Teachers will also benefit from this study because it will enable them to know where infrastructural facilities, tools, equipment are needed, types of teaching strategies available for effective teaching of the programme.

This study would assist vocational and technical teachers to appreciate the need to adopt suitable instructional methods in teaching vocational and technical subjects in technical colleges. It will provide vocational technical teachers an alternative method of teaching EIMW, for easier understanding and effective application by students. It would also provide more insight on how to use problem solving instructional technique in teaching EIMW in order to bridge the gap between ability level groups. Parents would also benefit from the findings of the study in that the better achievement of their ward and children would bring joy and satisfaction, for their education and good certification as an assurance of better future.

The student would also benefit from the study because the researcher recommendations specifically, problem solving strategies, facilities, tools and equipment if adequately provided will make both learning and teaching easier for both students and teachers because students will be able to put that theoretical knowledge into practical use, practice electrical installation and render better services to the society. Beef up literature on achievement and interest issues on problem solving strategies in electrical installation and maintenance work.

The findings would provide empirical information to readers and researchers on problem solving and the performance of students when taught with the use of **G**lencoe's and Rusbult's problem solving models. It would help students to solve theoretical and real-world problems which require various approaches to investigate, understand and apply EIMW concepts; to express ideas and solutions through appropriate EIMW and symbols; use science and technology reasoning to analyze and solve problems; make connections between technology and their daily lives; use technological skills to solve problems and to communicate ideas in our highly technological world. Sensitize teachers and teacher educators on constructivism and other theories of learning which are consistent with current cognitive theories of problem solving and science and technology views of problem solving involving exploration, pattern finding and thinking. Provide information to support and/or apply the existing and related theories on problem solving; stress the importance of models in problem solving, assist basic and applied researchers on their future researches involving problem solving by using **G**lencoe's and Rusbult's problem solving models. The researchers will also benefit from this research work because recommendation of this study will help them carryout research work on other areas that needs improvement and also Documentation of the findings of these study would significantly provide empirical research data for other researchers for further studies

The general public would also benefit from the skills and knowledge gained by students theoretically and practically, it will enable the students to contribute to the public and enable them get good services of electrical equipment and repairs of appliances.

1.5 Research Question

The following research questions were raised based on the objectives of the research.

1. What is the effects of Glencoe's and Rusbult's problem-solving strategies on students skills achievement in EIMW trade?.

2. What is the effects of Glencoe's and Rusbult's problem-solving strategies on students' cognitive achievement in EIMW trade?
3. What is he effects of Glencoe's and Rusbult's problem-solving strategies on students' interest in studying EIMW trade?.
4. What is the effects of ability level on skills achievement of students' in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies?
5. What is the effects of ability level on cognitive achievement of students' taught EIMW with Glencoe's and Rusbult's problem-solving strategies?.
6. What is the effect of ability level on interest of students' in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies?

1.6 Scope of the Study

The study covered the two themes in EIMW trade curriculum contents: battery charging and electrical machines. Therefore, the study covered all the sub-themes of battery charging and electrical machines, which includes: Cell and battery circuits, Constant voltage battery charging, Constant current battery charging, DC Machines, DC Generators, DC Generator Characteristics, DC Generator Characteristics II, DC Motors, Series-wound and Compound-wound Motors, Alternating Current Motors. The choice of these sub-themes was informed by the fact that they are the topics covered by TC II for their second term. Also, TC II was chosen because the students have spent more than one year in the college and have settled to learn, at this level they can concentrate to learn all these topics. Also, the students had acclimatized with the technical college system and have a relatively stable academic calendar. In the same vein, second term was chosen because securing the necessary approvals to embark on fieldwork often take some time, second term allow ample time for the approval.

Other topics such as ducts and trunking, soldering and braising and underground cable installation in the EIMW curriculum was not part of the contents of this study because they are not part of TC II second term curriculum and so are beyond scope of the study. TC I students were not part of the study because core topics relating to EIMW are not being offered at that the level and TC III students are not part of the study because they considered exit class, and by second term, they would be pre-occupied with preparations for their final examination.

1.7 **Hypotheses**

The following null hypotheses were formulated and was tested at 0.05 level of significant

HO_1: There is no significance difference in the skills achievement mean scores between the EIMW students when taught using Glencoe's and those taught using Rusbult's problem-solving strategies

HO_2: There is no significance difference in the cognitive achievement mean scores between the EIMW students when taught using Glencoe's and those taught using Rusbult's problem-solving strategies

HO_3: There is no significance difference in the interest mean scores between EIMW students taught using Glencoe's and the Rusbult's problem-solving strategies

HO_4: There is no significant difference in the mean scores of ability level and skills achievement between the students' taught EIMW using Glencoe's and Rusbult's problem-solving strategies

HO_5: There is no significant difference in the mean scores of ability level and cognitive achievement between the students' taught EIMW using Glencoe's and Rusbult's problem-solving strategies

HO_6: There is no significant difference in the mean scores of ability level on interest between the students' taught EIMW using Glencoe's and Rusbult's problem-solving strategies

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical Framework

A theoretical framework can be referred to as a theory that a researcher uses to guide him in his research. Thus, a theoretical framework is the utilization of set of theory, or arrangement of ideas drawn from one and the same theory to offer a clarification of an occasion, or shed some light on a specific phenomenon or research issues (Nfon, 2013). He added that a theoretical framework consists of concepts, together with their definitions, and existing theory/theories that are used for your particular study and it must demonstrate an understanding of theories and concepts that are relevant to the topic of your research paper and that will relate it to the broader fields of knowledge.

2.1.1 Gagné's Learning Theory

Gagné's theory of learning proposed a method of learning known as "programmed learning" and emphasized guided learning. Robert Gagnes formulated this theory of learning in 1985. The programmed learning materials are designed to present information to the learner who is expected to respond to it by filling a blank or answering a question (problem-solving). After response, an answer frame is exposed which informs one of the correct answers. If this correct, then proceeds to the next frame. Otherwise, repeats the exercise before continuing to next step. This exercise is continued throughout the programmes. Gagné categorized learning into eight different types in a hierarchical order. The eighth category stated that problem solving is a type of learning that calls for the internal process of thinking. Two or more principles learned are somehow combined to produce "higher order" rule. In order to achieve problem solving, the students must recall learned principles, link together these principles so as to formulate “Higher order” rules and be allowed sufficient time for problem solving to occur.

Gagné’s conditions of learning theory draws upon general concepts from various learning theories in order to define what learning is. The theory looks at the observable changes in human behaviour that confirm that learning has occurred. Gagné’s theory provides an answer to the question, “what is learning?” In answering that question, Gagné provides a description of the conditions under which learning takes place by referring to situations in ordinary life and in school where learning occurs, and by referring to experimental studies in learning. Gagné postulates that proof of learning shows by a difference in a learner’s performance before and after participating in a learning situation. He claims that the presence of the performance does not make it possible to conclude that learning has occurred; but instead, it is necessary to show that there has been a change in performance. In other words, the capability for exhibiting the performance before learning requires consideration as well as the capability that exists after learning. The following four elements provide the framework for Gagné’s Conditions of learning theory.

a. Conditions of Learning

b. Association Learning

c. The Five Categories of Learning Outcomes

d. The Nine Events of Instruction

A. Conditions of Learning

Gagné (1985) describes two different types of conditions that exist in learning: internal and external. Capabilities that already exist in a learner before any new learning begins make up the internal conditions necessary for learning. These internal conditions are transformed during the learning process. External conditions include different stimulus's that exist outside the learner such as the environment, the teacher, and the learning situation. This means that each new learning situation begins from a different point of prior learning and will consist of a different external situation, depending on the learner and on the learning environment. Therefore, the useful prototypes of learning by association (described next) are delineated by internal and external learning conditions.

B. Association Learning

There are three basic prototypes of learning that demonstrate the characteristics of associative learning: classical conditioning, operant conditioning, and verbal association. Gagné adds a fourth that relates to the three prototypes: chaining. Classical conditioning is the process where the learner associates an already available response with a new stimulus or signal. Operant conditioning is the process where a response in a learner is instrumental and thereby leads to a subsequent reinforcing event. Verbal association occurs when the learner makes verbal responses to stimuli that are words or pairs of words. Chaining is a process where a learner connects individual associations in sequence. For example, a learner can recite verbal sequences consisting of lists of words, or the alphabet from A-Z (Gagné, 1985). Gagné believes these four prototypes of associative learning are components of learned human capabilities and link together as basic forms of learning. Gagné refers to them so he may present a comprehensive picture of how these prototypes of learning relates to the five categories of learning outcomes. One of the themes of Gagné's theory is distinguishing the types of outcomes that learning has: the categories of learned capabilities – observed as human performances – that have common characteristics. Gagné describes five categories of human performance established by learning:

a. Intellectual skills ("knowing how" or having procedural knowledge)

b. Verbal information (being able to state ideas, “knowing that”, or having declarative knowledge)
c. Cognitive strategies (having certain techniques of thinking, ways of analyzing problems, and having approaches to solving problems)
d. Motor skills (executing movements in a number of organized motor acts such as playing sports or driving a car)
e. Attitudes (mental states that influence the choices of personal actions)

C. The five categories of learning outcomes

The five categories of learning outcomes provide the foundation for describing how the conditions of learning apply to each category. Gagné (1985) postulates that if the five categories of learning outcomes and the ways of analyzing learning requirements are combined in a rational and systematic manner, then it will be possible to describe a set of ideas that make up a theory of instruction. He adds that a theory of instruction should attempt to relate the external events of instruction to the outcomes of learning by showing how these events lead to appropriate support or enhancement of internal learning processes. The events of instruction are the external events that help learning occur, and are designed to achieve each of the five different learning outcomes. Gagné numbers the instructional events from one to nine, showing a sequential order.

D. The Nine Events of Instruction

The nine events are as follows:

a. Gaining Attention
b. Informing Learners of the Objective
c. Stimulating Recall of Prior Learning
d. Presenting the Stimulus

e. Providing Learning Guidance

f. Eliciting Performance

g. Providing Feedback

h. Assessing Performance

i. Enhancing Retention and Transfer

Together, the conditions of learning, association learning, the five categories of learning outcomes, and the nine events of instruction provide a description of the framework for Gagné's conditions of learning theory.

Thinking is both physically and socially situated that problem tasks can be significantly shaped and changed by the tools made available and the social interactions that take place during problem solving. Situated cognition, a new model of learning, emphasizes apprenticeship, coaching, collaboration, multiple practice, and articulation of learning skills, stories, and technology (Brown, *et al* 2019). Flavell (2016) first invented the term metacognition and defined it as one's knowledge regarding one's own cognition as well as control and monitor one's own cognition. A self-regulated (or metacognitive) leaner is aware when one knows a fact or has a skill and when one does not. They view acquisition as a systematic and controllable process, and learner accepts greater responsibility for achievement. In other words, he/she is the initiator of the learning process. Self-regulation (or metacognition) plays a crucial role in all phases of learning and cross-domains. Schoenfeld (2007) stated that self-regulation has the potential to increase the meaningfulness of students' classroom learning, and the creation of a "learning culture "in the classroom best fosters metacognition. Schoenfeld (2013) showed that many problem-solving errors are due to metacognitive failure rather than lack of basic knowledge. Schoenfeld further said that all metacognitive strategies are illustrated in action, should be developed by students, and not declared by the teachers.

It is assumed that students can be taught to become more self-regulated learners by acquiring effective strategies and by enhancing perceptions of self-efficacy. Poor learners can benefit from reciprocal teaching that through process of modeling, guiding, and collaborative learning. The major responsibility of teachers is not to dispense knowledge, and no single teacher can teach students everything they need to know in their entire lifetime. Equipping students with self-regulated strategies will provide them with necessary techniques for becoming independent thinkers and lifelong learners. Programmed learning requires that EIMW concepts should be linked up during teaching and learning such that the understanding of simpler concepts may generate understanding of the higher and more complex ones. The use of models, guidance and collaborative learning is also of great importance in the teaching and learning of EIMW in Technical Colleges in North Central states.

2.1.2 Constructivist Learning Theory

The constructivist learning theory is another problem solving theory propounded by Jerome Bruner in 1978. Constructivism states that knowledge is not 'about' the world, but rather 'constitutive' of the world (Sherman,1995). Knowledge is not a fixed object; it is constructed by an individual through his/her own experience of that object. Constructivist approach to learning emphasizes authentic, challenging projects that include students, teachers and experts in the learning community. Its goal is to create learning communities that are more closely related to the collaborative practice of the real world. In an authentic environment, learners assume the responsibilities of their own learning, they have to develop metacognitive abilities to monitor and direct their own learning and performance. When people work collaboratively in an authentic activity, they bring their own framework and perspectives to the activity. They can see a problem from different perspectives, and are able to negotiate and generate meanings and solution through shared understanding (Lin & Hsiao, 2018).

The contemporary constructivist theory of learning acknowledges that individuals are active agents, they engage in their own knowledge construction by integrating new information into their schema, and by associating and representing it into a meaningful way. Constructivists argue that it is impractical for teachers to make all the current decisions and dump the information to students without involving students in the decision process and assessing students' abilities to construct knowledge. In other words, guided instruction is suggested that puts students at the center of learning process, and provides guidance and concrete teaching whenever necessary. Constructivist learning is based on students' active participation in problem-solving and critical thinking regarding a learning activity which they find relevant and engaging. They are "constructing" their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to a new situation, and integrating the new knowledge gained with pre-existing intellectual constructs (Lin & Hsiao, 2018).

Constructivism is one of the hot topics in educational philosophy which has profound implications for how current “traditional instruction” is structured, since it fits with several highly touted educational trends, for example: the transition of the teacher's role from "sage on the stage" (source/transmitter of knowledge) to "guide on the side" (facilitator, coach); teaching "higher order" skills such as problem-solving, reasoning, and reflection; enabling learners to learn how to learn; more open-ended evaluation of learning outcomes; and, of course, cooperative and collaborative learning skills. In recent years, however, many researchers have begun to focus on the potential of technology to support certain fundamental changes in the pedagogic models underlying our traditional approach to the educational enterprise (Brown *et al.*, 2019). Within this "constructivist" model:

1. Greater attention is given to the acquisition of higher-order thinking and problem-solving skills, with less emphasis on the assimilation of a large body of isolated facts.
2. Basic skills are learned not in isolation, but in the course of undertaking (often on a collaborative basis) higher-level "real-world" tasks whose execution requires the integration of a number of such skills.
3. Information resources are made available to be accessed by the student at that point in time when they actually become useful in executing the particular task at hand.
4. Fewer topics may be covered than is the case within the typical traditional curriculum, but these topics are often explored in greater depth.
5. The student assumes a central role as the active architect of his or her own knowledge and skills, rather than passively absorbing information proffered by the teacher (CTGV, 2013).

The contemporary constructivist theory of learning states that students should participate actively in the classroom activities to acquire knowledge during teaching and learning using models. It is based on students' active participation in class activity problem solving and critical thinking considering the importance and wide application of EIMW in our contemporary society. This theory relates to the teaching of electrical and maintenance work because it deals with both theory and practical activities that needs students active participation to enable them solve problems and at the same time think critically having in mind the importance and application EIMW trade to our society.

2.1.3. Models of Problem-Solving

The following are the models of problem-solving:

1. Craig Rusbult Model of Problem Solving:

Craig Rusbult design a model since (1989) consisting of four (4) Phases which are, The Orientation: Translate the problem's words, pictures and free information into a clear idea of NOW (the situation that is defined by the problem-statement) and GOAL (what the problem is asking you to do), Planning: Figure out how to get from where you are NOW to the GOAL, Action: Start doing your plan, and continue until you have reached the goal, Check: Ask yourself, "Have I answered the questions that were asked? Have I reached the GOAL?". Most people enjoy the stimulating challenge of a good problem and the satisfaction of solving it. You feel this satisfaction more when you master the tools of problem solving (Rusbult, 1989). Rusbult believes that you get "oriented" by using all available information (words, pictures, and free information) to form a clear, complete mental picture of the problem situation. By reading the problem statement carefully, you get accurate comprehension, the meaning of words and sentence structure, so as to gather all the important facts. Most problems are written clearly, so use standard reading techniques to accurately interpret what is written. You may re-read a problem carefully for details, using the "successive refinements" methods. Occasionally, a problem contains useless information (a decoy), so you need to learn to recognize what information to be used and what should be ignored. Study the diagram in the problem or make your own diagram because when the problem information (lengths, angles, forces, velocity and so on) is visually organized on paper, it is easier to understand it. This also helps to decrease your memory load, thus leaving your mind free to do creative thinking.

The problem-writer may expect you to assume certain reasonable things about the problem situation (free information), or to use data that is not given in the problem but is available in textbooks, tables or in a special part of the exam.

Rusbult (1989) suggested that in problem-solving, first you need to translate the problem's words, pictures and free information into a clear idea of NOW (the situation that is defined by the problem-statement) and GOAL (what the problem is asking you to do). Rusbult feels that it is often useful to plan in stages by looking for a point where you can say, "After I get to here, the rest of the way will be easy". This halfway point is called a sub-goal. Below is a summary of the overall strategy.

Step 1: Orientation: form a clear idea of the NOW and GOAL situations

Step 2: Plan a sub-goal.

Step 3: Do it: first reach the sub-goal, and then continue on to the goal.

Try as much as possible to keep sub-problems and make smooth transitions between these levels. After orientation, start doing something productive, anything seemingly useful until you reach a point where a solution plan becomes clear. Ask yourself, "What can I do with what I know?" Once you discover how the problem fits into a familiar pattern, the solution then becomes easy (Rusbult, 1989).

Rusbult (1989) opined that most problems are variations of previous problems, not duplicates. Form a clear mental image of the problem situation, and then search your memory for a match (pattern recognition). Look for matches at the level of principles, equations and sub-problems. Then use these individual tools, modified in whatever way needed, to solve the present problem. Your pattern-recognizing skills improve as you do more problems and as you learn to focus your attention on the relevant aspect of a problem situation. Rusbult also stated that good problem solvers generalize an equation to all appropriate situations but warned that over-generalization may make you use the equation when you should not and you may get an incorrect solution. Whereas, under-generalization may make you not recognize a situation where the equation is needed, and you may get no solution. Rusbult re-iterated the fact that your skill in solving problems may depend on whether you can use the stated tools quickly and easily (to free your mind for creative thinking), reliably (with minimum error) and flexibly (in a wide variety of problem situations); that with practice, you may get better at planning complex multi-step solutions, and you will be more comfortable when you must "improve as you go."

In relation to attitude, Rusbult (2005) said that your problem becomes more effective and more fun when you have a positive attitude. Attack each problem with enthusiasm and good tools, confident that you may be able to find an answer quickly. Rusbult advised that you should avoid the extremes of passive inactivity, simply because you are afraid to make a mistake and unconstrained action when you never check for correctness. A useful strategy in problem solving is the creative process of brainstorm-and-edit. In effective problem solving, there is therefore an overlap between the phases of orientation, planning, action and checking. During orientation, you search for a solution plan and check it for correctness in quick brainstorm-and-edit cycles. With go-and-improvise, you begin action before the entire strategy is planned. The following statements were made and questions posed by Rusbult (1989) on how to learn more from your problem-solving experience:

1) When you finish solving a problem, review what you have done and ask; what can I learn from this problem that will help me do better in the future?
2) If you solved the problem, ask; what did I do, and why did it work?
3) If you initially had trouble but eventually solved the problem, ask; what was wrong with my original approach? Was my orientation incomplete or inaccurate? Did I

lack skill in using the necessary tools? How can I change my approach so that the next time I see a similar problem it will look different-more like it should for inspiring a solution?

For simple problems, the four (4) stage Polya's method and the scientific method can be followed without any difficulty. When the problem is tough it often takes a lot of forward and backward processes before the problem is finally solved (if it is solvable). In other words, problem solvers should keep sub-problems and the overall goal in mind at the same time during problem solving and should make smooth transitions between the problem-solving sub-units. The description of the 5-step plan of the Glenco's (1989) problem-solving strategy is as follows:

- Understanding the problem: Determine what information is given in the problem and what you need to find. Ask yourself questions as: "what is the problem all about?", "what am i given and not-given?", "what do I need to find?"
- Make a plan: After you understand the problem, select a strategy for solving it; look for pattern, making table or work backward.
- Carry out the plan: Solve the problem by carrying out your plan. Perform the necessary computations and describe the steps that you take.
- Evaluate solutions: examine your answer carefully to see if it fits the facts given in the problem. Check if there might be other solutions or strategies which will yield the same solution. Students/teachers must indicate all questions, attempts, frustrations or any restrictions they may have placed on a problem. Within the context of solving a given set of problems, probing questions are posed such as: Are all the given data relevant to the solution? Do any assumptions have to be made? Are there different ways of interpreting the given information or conditions? As the questions are posed, students reach a good understanding of each problem.

- Posing related problems: Pose a related mathematical problem by simply changing the unknown(s) in the solved problem. That is, change the conditions of the current problem. Use the given problem and modify it to obtain a variation of the given problem. Students pose a related problem(s) by changing the values of the given data and by changing the context of the original problem. This does not mean that the students have to modify or change the solving strategy used in the original problem.

The 4-step plan of the Rusbult's (1989) problem-solving strategy is described as follows:

(a) Orientation: Translate the problem's words, pictures and free information into a clear idea of NOW (the situation that is defined by the problem-statement) and GOAL (what the problem is asking you to do).

(b) Planning: Figure out how to get from where you are NOW to the GOAL.

(c) Action: Start doing your plan, and continue until you have reached the goal.

4) Check: Ask yourself, "Have I answered the questions that were asked? Have I reached the GOAL?" This study investigated the differential effects of Rusbult's and Reda's problem solving strategies on an important but problematic topic like trigonometry. The choice of these strategies is that they are both cyclic adaptations of Polyas (1965) strategy but differ at the level of checking and posing related problems. Rusbult stated that to check you need to ask yourself, "Have I answered the questions that were asked? Have i reached the GOAL?" If yes, then you should move to the next higher learning experience but if no, you need to go through all the steps of the solved problem and correct or complete the solution. Glence on the other hand said that to check, examine your answer carefully to see if it fits the facts given in the problem. Then, pose a related mathematical problem by simply changing the unknown(s) in the

solved problem. This problem posing technique ensures further practice, understanding and evaluation of the concepts taught. It also raises a problem which leads into the future work when the day's work is finished. This study considered problem-solving at both the lower and higher levels. It involves the cyclic and the scientific approaches for trigonometry problem solving which are contained in the Rusbult's and Glenco's problem solving strategies of "looking back".

2. Glencoe Model

Glencoe design a model consisting of four (4) Phases such as Explore: Determine what information is given in the problem and what you need to find, Plan: Select a strategy for solving it, Solve: Solve the problem by carrying out your plan and Examine-Finally, examine your answer carefully to see if it fits the facts given in the problem (Glenco's, 1989). Glencoe's model consisting of four (4) Phases are explained below:

Phase 1: Explore the problem in such a way of determining what information are given in the problem and what you need to find. Understanding the problems seems so obvious that it is often not even mentioned, yet students are often stymied in their efforts to solve problems simply because they don't understand it fully or even in part. Glencoe taught teachers to ask students questions such as: Do you understand all the words used in stating the problem? What are you asked to find or show? Can you restate the problem in your own words? Can you think of a picture or diagram that might help you understand the problem? And Is there enough information to enable you to find a solution? You have to understand the problem. What is the unknown? What are the data? What is the condition? Is it possible to satisfy the condition? Is the condition sufficient to determine the unknown? or is it insufficient or redundant? or contradictory?

Phase 2: Devise a plan and a strategy of solving the problems. The skill at choosing an appropriate strategy is best learned by solving many problems. You will find choosing a strategy increasingly easy. A partial list of strategies is included: Guess and check, look for a pattern, make an orderly list, draw a picture, eliminate possibilities, solve a simpler problem, Use symmetry, use a model, consider special cases, Work backwards, use direct reasoning, use a formula, solve an equation and Be ingenious. Find the connection between the data and the unknown. You may be obliged to consider auxiliary problems if an immediate connection cannot be found. You should obtain eventually a plan of the solution. Have you seen it before? Or have you seen the same problem in a slightly different form? Do you know a related problem? Do you know a theorem that could be useful? Look at the unknown and Try to think of a familiar problem having the same or a similar unknown. Here is a problem related to yours and solved before. Could you use it? Could you use its result? Could you use its method? Should you introduce some auxiliary element in order to make its use possible? Could you restate the problem? Could you restate it still differently? Go back to definitions. If you cannot solve the proposed problem, try to solve first some related problem. Could you imagine a more accessible related problem? A more general problem? A more special problem? An analogous problem? Could you solve a part of the problem? Keep only a part of the condition, drop the other part; how far is the unknown then determined, how can it vary? Could you derive something useful from the data? Could you think of other data appropriate to determine the unknown? Could you change the unknown or data, or both if necessary, so that the new unknown and the new data are nearer to each other? Did you use all the data? Did you use the whole condition? Have you taken into account all essential notions involved in the problem?

Phase 3: Carry out the plan. This step is usually easier than devising the plan. In general, all you need is care and patience, given that you have the necessary skills. Persist with the plan that you have chosen. If it continues not to work discard it and choose another.

Don't be misled, this is how mathematics is done, even by professionals. Polya's Fourth Principle: Look back Polya mentions that much can be gained by taking the time to reflect and lookback at what you have done, what worked, and what didn't. Doing this will enable you to predict what strategy to use to solve future problems. So starting on the next page, here is a summary, in the master's own words, on strategies for attacking problems in mathematics class. This is taken from the book, how to Solve It,

Phase 4: Examine the solution obtained. Can you check the result? Can you check the argument? Can you derive the solution differently? Can you see it at a glance? And Can you use the result, or the method, for some other problem?

Once you have a potential solution, check to see if it works.

a. Did you answer the question?
b. Is your result reasonable?
c. Double check to make sure that all of the conditions related to the problem are satisfied.
d. Double check any computations involved in finding your solution.

If you find that your solution does not work, there may only be a simple mistake. Try to fix or modify your current attempt before scrapping it. Remember what you tried—it is likely that at least part of it will end up being useful.

Is there another way of doing the problem which may be simpler? (You need to become flexible in your thinking. There usually is not one right way. Can the problem or method be generalized so as to be useful for future problems?

2.2 Conceptual Framework

A conceptual framework is an instrument that is use by researcher to guide his or her inquiry; it can be seen as a set of ideas which is used to structure the research and give it correct outcome (Alutu, 2016). Alutu added that conceptual framework enables the researcher to make a links between the literatures that exist and the research goals, it serves as a finished after effect of uniting various related ideas to clarify or foresee a given occasion, or give a more extensive understanding of the phenomenon of interest or simply a research problem. The conceptual framework serves the basis of summarizing and linking the knowledge on the area of study, it provides meaning for causal linkages and it is used for generating hypotheses (Deubel, 2013). In this study, the conceptual framework can be viewed as relationship that exists between the concepts, variables that provide a support and basis of this study as shown in figure 1.

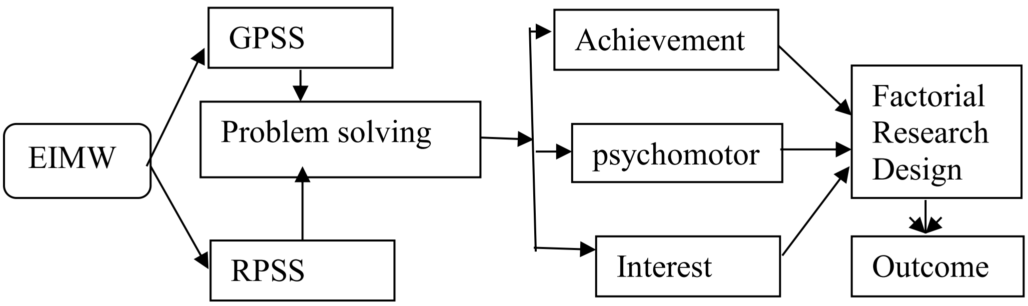

Figure 1: Conceptual Framework

Electrical installation and maintenance work (EIMW) is a course offered in technical colleges and the content as specify in NBTE syllabus is having some areas where student needs better understanding such as battery charging and electrical machines. Therefore, there is need to teach these difficult contents areas with the use Glencoe's and Rusbult's problem-solving strategies to improve the students' academic achievement, interest and their mental ability in manipulation of skills thereby producing a required desire goal in EIMW. This study would cover all the sub-themes of battery charging and electrical machines, which includes: Cell and battery circuits, Constant voltage battery charging, Constant current battery charging, Direct Current (DC) Machines, DC Generators, DC Generator Characteristics, DC Generator Characteristics II, DC Motors, Series-wound and Compound-wound Motors, Alternating Current Motors. These sub-themes are the topics covered by TC II which are the respondents for this study and are among others having difficulty in these selected areas and thereby having little or no interest in it, poor academic achievement and skills. Therefore, the need for using the Glencoe's and Rusbult's problem-solving strategies for teaching EIMW to achieve the desired goal or outcome become very important,

2.2.1 Philosophy and Objectives of Electrical Installation and Maintenance Work in Technical Colleges

Technology is a process of integration of science and practice in the application of tools and equipment and also the development, and application of devices, machines, and techniques for manufacturing and productive processes (Bakare, 2012). Electrical technology refers to the energy that course potential difference (p.d.) or known as the movement of electrons in a conductor and is produce in chemical or mechanically for societal used when to installing in a building. According to Modes (2008) electrical installation could be describedas an installation in a building, which comprises various kind of electrical apparatus fixed in a position ready for used, together with the necessary wiring, control gears. Mode went further to mention the following: as the various types of electrical installation. Aluminum conductors wiring, conduit wiring, rubber sheathed wiring, P.V.C. polyvinyl chloride wiring, lead-alloy sheathed wiring, earthed concentric installation, mineral-insulated installation. Electrical Installation is seen to be the most suitable not for all conditions for a particular condition or environment would be employed. None regarded as the best for all situations or the environment. Installation: an act of installing equipment, the process of putting a piece of equipment or machine in place and making it ready for use such as housing equipment or machinery for a particular use, systems that have been put in place, made ready for use. Thompson (2012) ascertained that adequate training of electrical installation programs would equip students with broad knowledge of the world of work and prepare the student to grow and develop about the world. The field of electrical installation and maintenance work trades includes Generation of electrical energy, Protective Devices; Disturbance-monitoring equipment, Performance measures, Industrial installation, electric machines and battery charging among others (Bakare, 2012).

Battery charging according to the NBTE syllabus to be covered by TC 11 in its content consist of cells types, working principles of cells, construction of cells, materials to be used for cells constructions, equipment methods, tools used for charging of batteries, detects cells faults, repairs and maintenance and replacements of cells and among others and also in areas of electric machines contents to be covered includes principles and operation of electric machines, types, maintenance, applications and construction of electric machines, lubrication grades and their applications, operation and testing of electric machines, troubleshooting techniques, tools and equipment use for diagnosing faulty electric machines among others (NBTE, 2018).

Electricity involves many hazards; Ogbuanya and Abdullahi (2011) described electricity as a good servant but a bad master. Anyone can be exposed to these hazards: at home, at school, at work, or even outdoors. Therefore, electrical installations can only be carried out by appropriately qualified or trained personnel who are able to recognize electrical hazards or potentially unsafe conditions. Ogbuanya and Abdullahi (2011) maintained that despite the risk and hazards involved in electrification, teaching and learning has a major role to play in the provision of electricity for industries. It is expected that students should possess skills that enable them to perform in their areas of discipline. EIMW is one of the courses offered in technical colleges in Nigeria. It comprises basic electricity, battery charging, domestic installation, industrial installation, cable jointing, and winding of electrical machines as contained in the NBTE (2018) curriculum. An electrical installation according to Ogbuanya *et al,* (2017) is an installation in a building, which comprises various kinds of electrical apparatus fixed in a position ready for use, together with the necessary connecting wires and control gears. Hence, the installation type seen to be the most suitable for a particular condition or environment can be employed.

According to Ogbuanya and Abdullahi (2010), none is regarded as the best for all situations or environments. He added that domestic installation is concerned with installation of electrical components or equipment in a building such electrical components include home appliances fixed in position ready for use. Domestic installation involves surface wiring, conduit wiring, as well as maintenance of electrical fittings, such as illumination lamps used in homes, mostly in the 0.50–415 V range (Ogbuanya*et al* 2017). Industrial installation, however, involves industrial consumption of high-tension conductors made from aluminum or copper and alloy. High voltages from 415 V and above are transmitted through over-head conductors, underground, and trunking, as either alternating current or direct current for machines and equipment through cable joints with control gears for protection. Cable jointing according to Cosmas (2010) means one or more conductors with or without insulating covering in different types, sizes, and shapes such as armored cable, over-head conductors, boss bars, and commercial cable joints, or termination in transmission. Transmission is the means of conveying, distributing, and installation for effective use in homes and industries.

Technical colleges are the institutions where students are trained to acquire relevant knowledge and skills in different occupations for employment in the world of work (NBTE 2018). Technical colleges are regarded as the principal vocational institution in Nigeria (Okoro 2012). According to the Federal Ministry of Education (FME, 2014) Technical college is a segment of technical and vocational schools (TVE) designed to produce craftsmen and master craftsmen at the advanced craft level.The goals of the functional colleges are to produce trained manpower in the applied science, technology and business particularly at craft, advanced craft and technician levels; provide the technical knowledge and vocational skills necessary and give training and impart the necessary skills required for agriculture, commercial and economic development and give training and impart the necessary skills to individual who shall be self – reliant economically (Ogbuanya & Abdullahi, 2011).

Teaching in technical colleges involves practical training using newer methodologies of applying science, material, tools, devices equipment, machining and other resources to enable expert electrician to solve practical problems. These involve manipulation of materials or objects in the form of work task such as lighting, a lamp, tightening or unscrew a socket outlet complex as the process of dismantling and reassembling a bund distribution chamber in electrical installation. Competencies will be useful in proportion as it trains the individual directly and specifically in the thinking habits and manipulative practices required in the occupation itself, it enables each to capitalize his or her interest, aptitude, and intrinsic intelligence to the highest possible degree. Nwachukwu (2006) express Technical College product as who shall be enterprising and self-reliant. Their existence, are to stimulate technological and industrial development by developing and utilizing technologies for industrial and economic advancement.

Technical college is an integral part of the total educational system. It contributes towards the development of good citizenship by developing the physical, social, civic, cultural and economic competencies of the individual (Sanni, 2012). In technical colleges, students are trained to acquire relevant knowledge and skills in different occupations for employment in the world of work (NBTE, 2018). Technical colleges are regarded as the principal vocational institutions in Nigeria. They give full vocational training intended to prepare students for entry into various occupations. Technical colleges train craftsmen in auto mechanics, plumbing, carpentry and joinery, cabinet making, painting and decorating, welding, electrical installation, radio and TV repair, building construction and a few other areas. On completion of the course of training, students obtain work in industries or established business on their own. The programmes in the college were designed to train craftsmen and artisans for the profiting of the individual and the economy. The success of technical and vocational education programme in making substantial contribution to the economy of a nation like Nigeria depends largely on the success of the process of imparting the required knowledge, attitude and skills to the students.

2.2.2 Academic Achievement in Electrical Installation and Maintenance Work

Academic achievement refers to knowledge and skills attained by a student in school subjects, designated by a score obtained in an achievement test. Accordingly, a test is an instrument administered to an individual to elicit certain desires and expected responses, as demanded in the instrument, performance on which the individual is assigned a score representing his achievement. Artherton (2013) noted that academic achievement is always denoted by a score, which represent the amount of learning acquired, knowledge gained or skills and competencies developed in the school subject. Artherton maintained that academic achievement is hinged on several factors including, teaching method, intelligence, background, organization, opportunity, motivation, instructional procedures, teaching aids, interest of the learner, and other environmental variable. Others include learner‘s mental ability, his goals and purposes, his identification with learning, his maturation, and methods of guidance, availability of facilities and methods of testing. Brown *et al.,* (2019) wrote that studies have been conducted to articulate the characteristics of a good teaching and how it relates to students academic achievement. One can be confident that the methods and tools employed by a teacher to impact the lesson could lead to students learning and higher academic achievement. Bar-yam *et al* (2016) asserted that the effectiveness of teaching and the pertinence of the assessment of learning achievement can be enhanced by teachers adaptation of instructional strategies to students learning style. Therefore, the characteristic of a good teacher to a successful learning achievement are: one characteristic of a good teacher that is considered relevant to student achievement is a sound knowledgebase of the subject matter, classroom planning, management and instructional skills. Teachers must demonstrate that they possess these skills. This implies that a good teacher characteristic enhances efficient and effective students' achievement.

2.2.3 Ability grouping and academic achievement

Ability grouping also known as Homogeneous grouping has been defined as "placing students in classrooms based on their current academic ability level in a certain subject" (Davidson, 2019). In the United States, students have been placed into ability groups based on their academic strengths and weaknesses (Davidson, 2019). In some educational settings, students were placed into classrooms that were not grouped homogeneously, and educators gave group instruction in respect to the specific individual need of students. In some instructional settings, students were placed into homogeneously-grouped classes based on academic ability or academic achievement

(Emery, 2017). Though homogeneous grouping is a common educational practice, there has been a great deal of research that supports both classrooms that are heterogeneously grouped and those that are homogeneously grouped (Campbell, 2014). Regardless of the educational practice implemented, the objective of placing students into instructional groups in respect to their capability level is to increase the academic success of students (McCarter, 2014).

In education, placing students into classrooms based on academic achievement is a common response to providing differentiated instruction for students. Homogeneous grouping, also known as ability grouping, is the educational method of placing students into groups in respect to their academic achievement level (Emery, 2017). In many countries including Nigeria, educators have used the method of homogeneous grouping in secondary schools by placing students into vocational, college, polytechnic or university tracks based on their chosen pursuit and academic capabilities. To meet the academic needs of students and increase academic growth, educators have utilized homogeneous placement as a common practice. However, research studies have indicated the kind of homogeneous grouping makes a difference in student development all through the school year (Holland & Ireson 2013). Even though homogeneous grouping has been a common educational practice in the United States, researchers have indicated that homogeneous grouping is a societal injustice and lowers the self-efficacy of students as well as their academic achievement (Fram *et al.,* 2017). Educators have increasingly maintained and applied stratification practices such as homogeneous grouping, streaming, and setting in order to raise levels of academic achievement (Trigg-Smith, 2011). Research has been conducted to determine if social inequality occurs when the practice of homogeneous grouping is implemented. According to existing research, data has verified that homogeneous grouping benefits advanced students more than other groups (Fram *et al,* 2017). The technique for homogeneous grouping has been frequently promoted in training as an approach to differentiated instruction. In spite of its prominent use, there are educational practices that take into account society and shifting vocabulary that encompass this educational topic. In the United Kingdom, ability grouping has been referred to as streaming or tracking, which is a form of between-class homogeneous grouping based on general academic ability. Banding is similar to streaming; however, it is more flexible and students are regrouped based on the particular subject area. Regrouping, also known as setting as an educational practice, is the least restrictive, and students are grouped based on their academic ability in each respective content area (Wouters *et al.*, 2012). Trigg-Smith (2011) discovered how student academic capability has reinforced the grouping practices and plausible frameworks for the exploration of equity within the grouping.

In respect to the negative academic effect of homogeneous placement, Wouters *et al* (2012) in his study of 29 international studies, found no correlation between academic achievement and ability placement. Based on their type of academic grouping, Holland and Ireson, (2013) indicated that, while higher achieving students benefited from homogeneous placement, lower performing students did not have a significant amount of improvement. While Kulik (1992) noted there was a positive effect on higher performing students, there was not a statistically significant effect in respect to the lower academically performing students as a result of homogeneous placement. Trigg-Smith (2011) conducted one of the most comprehensive reviews of research of homogeneous grouping in elementary (1987) and secondary (1990) schools. Trigg-Smith argued that homogeneous grouping has no effects on productivity or inequality. As a result of homogeneous grouping, some of the studies indicated positive results while others indicated negative results.

Therefore, Trigg-Smith concluded that homogeneous grouping had no effect and the positive effects appeared in many studies resulted from random or systematic errors of measurement. In agreement with Slavin (2017) considered homogeneous placement to be an unacceptable approach for the grouping of students. In Slavin study, the overall impact of homogeneous placement was analyzed in respect to different academic populations. For example, students that were identified in this study were gifted, racially diverse, exceptional, and economically disadvantaged. Research studies have indicated that the utilization of homogeneously grouped classes have a negative impact upon minority students, lower socio-economic students, and students with lower academic capabilities (Slavin *et al.,* 2009). Furthermore, homogeneous grouping could potentially deny students their right to an equal educational opportunity.

As noted by Collins and Gan (2013), a list of the negative aspects of homogeneous grouping has been given:

a. Students have a tendency to be grouped in high, middle, and low ability classes.
b. Students placed in lower achieving classes can have a negative impact on one's self-efficacy.
c. Often times, the students from higher socio-economic status are placed in the higher achieving classes and the students from the lower socio-economic status are placed in the lower achieving classes.

Research has shown both advantages and disadvantages concerning grouping by capability in education. However, Catsambis and Buttaro (2012) concluded there are some benefits to homogenous classrooms grouped by ability for higher academically achieving students. Concerning kindergarten and primary school academic placement, Catsambis and Buttaro's research indicated that, when placed into small groups for reading, students in higher achieving groups had a positive attitude concerning reading.

However, students placed in lower achieving groups had a negative attitude concerning reading. Catsambis and Buttaro analyzed the psycho-social impact that homogeneous-grouped classes had on students. The researchers indicated that the higher academically achieving groups had a more positive outlook on education, which correlated to their academic performance. However, the lower achieving groups had a lower academic performance due to their negative outlook on their academics. In a similar study, Fram *et al.,*(2017) found that high school students performed in like fashion. As a whole, with the exception of gifted and talented students, those grouped by ability did not perform significantly higher. With these studies in mind, it appears that homogeneous grouping increases the success of high academic achievers. However, it has a negative impact on lower academically achieving students.

Research have indicated that higher academically achieving students in kindergarten through grade 12 have an increased level of learning when placed in homogeneous groups (Totten & Bosco 2008). However, in the low to middle level groups, students showed higher levels of academic productivity when they were instructed in heterogeneous ability groups. Burris *et al.,* (2017) indicated contradictory results to Totten and Bosco (2008). In this study, the researchers revealed that higher academic achieving students were not affected when assimilated with students whose academic capability were lower. The practice of sorting students according to ability continues in spite of the research illustrating the manner in which low-track classes fail to serve students. Further, school administrators who sort students in this manner create an even more damaging learning environment for disabled and economically disadvantaged students (Mode, 2008). Mode and others have posited that the practice of tracking persists due to inherent institutional politics, beliefs, values, and culture as much as to "technical, structural, or organizational needs" (Burris *et al.*, 2017). Intuitively, many educators and parents finny believe that segregating high achievers according to their abilities will provide learning benefits not found in a less-challenging curriculum. Findings on the influence of heterogeneous grouping upon student achievement have provided mixed results. Results from some studies have suggested improved achievement for low-tracked students in mixed-ability instructional groups (Burris, *et al.*, 2017; Slavin, *et al.*, 2009), while others have suggested that high-achieving students may well suffer in heterogeneous groups (Kulik, 1992). Several researchers have even suggested that there is no statistically significant influence on high achieving students assigned to mixed-ability instructional groups (Slavin, *et al.*, 2009). However, there is now emerging research to strongly indicate that detracting can and does improve achievement results for marginalized students in wealthier, suburban communities (Welner & Burris, 2006).

Tracking or "ability grouping" continues to be employed in schools to group students with the same skill levels or ability for the purpose of achieving specific goals which are believed to be attainable by each student in the group. Tracking takes on many different forms, depending on the particular school's or individual teacher's policies. Ability grouping can begin or take the form of students being grouped within a classroom where they break into small groups within the class to receive specific instruction. Often, this type of differentiated instruction occurs in the earliest grades. However, as students progress into higher grades they may be grouped into entirely separate classrooms where students of different ability groups take classes with different teachers, instructional materials, or at a different pace. Eventually, these students may be separated into different courses or "tracks" of instruction. When tracked students reach high school, some have already been "tracked" into courses that will lead to a college preparatory course of study and exposure to the materials that will be tested on high school graduation tests or college entrance exams, whereas other students may be directed to vocational opportunities. The effect of tracking often has the unintended consequence of negative attitudes and perceptions, which may influence student learning and subsequent scores on New York State standardized testing in the area of middle level mathematics (Boaler, 2007). Boaler added that in homogenous grouping Activities may be limited and Students may have more opportunities for interaction.

2.2.4 Students Interest in Learning Electrical Installation and Maintenance Work (EIMW)

Interest is the focusing of the sense organs on or giving attention to some person, activity, situation or object, it is an outcome of experience rather than a gift and could either result or cause motivation. It could also be regarded as a pre-determinant of one's perceptions that is, what aspect of the world one is mostly likely to see always (McClnermey, *et al.*, 2015). It could be a temporary or permanent feeling of preference. It could also be viewed as a condition in which an individual associates the essence of certain things or situation with his needs or wants. They added that genuine interest is the accomplishment of the identification, through action of the self with some object or idea. They further stated that this is necessary because of the necessity of that object or idea, for maintenance of a self-initiated activity. Interest according to them is a name for the fact that a course of action, an occupation or pursuit absorbs the power of an individual in a thorough going way. Going by this definition, interest thus seems particularly useful as the relationship between identification, absorption and the maintenance of a self-initiated activity which offers a straight forward way to analyze classroom activities.

Interest in learning, could most probably be a very powerful affective psychological trait and a very strong knowledge emotion as well as an overwhelming magnetic positive feeling, a sense of being captivated, enthralled, invigorated and energized to cognitively process information much faster and more accurately in addition to most effective application of psychomotor traits like self-regulatory skills, self-discipline, working harder and smarter with optimum persistence (Kpolovie, 2010).He recommended the need for ascertaining the actual role that interest in learning plays in students academic attainment at all levels of the educational system. The nature and strength of one‘s interest in learning and in schooling may represent an important aspect of personality (Abdurahaman *et al.,* 2016). The characteristic, interest, may substantially influence educational and occupational achievement, interpersonal relations, the enjoyment one derives from leisure activities, and other major phases of daily living.

Interest as defined by Holland and Ireson (2013) is an activity or a hobby that a person enjoys and spends free time doing or studying. Okoro (2012) refers interest to mean what an individual likes or dislikes and that they are usually associated with activities. He refers interest to be the positive state of mind or a quality that attract your attention to the learning processes. Interest in a particular subject depends on the affective domain of the learners or students towards that subject. The classification of interest skills according to Huitt (2001) are:

a. Receiving – Students being aware of or attending to something in the classroom.
b. Responding – Showing some new behaviours as a result of experience.
c. Valuing – showing some definite involvement or commitment and organization, that is, integrating a new value into ones general set of values, giving it some ranking among ones general set of values.

Udeani and Sunday (2011) opined generation of interest as follows:

a. Use of gesture, eye contact and vocal reflection

b. Use of apt examples and analogies can generate interest and understanding.
c. Use of an appropriate mode of explaining. Three modes have been observed – the narrative, the anecdotal and the conceptual.

Measurement of affective behaviour is currently receiving emphasis in Nigerian school. The FGN (2013) gives two affective objectives of Nigerian education. These are the inculcation of national consciousness and National unity and the inculcation of the right type of values and attitudes for the survival of individual and Nigeria society. Hence, education should lead not only to the acquisition of cognitive knowledge and psychomotor skills but also to the development of appropriate attitudes. Any education that does not promote the right values, attitudes and interest to work, life and society is of limited value. In other words, teaching of appropriate values, attitude and interest should form part of every well-organized educational programme. Okoro (2012) noted that Tyler classified affective objectives into four broad categories namely: attitudes, interest, value and appreciations. Writing on vocational interest of men and women, Strong is referred to interest as likes, while dislikes are labeled aversion.

Interest in EIMW can also be an expressed motive that satisfies objectives in vocational education as a field of study. According to Udeani and Sunday (2011), the first systematic efforts to measure interest appeared to have been made in 1915 at the Carnegic institution of technology, where James miner developed a questionnaire to assist students in their vocational choices. A further giant steps forward in interest appraisal were taken in 1927 when strong published his first edition of vocational interest Blank (SVIB), and in 1937 when Kuder made available the initial form of the Kuder Performance Record (KPR). The strong inventory was designed to distinguish successful men in given occupational group from men in general. Strong thought that the interest typical of any one occupational group will differ from a people in general group and at least a little from any occupational group. Several different methods are employed by psychologist in personality, attitude and interest measurement (Okoro, 2012).

Interest has the power to transform struggling performers, and lift high achievers to a new plane. Paul (2014) found that interest cognitively engages students and statistically fosters learning. Interest could be seen as a psychological state of engagement, experienced in the moment, and also a predisposition to engage repeatedly in particular ideas, events, or objects over time. Paul added that interest simultaneously diversifies one‘s experience and focuses his experience; leading him to pay attention to only certain things and not to some other things that tend to stimulate the person‘s attention. Interest in an activity, such as learning a technical and vocational education trades which EIMW inclusive could most probably be a very powerful affective psychological trait and a very strong knowledge emotion as well as an overwhelming magnetic positive feeling, a sense of being captivated, enthralled, invigorated and energized to cognitively process information much faster and more accurately in addition to most effective application of psychomotor traits like self-regulatory skills, self-discipline, working harder and smarter with optimum persistence (Kpolovie, 2012). Growing knowledge leads to growing interest as new information increases the likelihood of conflict, conflict of coming across a fact or idea that does not fit into what the individual has already learnt) (Paul, 2014). The more a person knows or learns about a domain, the more interesting the domain becomes to him. This is most probably because of the phenomenon of more learning leading to more questions, which in turn increases learning.

2.2.5 Psychomotor performance

Psychomotor is related to the movement or muscular activity associated with mental and affect processes and it connects to the physical skills and the ability to move, act, or manually manipulate the body to perform a physical movement (Parrott & Hindmarch (2008). With learning perspective, psychomotor is closely associated with skill based and the learning of skills and the development of skills requires practice and it is measured regarding ability, speed, precision, distance, procedures, or techniques in execution. Based on the Taxonomy Bloom (Huitt, 2009) perception, set, guided response, mechanism, complex overt response, adaptation, origination and words are the seven major components of psychomotor skills:

i. Perception: The ability to use sensory cues to guide motor activity. Ranges from sensory stimulation, through cue selection, to translation.

ii. Set: Readiness to act. Includes mental, physical, and emotional sets. These three sets are dispositions that predetermine a person's response to different situations (sometimes called mindsets).

iii. Guided Response: The early stages of learning are the complex skills that include imitation, trial, and error. Adequacy of performance is achieved by practicing.

iv. Mechanism: This is the intermediate stage in learning a complex skill. Learned responses have become habitual, and the movements can be performed with some confidence and proficiency.

v. Complex Overt Response: The skillful performance of motor acts that involve complex movement patterns. Proficiency is indicated by a quick, accurate, and highly coordinated performance, requiring a minimum of energy. This category includes performing without hesitation and automatic performance. For example, players are often utter sounds of satisfaction or expletives as soon as they hit a tennis ball or throw a football because they can tell by the feel of the act what the result will produce.

vi. Adaptation: Skills are well developed, and the individual can modify movement patterns to fit special requirements.

vii. Origination: Creating new movement patterns to fit a particular situation or specific problem. Learning outcomes emphasize creativity based upon highly developed skills.

The development of psychomotor skills and the ability to perform the task are critical and the capability to perform the skill is based on the learning of how to do it correctly (Wulf, *et al.*, 2010). They highlighted three phases in developing student psychomotor skill; a) cognitive -students must understand the skill and know how to perform accurately; b) associative- refining movements to become more consistent in working performance and; c) autonomous - keep practicing until the skill is automatic and the step has become pontaneous. Girot (1993) argues that the opportunity to practice repetitively and getting feedback from the performance will enhance students' psychomotor skill or skillful, however, without frequent practice, psychomotor skills cannot be retained.

2.2.6 The Need for change of methodology

Every field of endeavour continuously encounter fresh challenges and it is imperative to challenges. According to Ogwo (2010) Nigeria is saddled with educational problems of great magnitude, which the traditional methods of teaching and learning alone cannot solve. He further stressed and maintained that the traditional approach of delivering knowledge through lecture must be replaced with methodologies which allow students to learn needed skill in the context within which the skill are used in the real world. With the recent trend in the electronic industry, there is a great need for electrical and electronic trade students in the technical college to be well trained for the required knowledge and skill needed for the maintenance, troubleshooting, repair, and servicing of the latest electronics. For this to be achieved, there must be a change in the lecture method approach adopted in teaching students to a more fascinating strategy that could enhance good performance. The study will therefore adopt the use of mind maps as an alternative strategy in the teaching of electrical and electronic trade students in technical colleges. According to Boyle, *et al*., (2013), these methods emphasize knowledge transmission from the teacher to passive students; encourage rote memorization of facts.

The challenges to equip student in vocational and technical education with the workplace basic skills required in the 21st century, therefore, necessitate a shift from the behavioral learning theories to those rooted in cognitive psychological learning theories (Karen, 2017). The cognitive theories view learning as an internal mental phenomenon inferred from what learners say and do and focuses on how to engage learners' cognitive process during teaching (Lin &Hsiao 2018). These cognitive theories emphasize making knowledge meaningful and taking into account learners' perceptions of themselves and their learning involvements. UNESCO (2003) maintained that a shift from teacher-centered instruction to learner-centered instruction is needed to enable students to acquire the new 21st century knowledge and skills. In view of this UNSECO pointed out that in contrast to the traditional teaching-learning paradigm, a new paradigm of the teaching-learning process is emerging, based on three decades of research in human learning that encompass the following views of the human learning process.

- Learning is a natural process: Not everyone learns in the same way. There are difference in perceptual and personality styles that must considered in the design of learning experiences for the individual student. Given interesting and rich learning environments, and supportive and stimulating teacher, students will learn. Teachers have often noted that children who appear disruptive or to have short attention spans when confronted with typical classroom instruction may spend large periods engaged in meaningful and interesting activities.

- Learning is a social process: The communal context of knowledge and learning is beginning to be rediscovered, as evidenced by the rapid growth of quality circle and computer – supported collaborative work in business, government, medicine, and higher education. Students learn best in collaboration with peers, teachers, parents, and others when they are actively engaged in meaningful, interesting tasks. ICT provide opportunities for teachers and students to collaborate with others across the country and across the globe. They also provide new tools to support this collaborative learning in the classroom and online.
- Learning is an active and not a passive: In most fields, people are faced with the challenges of producing knowledge rather than simply reproducing knowledge to allow students to move toward competence. They must be actually engaged in the learning process in activities such as solving real problems. Producing original writing, completing scientific research projects (rather than simply studying about science), dialoguing with others on important issues, providing artistic and musical performances and constructing physical objects. The traditional curriculum asks students only to recall and describe what others have accomplished or produced. While all production of knowledge must be based on an understanding of prior knowledge, the mere reproduction of knowledge, without its connection to the production of knowledge, is largely a passive actively that neither fully engages nor challenges the students.
- Learning may either be linear or non-linear: Much of what now happens in schools appears based on the notion that the mind works like a serial processor that is designed to process only on piece of information at a time in sequential order. But the mind is a wonderful parallel processor that may attend to and process many different types of information simultaneously. Cognitive theory and research sees

learning as a reorganization of knowledge structures. The knowledge structures are stored in semantic memory as schema or cognitive maps, many of which overlap or are interconnected through a complex network of association. There are many ways that students may acquire and process information and assimilate it into their existing knowledge structures.

- Learning is integrative and contextualized: Pribam‘s holistic brain theory suggests that information presented globally is more easily assimilated than information presented only in a sequence of information. It is also easier for students to see relations and make connections.

Learning is based on a strength model of students' abilities, interest, and culture: Based on the work of Howard Gardner and others, schools are beginning to consider the specific strengths and interests that students bring to the learning environment, and are designing learning activities that build on student strengths rather than focusing only upon remediating weakness. In addition, schools increasingly recognize diversity as a resource rather than a problem in the classroom. In contrast to the remedial and standardized concept of instruction, diversity and individual differences are valued and the learning process is designed to build on the strengths and assets brought by the learner to the classroom. Learning is assessed through task completion: Products and real problem solving of both individual and group efforts. Rather than simply evaluating students through peer and pencil test, assessments are made using portfolios of actual performances and work in both collaborative and individual learning tasks. The traditional view of the learning process is typically teacher-centered, with teachers doing most of the talking and intellectual work, while students are passive reacceptance of the information provided. This is not to indicate that the traditional lecture method is without value, as it allows the teacher to quickly convey lots of information to students.

Within the context, Ukoha and Enoegwe (2011) noted that the traditional ―chalk-talk method‖ where the teacher does all the classroom talking, doing and even thinking is no longer in vogue. Karen (2017) maintained that instructional techniques that are rooted in cognitive psychological learning theories should be adopted.

In summarily, the teaching of battery charging and electric machines in EIMW contents which are the major concern of this study is done through the lecture method in North Central states technical colleges. In this method, the teacher is the expert and the dispenser of knowledge to the students. It is largely a broadcast model of learning where the teachers serve as the repository and transmitter of knowledge to the students. Divers strategies that can be blended to the use of methods according to Karen (2017), and that can provide variety to students, so as to help engage their interest, enhance motivation, and generally increase the teacher's effectiveness are briefly discussed below.

a. The Inductive Teaching Strategy: Inductive teaching begins with the presentation of examples and proceeds in a guided manner to the realization of the point of the lesson. The inductive teaching approach maximizes students' participation. It is a great way to motivate students and get them focused on the goal for instruction. It also provides opportunities for incidental learning.
b. The Deductive Teaching Strategy: Deductive teaching begins with a definition of the concept to be taught and moves toward the examples. The deductive teaching approach is usually a quicker way to teach concepts. However, the trade-off for this efficiency is that not as many students will have opportunities to participate. As a result, the possibilities for incidental learning are minimized.
c. The Cooperative Unit Teaching Strategy: The cooperative unit strategy is an inductive approach that is suitable for teaching generalizations. Additionally, it is ideally suited for research-oriented tasks such as units of study. When using this

strategy, teachers guide students through a series of phases including listing, grouping, labeling, collecting, generalizing, comparing, explaining, and predicting. Upon closure, students may develop a deeper understanding of the generalization that they are studying.

d. The Inquiry Teaching Strategy: This teaching approach is both deductive and inductive in nature. The teacher poses a problem that is purposefully designed to be intriguing and motivating for the learners. Students hypothesize possible solutions to the problem. Then, through a process of researching and questioning, students test their hypotheses. This process continues until a hypothesis that accounts for all of the data is found.

e. Problem solving strategies which is the main thrust of this study.

2.2.7 Concept of Problem-Solving

When two people talk about problem solving, they may not be saying exactly the same thing. The rhetoric of problem solving has been so pervasive in the EIMW education of the 1980s and 1990s that creative speakers and writers can put a twist on whatever topic or activity they have in mind to call it problem solving. What is a problem and what is EIMW problem solving is relative to the individual (James *et al*., 2015). Similarly, Ishyaku (2015) said that to be solving a problem, there must be a goal, a blocking of that goal for the individual, and acceptance of that goal by the individual. They stated that what is a problem for one student may not be a problem for another either because there is no blocking or no acceptance of the goal. Ishyaku situated a problem as having been given the description but do not yet have anything that satisfies that description. Ishyaku described a problem solver as a person perceiving and accepting a goal without an immediate means of reaching the goal. The New Expanded Webster's Dictionary (1988) defined a problem as a question proposed for solution.

To solve a problem is to explain, to make clear, to unravel and to work out. A Problem can also be defined as a puzzle that requires logical thought and a process to solve it. It defined a strategy as the art of planning the best way to achieve something (a solution). It then defined problem solving as the activity of finding solutions to problems, especially in your job or work. According to Chris (2015) problem solving, in any academic area, involves being presented with a situation that requires a resolution. Chris said that being a problem solver requires an ability to come up with a means to resolve the situation fully. James *et al.,* (2015) said that in EIMW, problem solving generally involves being presented with a written-out problem in which the learner has to interpret the problem, devise a method to solve it, follow EIMW procedures to achieve the result and then analyze the result to see if it is an acceptable solution to the problem presented.

Abubakar and Danjuma (2012) defined problem solving as an approach of correlating sense, experience, and already accepted or established thought. Problem solving is defined as formulating new answers, going beyond the simple application of previously learned rules to create a solution. A problem has an initial state (the current situation, a goal) the desired outcome, and a path for reaching the goal. Problem solvers often have to set and reach subgoals as they move toward the final solution (Schunk, 1991). Problem solving is what happens when routine or automatic responses do not fit the current situation. Some psychologists suggest that most human learning involves problem solving (Anderson, 2013). In the same line of thought, Ogbodo (2007) said that problem solving technique comprises the identification and choosing of mathematical problems which grow out of the experiences of individual students, placing these problems before the students and guiding them in their solutions. Ogbodo believes that this definition follows the steps of scientific method as well as those of reflective thinking. The teacher guides the class in solving the mathematical problem as a group. This technique encourages students to arrange and classify facts or data as well as allow students to learn from their successes and failures, since it permits the students to participate in their learning.

McGraw-Hill (1997) said that problems represent gaps between where one is and where one wishes to be, or between what one knows and what one wishes to know. Problem-solving is thus the process of closing these gaps by finding missing information, re-evaluating what is already known or, in some cases, redefining the problem. McGraw-Hill further states that a well-structured problem is a typical situation with a known beginning, a known end, and a well-defined set of intermediate states. Solving a well-structured problem consist of finding an infrequently used path connecting the initial state of the problem with its end state. People solve well-structured problems not by exhaustively searching through the set of possibilities, but rather by heuristically identifying good starting places and productive lines of search. The activity of problem solving often consists of general strategies for linking up one stage with another in the search of a solution. A less powerful, though more general, strategy of a simple sort is referred to by computer scientists as generate-and-test and by psychologists as trial-and- error behaviour. It consists of picking a possible answer, trying it out, and if it does not work, trying another. Means-ends analysis and trial-and-error behaviour can require large amounts of time to complete, if the problem is complex, or may not lead to a solution at all in a practical amount of time. They have been successful in mathematical games and relatively simple problem-solving tasks. The activity of problem solving involves the use of problem-specific and knowledge-intensive methods and techniques, which are often referred to as heuristics. These heuristics are acquired through experience and represent the basis for expertise in a specific domain of problem-solving tasks such as physics, Technology or medicine (McGraw-Hill, 1997).

If the necessary problem-solving steps are known ahead of time, problem solving consists of the right steps to apply at the right time. If some of the problem-solving steps are not known, then the problem solving process requires creating or inventing new ways to convert one state of a task into another. Study of novices and experts observed when solving textbook problems through the technique of protocol analysis has identified two (2) types of problem solving steps: - representing the problem situation, and applying principles to the problem representation in order to generate a solution. Representation involves translating the problem statement into a standard form that is accessible by EIMW principles. Once a representation has been created, problem solving proceeds by finding mathematical principles that will generate a solution. In order to be applied efficiently either singly or in combinations, principles of EIMW need to be selected in such a way that they fit the assumptions and data of a given problem. Problem solving sometimes fail because relevant principles are either not known or have not been learned. Sometimes, mathematical complexities often make heuristics difficult to carry out. One such heuristic involves describing asymptotic behaviour of a system. Another heuristic is to specify a property of the system, such as energy or momentum, which is invariant over time. The power of heuristics as problem solving tools is derived from their development in the successful solution of particular types of problem and requires the expenditure of mental effort (McGraw-Hill, 1997). This study recommends the psychological view of problem solving because it consists of finding the right steps to apply at the right time or the creation/invention of new ways to convert one state of a task into another. That is, the representation of the problem situation and application of mathematical principles in order to generate a solution.

2.3 Review of Empirical Studies

Bawa (2011) carried out a research on the effects of problem solving instructional strategy on academic achievement and retention in ecology among secondary school students with different cognitive preferences in Zaria educational zone. A randomly selected sample of 240 students constituted the subjects for the study. A randomly selected sample of one hundred and twenty students who constituted the experimental group were taught using Problem Solving Instructional Strategy, while the remaining 120 students that constituted the control group were taught using the lecture method Instructional Strategy (LMIS). Two Secondary Schools served as the experimental group, while the other two served as the control group respectively. The study adopted the quasi experimental control group pretest-post-posttest design. Two instruments were used in this study for data collection, namely, the Cognitive Preference Test (CPT), and Ecology Achievement Test (EAT) in Ecology. The CPT was adopted from Heath (1964), while the (EAT) was developed by the researcher. A pretest was administered before the treatment to establish the equivalence of the experimental and control groups using Problem Solving Instructional Strategy (PSIS), while the control group was exposed to the Lecture Method Instructional Strategy (LMIS). Seven null hypotheses were subjected to statistical analyses involving the use of t-test, ANOVA on Achievement and Retention. ANOVA was used to test for the difference in the level of significance in the mean scores of the experimental groups of Recall, Application, Principles and Questioning in favour of the experimental groups in these fields. The findings of the study showed among others that there was significant difference between the posttest mean scores of the experimental and control group of recall variable in favour of the experimental group. Significant differences exist between the posttest mean scores of the experimental and control groups in Application variables in favour of the experimental group. There was significant difference] between the posttest mean scores of the experimental and control groups in principles, in favour of the experimental group. Posttest mean scores of the experimental and control groups in principles variable were statistically different in favour of the experimental group. Posttest mean scores of the experimental and control groups in Questioning variable were also statistically different in favour of the experimental group. The posttest mean scores of the experimental and control groups were found to be statistically significant in favour of the experimental group in Retention of the ecology concepts. Seven recommendations were made in the study, one of which was that the study of ecology results in the accruing of many benefits to mankind; therefore, the study of ecology is viewed to be very important in Secondary Schools. It was therefore suggested that a wider coverage, patronage and publicity should be accorded the study of Ecology in the school curriculum syllabus, and all facets of human endeavour.

The study was carried out to investigate the effects of Problem Solving Instructional Strategy on Academic Achievement and Retention in Ecology among Senior Secondary School students with different cognitive preferences four Senior Secondary Schools in Zaria Education Zone, comprising Zaria and Sabon Gari areas of Kaduna State while the present study is concerned with the differential effects of Rusbult's and Glencoe's problem solving strategies in EIMW in North Central Nigeria and is limited to EIMW content areas students mostly perform poorly which are battery charging and electric machines. The study adopted the quasi experimental control group pretest-post-posttest design, while the present study adopted the factorial research design will be used for this study. The two studies are related in terms of methodology employed in the conduct of the study. This is because both involves the use of pre-test and post- test.

Jacobson *et al.,* (2011) assessed the effects of Problem Solving Instructional Strategies on Students' Achievement and Retention in Chemistry with Respect to Location in Rivers State. A pre-test, post-test, non-equivalent control group design was adopted. Two research questions and two hypotheses were respectively answered and tested. Purposive and stratified random sampling was used to select 428 SS II students from two rural and two urban local government areas of Rivers State. These students were randomly assigned to the two treatment groups. Problem solving with Model and Feedback – Correctives (PF), Problem solving with Model Only (PM), and the control Problem Solving by the Conventional Method (PC). A researcher developed and modified instrument, Chemistry Achievement Test (CAT) and lesson plans were used for the study. Data collected were analyzed using Mean, Standard Deviation (SD) and some gains of achievement and retention and that the hierarchical order of achievement is PF, PM and PC. No significant differences were observed in the post-test mean scores of urban and rural subjects in the achievement is PF, PM and PC. No significant differences were observed in the post-test mean scores of urban and rural subjects in the achievement and retention tests administered in the course of the study. Based on the findings, it is recommended that both rural and urban Chemistry teachers use problem solving instructional strategies, particularly that in which use of a model is supplemented with feedback-correctives in teaching.

The relationship between the reviewed study and the present study is that both studies are involved in the use of problem solving strategies to enhance students learning outcome. However, while the reviewed study focused on the Secondary School Chemistry students in River State, the present study is on Technical Colleges EIMW students in North Central States in Nigeria. Furthermore, the two studies are the same in terms of research methodology. The pre-test, post-test, non-equivalent control group design was adopted for both study. The review study focus on student achievement and retention student in Chemistry with Respect to Location in Rivers state while the present study is on achievement and interest of student in EIMW in North Central Nigeria.

Nekang, (2011). Conducted a study on Differential Effects of Reda's and Rusbult's Problem-Solving Strategies on Male and Female Students' Achievement and Interest in Trigonometry in Cameroon. The study investigated the differential effects of Rusbult's Problem Solving Strategy (RUPSS) and Reda's Problem Solving Strategy (REPSS) on male and female secondary school students' achievement and interest in trigonometry in Fako Division in Cameroon. The target population of the study was all the two thousand five hundred and seventy-six (2576) form four (F4) students for the 2008/2009 academic year from all the 52 colleges in the division. A total of 366 form four students consisting of 186 males and 180 females were drawn from three colleges in the division by purposive and simple random sampling techniques. The instruments used for data collection are Trigonometry Achievement Test (TAT) and a Trigonometry Interest Inventory (TII). The internal consistency reliability coefficient of TAT scores was estimated at .77 using Cronbach Alpha (α) formula since the test consisted of essay type questions. The internal consistency reliability coefficient of TII scores was estimated at .62 using Cronbach Alpha (α) formula since the test consisted of continuously scored items. Two lessons, one on teaching trigonometry via Rusbult's Problem-Solving Strategy (RUPSS) and another lesson on teaching trigonometry via Reda's Problem-Solving Strategy (REPSS) were used for the study which lasted for three weeks, Mean scores and standard deviations were used for analyzing data to provide answers for the eleven research questions. The hypotheses were tested at .05 level of significance using z-test and a two-way (2 x 2) Analysis of Covariance (ANCOVA). The findings showed that: Students exposed to the REPSS achieved higher than those exposed to the Conventional Problem Solving Strategy (CPSS); Students exposed to the RUPSS achieved higher than those exposed to CPSS; Students exposed to the REPSS and RUPSS showed greater interest than those exposed to CPSS; Males in the REPSS obtained a higher POSTTAT mean score compared to their female counterparts while males in the RUPSS obtained a higher POSTTAT mean score compared to their female counterparts; based on strategies, REPSS produced a greater students' achievement on trigonometry than the RUPSS which in turn produced a greater students' achievement than the CPSS i.e. REPSS> RUPSS> CPSS but based on gender, Male RUPSS > Male REPSS > Female REPSS > Female RUPSS > Male CPSS > Female CPSS. The study thus recommends the teaching/learning of trigonometry via problem-solving strategies. Authors and textbook writers should apply and provide proper illustration of problem-solving strategies in different areas of trigonometry and mathematics; Seminars and in-service programs should be organized by all mathematics associations, examination boards, the delegations of education and the pedagogic offices for teachers in the field to be acquainted with the teaching of trigonometry via problem-solving strategies.

The review study investigated the differential effects of Rusbult's Problem Solving Strategy (RUPSS) and Reda's Problem Solving Strategy (REPSS) on male and female secondary school students' achievement and interest in trigonometry in Fako Division in Cameroon, while the present study is concerned with the differential effects of Rusbult's and Glencoe's problem solving strategies in EIMW in North Central Nigeria. The quasi-experimental design with a non-equivalent comparison group consisting of pre-and post-test measures was utilized in the study, while the present study adopted the factorial research design and will be carried out North Central states of Nigeria.

The two study use pre-test and post-test and also achievement test. Nekang's (2011) study is related to the present study in the sense that it has to do with the comparative effects of two problem-solving model. Gender was involved in the reviewed study while gender will not be considered in the presented study. The study is at variance with the present study because, reviewed study used, Reda and Rusbult problem-solving strategies whereas the present study is on Glencoe and Rusbult problem solving strategies. Secondly, the study was carried out in Cameroon, while the present study will be carried out in Nigeria. The reviewed study was conducted in Mathematics in secondary schools while the present study was carried out using EIMW students in the technical colleges.

Similarly, Shodeinde, (2013) conducted a study on the effect of cognitive mind mapping on the achievement of electrical and electronic trades students in technical colleges in Ogun state. This study was designed to determine the effect of mind mapping on students' achievement in abstract contents of electrical and electronic trades in technical colleges. The study adopted the quasi-experimental research design, precisely, pretest, posttest non-equivalent control group design which involved groups of students in their intact classes. A sample of 193 Electrical and Electronic Trades Year II students drawn by multistage sampling technique, from a population of 354, in eight technical colleges in Ogun State was used for the study. Four research questions and four null hypotheses tested at 0.05 level of significance guided the study. Electrical/Electronic Achievement Test (EEAT) is the instrument used for data collection. The EEAT and lesson plans for both control and experimental groups were all validated by three experts. The reliability coefficient of the instrument was computed using KR-20 and found to be 0.81. Mean was used to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses. The study revealed that mind mapping instructional strategy was superior to the conventional method in enhancing student achievement in abstract contents. It also discovered that gender grouping did not contribute significantly to variance in students' achievement score, thus the effectiveness of mind mapping does not depend on gender. After pointing out some educational implications of the findings, it was thereafter recommended that mind mapping should be adopted in teaching abstract contents of Electrical and Electronic Trades in technical colleges, among others.

This study determines the effect of mind mapping on students' achievement in abstract contents of electrical and electronic trades in technical colleges. The study adopted the quasi-experimental research design, while the present study is concerned with the differential effects of Rusbult's and Glencoe's problem solving strategies in EIMW in North Central Nigeria and it will adopt the factorial research design. Pretest, posttest non-equivalent control group design which involved groups of students in their intact classes were used for both study, all in technical colleges but the study was particularly on electrical electronic while present study on electrical installation and maintenance work. The study is related to the present study in the sense that it has to do with the effects of instructional strategy on students achievement in Electrical/Electronic Engineering trades in Technical Colleges while present study is on EIMW. Secondly, the researchers adopted quasi experimental design and used the KR-20 reliability tools for calculating the reliability coefficient of the instrument. The study is at variance with the present study because, the reviewed study was carried out in Ogun State while the present study will be carried out in North Central States.

Nwoke (2015) conducted a study on the impact of Problem-Solving Approach on Senior Secondary School Students' Achievement in Mathematics. The study is carried out in

Owerri North local government area of Imo State. Based on the objectives of the study two research questions and two hypotheses guided the study. Quasi-experimental research method was applied in carrying out the study employing the pre-test post-test control type. A sample of 155 students was selected for the study from two purposively selected schools. 25 item researcher made objective test question entitled "Mathematics Achievement Test" (MAT) with reliability co-efficient of 0.73 determined through Kuder- Richardson method (KR20) was used in data collection. The data were analysed using mean and standard deviation to answer research questions while the hypotheses were tested using t-test statistical tool. The result of the study reveals that problem solving approach of teaching mathematics enhanced students achievement. Based on the findings, it is recommended that appropriate problem-solving approach should be applied by mathematics teachers in teaching so as to enhance students' achievement in the subject.

This study is similar to the present study in instructional approaches adopted, methodology. The reviewed study focused only on achievement of student while the present study is on achievement, retention and interest of students. The reviewed study was carried out on secondary school Mathematics students in Oweri, Imo State while the present study will be conduct in Technical college EIMW students in North Central zone of Nigeria. Furthermore, the study adopted t-test statistics to test the hypotheses while the present study will use Analysis Covariance (ANCOVA) to test the hypotheses formulated. The review study adopted the Quasi-experimental research method was applied in carrying out the study, both study use the pre-test post-test control type and the present study adopted the factorial research design.

Olaniyan and Mosewo, (2015). conducted a study on Effects of a Target-Task Problem-Solving Model on Senior Secondary School Students' Performance in Physics. The study investigated the Effects of a Target-Task Problem-Solving Model on Senior Secondary School Students' Performance in Physics. The research design was a quasi-experimental, non-randomized, non-equivalent pre-test, post-test using a control group. The study was conducted in two schools purposively selected and involved a total of 120 Senior Secondary School II students, 60 students per school. The experimental group was exposed to the Target-Task Problem-Solving Model while for the control group lecture method was used. The experimental and control groups were pre-tested in the first week of the research after which the treatment was applied and post-testing took place in the sixth week using a performance test on Current Electricity (PTCE). The data collected were analyzed using mean, standard deviation and analysis of covariance (ANCOVA), and the hypotheses put forward tested at an alpha level of 0.05. The study revealed that the Target-Task Problem-Solving Model enhanced performance of low scoring level male students. Other findings, implications, recommendations and suggestions for further studies were explored.

The reviewed study is related to the present study in the sense that it has to do with the effects of problem solving strategies on student performance. Secondly, the researchers used adopted quasi experimental design and ANCOVA to test the hypotheses while the factorial research design was used for the present study, a similar way it be used in the present study. The study is at variance with the present study because, the reviewed study was carried out on Biology students in secondary schools inn Enugu state, whereas the present study is on EIMW students in Technical Colleges in North central states of Nigeria.

Kurumeh*et al.,* (2016) carried out a study on enhancing Senior Secondary School Students' Achievement in Geometry through the Utilization of Rusbult Problem Solving Model in Keffi Metropolis, Nasarawa State, Nigeria. The study explored the effects of

Rusbult problem solving model on students' achievement in Geometry. To guide the study, two research questions and two hypotheses were generated. The design for the study was quasi-experimental design. The instrument for the study was the Geometry Achievement Test (GAT), which had reliability coefficient of 0.91. Multi-stage sampling technique was used to select a sample of 84, made up of 45 males and 39 females, from Keffi metropolis. The responses of the subjects to the instrument were scored and analyzed using mean, standard deviation and the Analysis of Covariance. The results of the data analysis indicated that there was a significant difference in the mean achievement scores of students in the experimental group and control group in favour of the experimental group who were taught geometry using Rusbult Problem Solving Model (RPSM). The result however showed that there was no significant difference in the mean achievement scores in geometry between male and female students exposed to RPSM.

The study concluded that achievement of students can be improved upon in geometry by teaching them using RPSM. It was, among others recommended that students should be taught geometry using RPSM in order to improve their achievement.

The relationship between the reviewed study and the present study is that both studies are concerned with use of problem solving strategies to enhance students' achievement. The methodology and statistical tools used for analysis are the same However, while the reviewed study focused on Geometry in Mathematics, the present study will focus on EIMW in Technical Colleges in North Central zone of Nigeria. The design for the study was quasi-experimental design while the present study used factorial research design.

Nwaodo (2016) determined the relative Effectiveness of Reda and Rubult Problem Solving Models on Metal Work Students' Academic Achievement, Interest and

Retention in Technical Colleges in Enugu State, Nigeria. This study was designed to determine the effect of two models of problem solving on technical college students' academic achievement, interest and retention in metalwork. The study adopted the quasi-experimental research design, precisely, pre-test, post-test nonequivalent control group design. The population for the study was 210 National Technical Certificate (NTC II) metalwork students (175 males and 35 females) in Technical Colleges. Six research questions and six hypotheses tested at 0.05 level of significance guided the study. The instrument used for data collection were Metalwork Cognitive Achievement Test (MWCAT) and Metalwork Interest Inventory (MWTII).

The Reda's and Rusbult's models lesson plans were used to teach the students, Data obtained from the administration of the instrument was analyzed using mean to answer the six research questions and Analysis of Covariance (ANCOVA) statistic was used to test the six hypotheses. The study revealed that Reda's model is more effective in improving students achievement in metalwork than Rusbult's model. It was also discovered that Reda's and Rusbult's model are effective in stimulating students interest but that Reda's model improves retention of learnt knowledge than the Rusbult's model in metalwork. There was no significant effect of gender on students' achievement, interest and retention in metalwork. It was recommended that Ministry of Education, National Business and Technical Examination

The review study focused on the relative Effectiveness of Reda and Rubult's Problem Solving Models on Metal Work Students' Academic Achievement, Interest and Retention in Technical Colleges in Enugu State, Nigeria while the present study is concerned with the differential effects of Rusbult's and Glencoe's problem solving strategies in EIMW in North Central Nigeria. The study was carried out in Enugu state and the study was limited only to metal work students Academic Achievement, Interest and Retention in Technical Colleges in Enugu state, while the present study was carried out North Central states of Nigeria and is limited to EIMW content areas students mostly perform poorly which are battery charging and electric machines. The study adopted the quasi-experimental research design, precisely, pre-test, post-test nonequivalent control group design while the present study adopted the factorial research design will be used for this study. However, the two study differs in terms of subject area covered and geographical area of study.

Ogbuanya and Akinduro (2017) investigated the effect of Floating Facilitator and Peer Tutor Instructional Approach on Students' Psychomotor Achievement in Electrical Installation and Maintenance in Technical Colleges in Ondo State, the design used was quasi-experimental design. Purposive sampling technique was used to select 171 students from four technical colleges. Two technical colleges each were randomly selected to peer tutor as group A and the other two colleges to floating facilitator as group B. The instrument used for data collection was Electrical installation and maintenance Psychomotor Test (EPT). The treatment group A used the peer tutor approach while treatment group B used the floating facilitator approach. The treatment lasted for six weeks for the groups concurrently each topic covering two weeks. The data obtained were analyzed descriptively and inferentially. The mean and standard deviation were used to answer the research questions while all the null hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA) statistics and partial eta square for the effect size. The results obtained showed that peer tutor approach had a significant effect on students psychomotor achievement compared to floating facilitator approach.

There was a significant influence of gender on the psychomotor achievement of male and female students also, there was a significant influence in ability level of students in their psychomotor achievement, from the post hoc test, the significance lies between the average and low ability level. These findings imply among others that given a conducive learning environment provided through the use of peer tutor approach, the psychomotor achievement of students will be greatly improved. Based on the findings of this study, some recommendations and suggestions for further research were made. The relationship between the reviewed study and the present study is that both studies are concerned with testing the effectiveness of two instructional strategies on performance of students in EIMW and quasi experimental design was also adopted. The two studies are similar in method of data analysis However, while the reviewed study focused on psychomotor achievement, the present study focus on cognitive achievement and interest of the study.

The reviewed study was conducted in Ondo State while the present study will conducted in North Central States of Nigeria. The present study is concerned with the differential effects of Rusbult's and Glencoe's problem solving strategies in EIMW in North Central Nigeria. This study attempted to investigate the effect of RUPSS and GPSS on technical college students' achievement, retention and interest in EIMW, the present study will determine the effect of the problem solving on students EIMW. The related study investigated the effect of Floating Facilitator and Peer Tutor Instructional Approach on Students' Psychomotor Achievement in Electrical Installation and Maintenance in Technical Colleges in Ondo State, The design used was quasi-experimental design and the study was influence of gender on the psychomotor achievement of male and female students, while the present study will be carried out North Central states of Nigeria and is limited to EIMW content areas students mostly perform poorly which are battery charging and electric machines. The study adopted the quasi-experimental research design, precisely, pre-test, post-test nonequivalent control group design while the present study adopted the factorial research design for this study.

Mandina and Ochonogor (2018) investigated the Comparative Effect of Two Problem-solving Instructional Strategies on Students' Achievement in Stoichiometry in Zimbabwe. The study compares the effects of problem-solving instructional strategies on Advanced Level students' achievement in Stoichiometry. The quasi-experimental design with a non-equivalent comparison group consisting of pre-and post-test measures was utilized in the study. The participants were 525 Advanced level chemistry learners drawn from 8 high schools from Gweru district. Data were collected using standardized achievement Tests in stoichiometry. The problem-solving instruction was implemented in four experimental schools while the remaining four control schools were taught using the conventional lecture method. Analysis of Covariance (ANCOVA) was used to analyze data. The findings indicated a statistical significant difference in the performance of students taught using the two problem-solving strategies and those taught using the conventional method. The Scheffe's post- hoc test indicated that students taught using the problem-solving instructional strategy performed significantly better than those taught with the Selvaratnam and Fraser problem-solving strategy. Furthermore, it was also found that the performance of students in the experimental group was not influenced by gender. Chemistry teachers are therefore strongly recommended to use problem-solving instructional strategies in their classes to improve the abilities of learners in solving stoichiometry problems.

The review study was carried out to investigated the Comparative Effect of Two Problem-solving Instructional Strategies on Students' Achievement in Stoichiometry, the study compare the effects of Selvaratnam, and Fraser and Ashmore problem-solving instructional strategies on Advanced Level students' achievement in Stoichiometry in

Zimbabwe while the present study is concerned with the differential effects of Rusbult's and Glencoe's problem solving strategies in EIMW in North Central Nigeria. The quasi-experimental design with a non-equivalent comparison group consisting of pre-and post-test measures was utilized in the study, while the present study uses the factorial research design and will be carried out North Central states of Nigeria and is limited to EIMW content areas students mostly perform poorly which are battery charging and electric machines. Mandina and Ochonogor's study is related to the present study in the sense that it has to do with the comparative effects of two problem-solving model. Secondly, the design was quasi experimental design. The study is at variance with the present study because, reviewed study used, problem-solving strategies whereas the present study Glencoe and Rusbult problem solving strategies. Secondly, the study was carried out in Zimbabwe, while the present study will be carried out in Nigeria.

Shadreck (2018) Investigated the use of structured problem-solving strategies to improve the teaching and learning of chemistry in Zimbabwe. The study aimed to investigate effect of structured problem -solving instructional strategies on Advanced Level chemistry learners' achievement in stoichiometry and ionic equilibria. The population of the study consisted of Advanced Level Chemistry learners from 15 high schools in Gweru urban District of the Midlands province in Zimbabwe. Using convenience sampling techniques 8 high schools with n=525 Advanced level Chemistry learners and 8 teachers participated in the study. Four schools formed the experimental group (n=250) and the other four school formed the control group (n=275). The study employed a quasi-experimental design with a non-equivalent control group approach consisting of pre-and post-test measures. Intact classes participated in the study as it was not possible to randomly select participants for the study. The qualitative part of the study involved conducting semi structured interviews with teachers, focus group discussions with learners as well as classroom observations. The quantitative data were collected using standardized achievement tests in stoichiometry and ionic equilibria.

The problem-solving instruction was implemented in four experimental schools by the respective chemistry teachers who had been trained as research assistants on the use of the problem-solving strategies in chemistry teaching. Analysis of Covariance (ANCOVA) was used to analyze data. The results of this study indicated that the participants in experimental schools performed significantly better than participants in control schools on certain aspects of problem solving performance. Furthermore, semi-structured interviews, focus group discussions and classroom observations revealed that participants rated problem-solving instruction highly as an effective teaching strategy to enhance the problem solving skills of learners in A' level chemistry. The Scheffe's post hoc test indicated that students taught using the Ashmore et al problem-solving instructional strategy performed better than those taught with the Selvaratnam-Fraser problem-solving strategy.

The study also revealed that student had difficulties with the mole concept, Avogadro's number, limiting reagents as well as determining theoretical and percentage yields. Students were also found to have difficulties with acid-base theory, buffer solutions, and application of Le Chatelier's principle in solving buffer equilibria problems and solubility equilibria. Furthermore, the study revealed that students rely on algorithmic strategies when solving stoichiometry and ionic equilibria problems and do not demonstrate adequate understanding of the concepts involved. It is therefore strongly recommended that chemistry teachers use problem-solving instructional strategies in their classes to facilitate students' problem-solving performance. In addition, pre-service chemistry teachers should be properly trained in instruction that promotes problem solving and how to implement effective problem-solving instruction.

Furthermore, in-service training for practicing chemistry teachers is recommended so that they can embrace the skills of the problem-solving strategies for effective implementation of the strategies in teaching chemistry.

The relationship between the reviewed study and the present study is that both studies are concerned with use of problem solving strategies to enhance students' achievement. The methodology and statistical tools used for analysis are the same. However, while the reviewed study focused on determining the effects of problem solving strategies on students achievement in chemistry, the present study will focus on achievement and interest of students in EIMW. The reviewed study was carried out in Zimbabwe, while the present study will be carried out in North Central states of Nigeria. The present study is concerned with the differential effects of Rusbult's and Glencoe's problem solving strategies in EIMW in North Central Nigeria. The related study Investigated the use of structured problem-solving strategies to improve the teaching and learning of chemistry in Zimbabwe and the study was limited to the effect of structured problem - solving instructional strategies on Advanced Level chemistry learners' achievement in stoichiometry and ionic equilibria, while the present study was carried out North Central states of Nigeria and is limited to EIMW content areas students mostly perform poorly which are battery charging and electric machines. The study adopted the quasi-experimental research design while the present study adopted the factorial research design.

In addition, Akinwumi *et al.,* (2018). conducted a study on the effect of Problem-Solving Teaching approach on Students'. Academic Performance in Biology in Senior Secondary School. This study investigated effects of problem-solving teaching approach on students' academic performance in Biology in senior secondary school. The design for this study was a two-group Pretest-Posttest Quasi-Experimental. The population for the study was all the senior Nigeria. The sample comprised of sixty (60) senior secondary class two students selected from two senior secondary schools in the Ikere Local Government Area of Ekiti State. Three null hypotheses were formulated and tested at 0.05 level of significance to guide the study. The instrument for data collection was twenty (30) standardized objective questions tagged:‘ Biology Achievement Test (BAT)’. The data collected were analyzed using t-test statistical analysis. The findings showed that students taught using the Problem–Solving teaching strategy performed significantly better than their counterparts taught using the conventional method. Also no significant difference existed between male and female students in the experimental group. Based on the findings of the study, conclusion and recommendations were made.

The reviewed study is related to the present study in areas of instructional strategies for enhancing students’ learning. More so, both studies involved the use of quasi experimental design and method of data collection. The study under review used t-test for data analysis while the present study adopted ANCOVA for data analysis. The reviewed study was carried out in Ekiti state using Biology students in Secondary school while the present study will be conducted using EIMW student in technical college in North Central states of Nigeria. The present study is concerned with the differential effects of Rusbult’s and Glencoe’s problem solving strategies in EIMW in North Central Nigeria.

This study attempted to investigate the effect of RUPSS and GPSS on technical college students’ achievement and interest in EIMW, the present study will determine the effect of the problem solving on students in EIMW. The related study conducted a study on the effect of Problem-Solving Teaching approach on Students’. Academic Performance in Biology in Senior Secondary School. This study was limited to the effects of problem-solving teaching approach on students’ academic performance in Biology in senior secondary school. The design for this study was a two group Pretest-Posttest Quasi-Experimental, while the present study was carried out North Central states of Nigeria and is limited to EIMW content areas students mostly perform poorly which are battery charging and electric machines and the present study adopted the factorial research design.

In a similar vein Ogumah et al (2019) conducted a research on the effect of guided inquiry teaching method on students academic performance in Electrical installation and maintenance work in technical colleges in Gombe State. Two research questions and two null hypotheses guided the study. The hypotheses were tested at 0.05 level of significance. Quasi-experimental design was adopted for the study. The samples for the study were 118 NTC2 students made up of 95 males and 23 females. Purposive sampling technique was used to select two schools from Gombe and Yamaltu Deba Educational zones. The instruments used for data collection were 50 objective questions. Pearson correlation coefficient formula was used to establish the reliability of the instrument which yielded 0.81correlation coefficient. The research questions were answered using mean scores whereas the hypotheses were tested using ANCOVA. The result showed that guided inquiry significantly impacted on the academic performance of the students. It also showed that the effect of guided inquiry on academic performance was not significant in relation to gender. In view of the findings, it was recommended among others that guided inquiry should be adopted in technical colleges, secondary schools and Vocational schools for instruction in EIMW to improve academic performance of the students.

The study is related to the present study on the use of instructional strategies for enhancing students' achievement in EIMW, though the instructional method guided inquiry while the present study is on problem solving strategies. The reviewed study also adopted quasi experimental design while factorial research design will be use for the present study. However, the reviewed study is concerned with the achievement of male and female students in Gombe State, while the academic achievement and interest of students of EIMW in North Central will be considered in the present study. The present study is concerned with the differential effects of Rusbult's and Glencoe's problem solving strategies in EIMW in North Central Nigeria. The present study will determine the effect of the problem solving on students in EIMEW, while gender was not part of the reviewed study. The study was on the effect of guided inquiry teaching method on students academic performance in Electrical installation and maintenance work in technical colleges in Gombe State and the study was limited to the effect of gender on academic performance of EIMW students, while the present study will be carried out North Central states of Nigeria and is limited to EIMW content areas students mostly perform poorly which are battery charging and electric machines. The study adopted the quasi-experimental research design, precisely, pre-test, post-test nonequivalent control group design while the present study adopted the factorial research design was used for this study.

2.5 Summary of Literature Reviewed

A review of literature showed that students do commit errors in problem-solving while carrying out their studies. Several variables, mainly teacher characteristics, also affected students when learning EIMW. Some of these factors include the lack of commitment, insufficient and unqualified staff and the teaching methods as the major problems associated with under-achievement in EIMW in North-Central States of Nigeria. Many teachers use strategies that are only known to them even if they are not appropriate to the concepts under study. Strategies for problem-solving suggest that problem solvers should keep sub-problems and the overall problem in mind at the same time and make smooth transition between the problem solving sub-units. Problem solving as a framework presented the linear, cyclic and scientific approaches. The researcher apprehended to the importance of considering problem solving at both the lower and higher cognitive levels and that a variety of problems should be solved in class and others given to students for practice and evaluation. The evaluation of problem solving revealed that the holistic approach, thinking aloud, interviews, students self-reports and the use of hints are the recommended problem-solving evaluation strategies. Theories and models which relate to the study were also reviewed. Under empirical studies, a review of some concepts such as electrical installation and maintenance work in technical colleges, technical colleges in Nigeria, academic achievement issues in technical education, interest and its measurement in vocational subjects, strategies of teaching in electrical installation and maintenance work trades in technical colleges,

Finally, the need for change of methodology, and concepts of problem-solving were reviewed. Considering the literature reviewed the teaching and learning of EIW remains a matter that needs to be tackled from all its ramifications. The methods and strategies employed to teach difficult topics like EIW in North Central need to be given serious attention. Although literatures review by researchers reveal that no research has been carried out on problem-solving involving on students achievement and interest in EIMW in technical colleges Nigeria but results have been found to be contradictory and inconclusive. Furthermore, the learning of EIMW especially in the area of battery charging like cells types, working principles of cells, construction of cells, materials to be used for cells constructions, equipments, methods, tools used for charging of batteries, detects cells faults, repairs and maintenance and replacements of cells and among others and also in areas of electric machines contents to be covered includes principles and operation of electric machines, types, maintenance, applications and construction of electric machines, lubrication grades and their applications, operation and testing of electric machines, troubleshooting techniques, tools and equipments use for diagnosing faulty electric machines among others has not been covered using Glencoe's and Rusbult's problem-solving strategies and there is no literature known to the researcher on effect of Glencoe's and Rusbult's problem-solving strategies on achievement and interest of EIMW in Technical Colleges in North-Central Nigeria. This gap in knowledge has brought about the present study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Design of the Study

A factorial research design was used in this study. Specifically, the pretest, posttest, non-equivalent control group design was adopted for the study. According to Gall *et al.,* (2017) Factorial design involves having more than one independent variable, or factor, in a study. Factorial designs allow researchers to look at how multiple factors affect a dependent variable, both independently and together. Factorial designs are a form of true experiment, where multiple factors (the researcher-controlled independent variables) are manipulated or allowed to vary, it allows researchers to examine the main effects of two or more individual independent variables simultaneously and researchers to detect interactions among variables. This design was considered suitable to conduct this study because intact classes (non-randomized groups) were used. The intact classes were assigned to the two different strategies of Problem-solving (Glencoe's problem-solving strategies and Rusbult's problem-solving strategies) in order to determine the effects of the problem-solving strategies on achievement and interest of EIMW students in Technical Colleges. The design is represented below.

Table 1: Factorial Design Groups Assigned to the two conditions

Ability Level	Types of Instruction	Dependent Variables		
Group 1 Low ability scores	Rusbult	Posttest score on cognitive achievement	Posttest score on skills achievement	Posttest score on interest
Group 2 medium ability scores	Rusbult	Posttest score on cognitive achievement	Posttest score on skills achievement	Posttest score on interest
Group 3 high ability scores	Rusbult	Posttest score on cognitive achievement	Posttest score on skills achievement	Posttest score on interest
Group 4 Low ability	Glencoe	Posttest score on cognitive	Posttest score on skills	Posttest score on interest

scores		achievement	achievement	
Group 5 medium ability scores	Glencoe	Posttest score on cognitive achievement	Posttest score on skills achievement	Posttest score on interest
Group 6 high ability scores	Glencoe	Posttest score on cognitive achievement	Posttest score on skills achievement	Posttest score on interest

Furthermore, in the analysis, 2×3 factorial design was adopted to present the treatments (Glencoe's problem-solving strategies and Rusbult's problem-solving strategies) at two levels of ability (low, medium and high) at three levels. Hence, the research has been able to assess the effect of the main independent variables (Glencoe's problem-solving strategy and Rusbult's problem-solving strategy) as well as the effects of moderator variable (Ability levels- low, medium and high) on cognitive achievement, skill achievement and interest of Technical College students in Electrical Installation and Maintenance Work Trade.

Group A: O1 X1 O2,

Group B: O1 X2 O2,

Where; O1 represents pretests scores

O2 represents posttests scores

X1 - Glencoe's problem-solving strategies treatment

X2 - Rusbult's problem-solving strategies treatment

3.2 Area of the Study

This study was conducted in the North-central geo-political zone of Nigeria. The North-central geo-political zone of Nigeria is comprised of: Benue, Nasarawa, Niger, Kogi, Kwara, Plateau and the Federal Capital Territory (FCT)-Abuja. The study was conducted in the North-Central geo-political zone. North-Central region of Nigeria also commonly called the Middle Belt with geographical area covering 242,425 Km^2 located between the latitudes of $6^0$431N to $6^0$451E and $6^0$601N to $6^0$801E. The zone comprises of six states which are Kwara, Niger, Nassarawa, Plateau, Benue and Kogi State and the Federal Capital Territory (FCT) Abuja (Ibikunle *et al.*, 2017). According to the 2018 NBS estimates, the North-Central geopolitical zone had **29,252,408** people. In the zone, Benue had 5,741,815, Kogi had 4,473,490, Kwara's population was 3,192,893, Nasarawa recorded 2,523,395 people, Niger's population was 5,556,247, Plateau had 4,200,442 while the Federal Capital Territory (FCT) had 3,564,126. Since in these areas there is an increasing demand for battery charging, winding of electrical machines and installation of generators and motors. leading to the need for the services of well-trained EIMW craftsmen.

3.3 Population of the Study

The population for this study comprised of 1013 NTC II students of EIMW in the 29 technical colleges in North-central geo-political zone of Nigeria. NTC II students was used for the study because of the nature of NBTE curriculum for technical colleges which provides that the topics on battery charging and electrical machines are taught in the second year of EIMW trade. The population data were obtained from the 2020/2021 session of students register in the Head of Department's (HOD's) office in each of the technical colleges. Appendix H shows the population distribution of the Colleges

3.4 Sample and Sampling Techniques

A two-stage simple random sampling technique and purposive sampling technique was used in the study. In the first stage, the simple random sampling technique was used to select 12 technical colleges from the list of 29 in the geo-political zone. The Technical Colleges are shown in the table below:

Table 2: List of Technical Colleges in North-Central Zone of Nigeria

S/N	Names of Technical Colleges	Number of Students
1	Government Technical College, Markudi students	45
2	Federal Science Technical College, Otukpo	38
3	Government Technical College, Ankpa	41
4	Government Technical College, Mopa	31
5	Government Technical College, Ilorin	30
6	Government Technical College, Pategi	34
7	Government Technical College, Mada Station	33
8	Government Technical College, Akwanga	35
9	Government Technical College, Minna	40
10	Federal Science and Technical College, Shiroro	32
11	Government Science and Technical College, Garki	35
12	Federal Science and Technical College, Orozo	36

Table 3: List of Technical Colleges in GPSS treatment Group

S/N	GPSS Group	Number of Students
1	Federal Science Technical College, Otukpo	38
2	Government Technical College, Ankpa	41
3	Government Technical College, Ilorin (30 students	30
4	Federal Science and Technical College, Shiroro	32
5	Government Technical College, Mada Station	33
6	Government Science and Technical College, Garki	35

Table 4: List of Technical Colleges in RPSS treatment Group

S/N	RPSS Group	Number of Students
1	Government Technical College, Markudi	45
2	Government Technical College, Mopa	31
3	Government Technical College, Pategi	34
4	Government Technical College, Akwanga	35
5	Government Technical College, Minna	40
6	Federal Science and Technical College, Orozo	36

The sample size for this study was 430 NTC II EIMW students (See Appendix M). In the second stage, random sampling technique was used to assign one TC each to the two treatment groups, Glencoe's problem-solving strategy and Rusbult's problem-solving strategy in each state. Six technical colleges were assigned to GPSS while six technical colleges were also assigned to RPSS. Therefore, six intact classes comprising of 209 students were assigned to GPSS, while the six intact classes comprising of 221 were assigned to RPSS. Furthermore, purposive sampling technique was used to assign 56 students to high ability level, 158 students to medium ability level and 216 students to low ability level. The assignment of the students into the ability levels was based on the established criteria by their respective teachers as shown in Table 2.

Table 5: Distribution of Students Based on Ability Levels

Students' Ability Levels	Description	Glencoe	Rusbult	Number
High Ability	Students that score 70 marks and above in EIMW during first term examination of 2021/2022 academic session	25	31	56
Medium Ability	Students that score 50 to 69 marks in EIMW during first term examination of 2021/2022 academic session	78	80	158
Low Ability	Students that score 49 marks and below in EIMW during first term examination of 2021/2022 academic session	106	110	216

3.5 Instruments for Data Collection

Three instruments were used in the study. They are: Electrical Installation Work Cognitive Achievement Test (EIWCAT), Electrical Installation Work Psychomotor Achievement Test (EIWPAT) and Electrical Installation Work Interest Inventory (EIWII). EIWCAT was used to generate information on students' cognitive achievement in EIMW. It consists of 40 multiple-choice items with four options, selected from the 72 items that were considered good items after subjecting the initial 90 items to psychometrics analysis at the pilot testing stage. The topics from which the test items were selected from the NBTE curriculum for EIMW. In constructing EIWCAT, the researcher prepared a table of specification (test blue print) to guide the test development, in accordance with NTC II EIMW curriculum. The items of EIWCAT were developed in accordance with the six cognitive levels as stipulated by Bloom's taxonomy of educational objectives. These were: knowledge, comprehension, application, analysis, synthesis, and evaluation (KCAASE). EIWCAT is shown in appendix C.

The second instrument that was used for the study was; Electrical Installation and Maintenance Work Psychomotor Achievement Test (EIMWPAT). EIMWPAT was designed to test the practical skills acquired by the students based on battery charging and electrical machines. The EIMWPAT contains tasks based on the EIMW curriculum in which 47 observable skills are measured. EIMWPAT is shown in Appendix E. The third instrument that was used for the study was EIWII. EIWII was designed to elicit information on the students' interest in EIMW. It is a 50 items structured questionnaire. EIWII is a four-point scale of: Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). These will be interpreted as; SA = 4 points, A = 3 points, D = 2 points, and SD = 1 point respectively. EIMWII is shown in appendix G.

Lesson Plans

The researcher prepared two sets of lesson plans that were used for teaching the two experimental groups (Appendix A & B). These were prepared to cover the two main topics and sub-themes of the study. Each set contained ten lessons that were used for teaching EIMW for ten weeks. One set of lesson plans was prepared based on Glencoe's

Problem-Solving Instructional Strategy and the other Rusbult's problem-solving instructional strategy was used.

3.6 Validation of the Instruments

The three instruments for the collection of data for the study and two sets of lesson plans were validated by three experts who are experienced in item development and Industrial and Technology Education. 1 of the validates was from the Department of Industrial and Technology Education, Federal University of Technology Minna and he was considered qualified to validate the instruments because of his experience in supervising students in micro-teaching and teaching practice, and also generate the items used for testing students in the courses he teaches at the university. The other two validators were from the Examination Development Department of the National Examinations Council (NECO). These validates were considered qualified to validate the instruments because, they taught EIMW for more than 10 years before joining the service of NECO and so they have experienced in the planning of lessons and test construction in EIMW. Also, the fact that they works with an examination body and are exposed to the rudiments of test development which makes them suitable. To aid the validation process the; title and objectives of the study were sent along with the instruments and lesson plans to the validates to look out for: alignment of the test items with the objectives of the lessons; clarity of the test items and appropriateness of the language to the class level. The suggestions made by the validates were incorporated in the final copy of the instruments and lesson plans.

3.7 Reliability of the Instrument

The instruments; EIWCAT, EIMWPAT and EIWII were subjected to a pilot test which ascertained their reliabilities. This was done by administering them to the 40 NTC III EIMW students of Government Technical College, Malali Kaduna State (Appendix C &

D). Government Technical College, Malali. Kaduna State is not part of area of the study. The technical college is similar to all the technical colleges in North-central Nigeria in terms of; staffing, infrastructure, school administrative set up and competencies of both teachers and students. Being the only technical college in Malali Kaduna State, using it for the pilot test was considered appropriate because it help the study to avoid experimental contamination of the subjects. NTC III students were used for the pilot test because they provided a reasonable number of subjects who have previous knowledge of the topics as reported by their class teacher on which the items of both EIWCAT and EIWPAT were developed.

The psychometric properties of EIWCAT were analyzed to determine the Difficulty and Discrimination Indices of each item in the test. An item is good if it has Difficulty Index ranging from 20 to 80; Discrimination of 0.20 and above and its entire distractor index a negative decimal (Okoro, 2012). Therefore, a total of the 70 items of the EIWCAT had good difficulty, discrimination and distractor indices as shown in Appendix K. After this, the coefficient of internal consistency of EIWCAT was determined using Kuder-Richardson formula 20 (K-R 20) and it was found to be 0.80. K-R 20 was used in establishing the reliability of EIWCAT because it is a multiple-choice test.

To determine the reliability of EIWPAT two raters were introduced to score the students while performing the tasks of the test. Then the inter-rater coefficient, which is the reliability value was calculated using Pearson's Product Moment Correlation (PPMC) and it yielded 0.82 (Appendix F). Similarly, the reliability of EIWII was determined using Cronbach's Alpha and it yielded 0.81. All the three instruments were considered reliable because they had reliability values higher than 0.70 (Appendix L).

3.8 Method of Data Collection

The EIMW teachers administered the pretest to the two treatment groups (Glencoe Problem solving strategy group and Rusbult problem solving strategies group) in their respective schools. In the pretest, the EIMW cognitive Achievement Test, EIMW psychomotor Achievement Test and the EIMW interest on both the two experimental groups respectively. Objective answer sheets were provided for the students to choose correct answers for the EIMW Cognitive achievement test. The students checked (√) to indicate the degree to which they agreed or disagreed with statement in the EIMW interest inventory. The researcher marked the answer sheets of the EIMWCAT and scoring guide for EIMWPAT to obtain the students' scores on the cognitive and skill achievement before the treatment while the interest inventory was scored by the researcher to determine each of the student's interest before the treatment. The exercise provided a baseline data on each of the two dependent variables (Cognitive Achievement, Skill Achievement and Interest of each treatment) before the treatment.

During the posttest, EIMW teachers administered the posttest to the two treatment groups (Glencoe Problem solving strategies group and Rusbult problem solving strategies group) in their respective schools. In the posttest, the EIMW Cognitive Achievement test, EIMW Psychomotor Achievement test and EIMW Interest Inventory were administered on the treatment and control groups. Objective Answer sheets were provided for the students to choose the correct answers for the EIMW Cognitive Achievement test while the skill achievement test scoring guide was used by EIMW teacher to rate the students. The students check (√) the answer to indicate the degree to which they agreed or disagreed with the statements in the EIMW interest inventory. The answer sheets were mark by the researcher to obtain the students' scores on the cognitive achievement. The EIMWPAT scores were collected from the EIMW teachers after treatment while the EIMWII were scored by the researcher which determine each of the student's interest after treatment. The exercise provided post treatment data for each of the two dependent variables (Cognitive Achievement, Skill Achievement and Interest) after the treatment.

3.8.1 Experimental Procedure

In order not to disrupt calendar of the colleges used for the study, the experiment took place during the normal school lesson periods. The regular school teachers were used for the study. On the first day before the lesson commenced, the three instruments; EIMWCAT, EIMWPAT and EIMWII were administered as pretest for the two groups, the data generated were collected and kept in the custody of the researcher for further processing. The lesson plans for each group as prepared by the researcher were used throughout the period. At the end of ten weeks, EIMWCAT, EIMWPAT and EIMWII was administered for the second time as post-test. The data collected were handed over to the researcher. The scripts were marked and scored with the used of the marking scheme as prepared by the researcher. The scoring of EIMWCAT was based on 50 marks, EIMWPAT on 20 marks while EIMWII was scored on 4 – point scale. The pre-test scores were used as the covariates of the post-test scores. The data generated were used for final analysis. Finally, the scores obtained from both groups were compared to determine the significant difference in cognitive achievement, psychomotor achievement and interest of the two groups.

3.8.2 Control of Extraneous Variable

The researcher made attempt to control the following variables.

a. Teacher Variable

The researcher organized uniform training for the research assistants, in order to control teacher variable, lesson plans was prepared by the researcher and made available to the participating teachers, to reduced teachers' effect on lesson preparation and presentation.

b. **Pre-test sensitization**:

Since the same instruments were used for both pretest and post-test for the measurement of EIMW achievement of the students, it was very easy for the students to get familiar with the test instrument and hence introduce error into the study. To control this pre-test sensitization therefore, the researcher withdraw all the instrument items from the students and the classroom teachers after the pre-testing and restructure the options in each test items in the pre-EIMWCAT, pre-EIMWPAT and pre-EIMWII before using it as post-EIMWCAT. Post-EIMWPAT and post-EIMWII

(d) Initial Group Differences

The researcher checked the issue of initial group difference through the application of Analysis of Covariance (ANCOVA) since the study was pre-test, post-test, non-equivalent control group design.

(d) Subjects Interaction

The researcher assigned each school to a different treatment to avoid interaction within the two groups (experimental and control). The four (4) schools that were drawn and the four (4) intact classes from each of them constituted four intact classes from four schools as the experimental groups, which controlled the issue of subject – interaction.

(e) Hawthorne Effect

Hawthorne effect is a situation where the performance of research is affected due to the fact that the students are conscious of the fact that they are involved in an experiment. In order to reduce this problem, the researcher used the normal classroom teachers for the two experimental groups. Also the researcher assigned each school to a single treatment.

3.9 Method of Data Analysis

Data collected for the study were analysed as follows: Mean and Standard deviation was used to answer all the research questions. Hypotheses formulated for the study were tested using Analysis of Covariance (ANCOVA) at $p<0.05$ level of significance. ANCOVA was used because it helps to determine the linearity between the dependent and co-variants variable, and the homogeneity of regression or parallelism can easily be tested. The pretest scores were used as covariance to the post-test scores. This is because ANCOVA is a statistical technique which removes the initial differences between groups, so that the selected or pre-tested groups can be correctly considered as equated or equivalent by removing score difference in the pretest performance across groups and reducing the between-group source variation (Nwaodo, 2016).

According to Ary *et al.,* (2010) ANCOVA is a method for analysing differences between experimental groups on the dependent variable after taking into account any initial differences between the groups on pretest measures or on any other measures of relevant independent variables. Such a measure used for control is called a covariate. Since students in their intact classes participated in this experiment, ANCOVA was considered appropriate for analyzing the differences between the main effects of the treatments on the dependent. The analyses was computed with the use of the Statistical Packages for Social Sciences (SPSS V20). Each item was regarded as Agreed, if the item is greater or equal to 2.50, while item below 2.49 was considered disagree and any hypotheses tested at exactly 0.05 or below is considered accepted while above 0.05 is rejected.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Research Question 1

What is the effect of Glencoe's and Rusbult's problem-solving strategies on students' skills achievement in EIMW?

The data for answering research question one is contained in Table 5.

Table 6: Mean of Pre-test and Post-test Skill Achievement Scores of Students Taught EIMW Using Glencoe's and Rusbult's Problem-Solving Strategies

Groups		Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain
Glencoe's Problem-Solving Strategy	221	23.23	3.16	75.37	1.63	52.14
Rusbult's Problem-Solving Strategy	209	20.60	2.84	78.89	1.97	58.29

Table 6 shows that, students taught EIMW using Glencoe's problem-solving strategy had pre-test mean skill achievement score of 23.23 with standard deviation of 3.16 and post-test score of 75.37 with standard deviation of 1.63. The mean gained between the pre-test and post-test skill achievement scores of the students taught EIMW using Glencoe's problem-solving strategy was 52.14. The students taught EIMW using Rusbult's problem-solving strategy had pre-test mean skill achievement score of 20.60 with standard deviation of 2.84 and post-test score of 78.89 with standard deviation of 1.97. The mean gained between the pre-test and post-test skill achievement scores of the students taught EIMW using Rusbult's problem-solving strategy was 58.29. This indicated that, even though both instructional strategies are good in improving students learning, students taught EIMW using Rusbult's problem-solving strategy had higher mean skill achievement scores than students taught using Glencoe's problem-solving strategy. The table also revealed that the standard deviation (SD) of skill achievement score of 3.16 using Glencoes and 2.84 using Rusbults in pre-test and during post-test using Glencoes it was 1.63 and using Rusbults it was 1.97. This signifies that the respondents had a high score on skill achievement during pre-test when taught using Glencoes than Rusbults and during post-test Rusbults had a high skills achievement score than Glencoes.

4.2 Research Question 2

What is the effect of Glencoe's and Rusbult's problem-solving strategies on students' cognitive achievement in EIMW?

The data for answering research question two is contained in Table 7.

Table 7: Mean of Pre-test and Post-test Cognitive Achievement Scores of Students Taught EIMW Using Glencoe's and Rusbult's Problem-Solving Strategies

Groups		**Pretest**		**Posttest**		
	N	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
Glencoe's Problem-Solving Strategy	221	13.57	4.50	78.43	1.89	64.86
Rusbult's Problem-Solving Strategy	209	13.32	3.71	71.72	1.59	58.40

Table 7 shows that, students taught EIMW using Glencoe's problem-solving strategy had pre-test mean cognitive achievement score of 13.57 with standard deviation of 4.50 and post-test score of 78.43 with standard deviation of 1.89. The mean gained between the pre-test and post-test mean cognitive achievement scores of the students taught EIMW using Glencoe's problem-solving strategy was 64.86. The students taught EIMW using Rusbult's problem-solving strategy had pre-test mean cognitive achievement score of 13.32 with standard deviation of 3.71 and post-test score of 71.72 with standard deviation of 1.59. The mean gained between the pre-test and post-test mean cognitive achievement scores of the students taught EIMW using Rusbult's problem-solving strategy was 58.40. This indicated that, even though both instructional strategies are good in improving students learning, students taught EIMW using Glencoe's problem-solving strategy had higher mean cognitive achievement scores than students taught using Rusbult's problem-solving strategy. The table also revealed that the standard deviation (SD) of skill achievement score of 3.16 in pre-test and post-test score 1.63. This signifies that the respondents had a high score in skill achievement during pre-test than the post-test. The table also revealed that the standard deviation (SD) of cognitive achievement score of 4.50 using Glencoes and 3.71 using Rusbults in pre-test and during post-test using Glencoes it was 1.89 and using Rusbults it was 1.59. This signifies that the respondents had a high score on cognitive achievement during pre-test and during post-test when taught using Glencoes than Rusbults.

4.3 Research Question 3

What is the effect of Glencoe's and Rusbult's problem-solving strategies on students' interest in studying EIMW?

The data for answering research question three is contained in Table 8.

Table 8: Mean of Pre-test and Post-test Scores of Students Interest Taught EIMW Using Glencoe's and Rusbult's Problem-Solving Strategies

Groups		Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain
Glencoe's Problem-Solving Strategy	221	34.42	1.67	67.39	1.12	32.97
Rusbult's Problem-Solving Strategy	209	34.22	0.99	78.35	0.90	44.13

Table 8 shows that, students taught EIMW using Glencoe's problem-solving strategy had pre-test mean interest score of 34.42 with standard deviation of 1.67 and post-test score of 67.39 with standard deviation of 1.12. The mean gained between the pre-test and post-test mean interest scores of the students taught EIMW using Glencoe's problem-solving strategy was 32.97. The students taught EIMW using Rusbult's problem-solving strategy had pre-test mean interest score of 34.22 with standard deviation of 0.99 and post-test score of 78.35 with standard deviation of 0.90. The mean gained between the pre-test and post-test mean interest scores of the students taught EIMW using Rusbult's problem-solving strategy was 44.13. This indicated that, students taught EIMW using Rusbult's problem-solving strategy had higher mean interest scores than students taught using Glencoe's problem-solving strategy. The table also revealed that the standard deviation (SD) of students interest score of 1.67 using Glencoes and 0.99 using Rusbults in pre-test and during post-test using Glencoes it was 1.12 and using Rusbults it was 0.99. This signifies that the respondents had a high mean on students interest score during pre-test and post-test when taught using Glencoes problem solving strategy.

4.4 Research Question 4

What is the effect of ability level on skill achievement of students' in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies?

The data for answering research question four is contained in Table 9.

Table 9: Mean of Pre-test and Post-test Skill Achievement Scores of High, Medium and Low Ability Students Taught EIMW Using Glencoe's and Rusbult's Problem-Solving Strategies

Ability Levels	Glencoe's Problem-Solving Strategy						Rusbult's Problem-Solving Strategy					
		Pretest		Posttest				Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain	N	Mean	SD	Mean	SD	Mean Gain
High Ability	25	27.08	0.85	83.85	0.86	56.77	31	26.99	0.98	82.65	0.93	55.66
Medium Ability	78	23.61	2.53	79.12	1.28	55.51	80	24.07	1.70	78.66	0.96	54.59
Low Ability	106	19.41	1.14	78.95	0.94	59.54	110	20.44	1.02	77.87	0.88	57.43

Table 9 shows that, the high ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean skill achievement score of 27.08 with standard deviation of 0.85 and post-test score of 83.85 with standard deviation of 0.86. The mean gained between the pre-test and post-test mean skill achievement scores of the high ability students was 56.77. The medium ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean skill achievement score of 23.61 with standard deviation of 2.53 and post-test score of 79.12 with standard deviation of 1.28. The mean gained between the pre-test and post-test mean skill achievement scores of the medium ability students was 55.51. The low ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean skill achievement score of 19.41 with standard deviation of 1.14 and post-test score of 78.95 with standard deviation of 0.94. The mean gained between the pre-test and post-test mean skill achievement scores of the low ability students was 59.54.

Furthermore, the high ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean skill achievement score of 26.99 with standard deviation of 0.98 and post-test score of 82.65 with standard deviation of 0.93. The mean gained between the pre-test and post-test mean skill achievement scores of the high ability students was 55.66. The medium ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean skill achievement score of 24.07 with standard deviation of 1.70 and post-test score of 78.66 with standard deviation of 0.96. The mean gained between the pre-test and post-test mean skill achievement scores of the medium ability students was 54.59. The low ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean skill achievement score of 20.44 with standard deviation of 1.20 and post-test score of 77.87 with standard deviation of 0.88. The mean gained between the pre-test and post-test mean skill achievement scores of the low ability students was 57.43. This indicated that, the combined low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean skill achievement score than the high and medium ability students.

4.5 Research Question 5

What is the effect of ability level on cognitive achievement of students' taught EIMW with Glencoe's and Rusbult's problem-solving strategies?

The data for answering research question five is contained in Table 10.

Table 10: Mean of Pre-test and Post-test Cognitive Achievement Scores of High, Medium and Low Ability Students Taught EIMW Using Glencoe's and Rusbult's Problem-Solving Strategies

Ability Levels	Glencoe's Problem-Solving Strategy						Rusbult's Problem-Solving Strategy					
		Pretest		Posttest				Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain	N	Mean	SD	Mean	SD	Mean Gain
High Ability	25	22.96	2.04	81.71	1.76	58.75	31	21.66	1.76	80.00	2.01	58.34
Medium Ability	78	14.15	0.65	77.06	1.10	62.91	80	16.19	0.89	78.06	1.07	61.87
Low Ability	106	10.47	0.51	76.92	0.92	66.50	110	12.06	0.88	76.67	1.60	64.61

Table 10 shows that, the high ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean cognitive achievement score of 22.96 with standard deviation of 2.04 and post-test score of 81.71 with standard deviation of 1.76. The mean gained between the pre-test and post-test mean cognitive achievement scores of the high ability students was 58.75. The medium ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean cognitive achievement score of 14.15 with standard deviation of 0.65 and post-test score of 77.06 with standard deviation of 1.10. The mean gained between the pre-test and post-test mean cognitive achievement scores of the medium ability students was 62.91. The low ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean cognitive achievement score of 10.47 with standard deviation of 0.51 and post-test score of 76.92 with standard deviation of 0.92. The mean gained between the pre-test and post-test mean cognitive achievement scores of the low ability students was 66.50.

Furthermore, the high ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean cognitive achievement score of 21.66 with standard deviation of 1.76 and post-test score of 80.00 with standard deviation of 2.01. The mean gained between the pre-test and post-test mean cognitive achievement scores of the high ability students was 58.34. The medium ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean cognitive achievement score of 16.19 with standard deviation of 0.89 and post-test score of 78.06 with standard deviation of 1.07. The mean gained between the pre-test and post-test mean cognitive achievement scores of the medium ability students was 61.87. The low ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean cognitive achievement score of 12.06 with standard deviation of 0.88 and post-test score of 76.67 with standard deviation of 1.60. The mean gained between the pre-test and post-test mean cognitive achievement scores of the low ability students was 64.61.

This indicated that, the combined low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean cognitive achievement score than high and medium ability students.

4.6 Research Question 6

What is the effect ability level on students interest in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies?

The data for answering research question six is contained in Table 11.

Table 11: Mean of Pre-test and Post-test Interest Scores of High, Medium and Low Ability Students Taught EIMW Using Glencoe's and Rusbult's Problem-Solving Strategies

Ability Levels	Glencoe's Problem-Solving Strategy						Rusbult's Problem-Solving Strategy					
		Pretest		Posttest				Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain	N	Mean	SD	Mean	SD	Mean Gain
High Ability	25	34.34	1.55	72.16	2.51	37.82	31	37.09	1.89	77.07	1.92	39.98
Medium Ability	78	34.23	1.04	72.41	2.47	38.18	80	35.34	1.32	76.98	1.21	41.64
Low	106	34.50	1.56	75.75	2.24	41.25	110	34.65	1.88	80.62	1.81	45.97

Ability

Table 11 shows that, the high ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean interest score of 34.34 with standard deviation of 1.55 and post-test score of 72.16 with standard deviation of 2.51. The mean gained between the pre-test and post-test mean interest scores of the high ability students was 37.82.The medium ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean interest score of 34.23 with standard deviation of 1.04 and post-test score of 72.41 with standard deviation of 2.47. The mean gained between the pre-test and post-test mean interest scores of the medium ability students was 38.18. Moreover, the low ability students taught EIMW using Glencoe's problem-solving strategies had pre-test mean interest score of 34.50 with standard deviation of 1.56 and post-test score of 75.75 with standard deviation of 2.24. The mean gained between the pre-test and post-test mean interest scores of the low ability students was 41.25.

Furthermore, the high ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean interest score of 37.09 with standard deviation of 1.89 and post-test score of 77.07 with standard deviation of 1.92. The mean gained between the pre-test and post-test mean interest scores of the high ability students was 39.98.The medium ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean interest score of 35.34 with standard deviation of 1.32 and post-test score of 76.98 with standard deviation of 1.21. The mean gained between the pre-test and post-test mean interest scores of the medium ability students was 41.64. The low ability students taught EIMW using Rusbult's problem-solving strategies had pre-test mean interest score of 34.65 with standard deviation of 1.88 and post-test score of 80.62 with standard deviation of 1.81. The mean gained between the pre-test and post-test mean interest scores of the low ability students was 45.97. This showed that, the combined low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean interest score than high and medium ability students.

4.7 Hypothesis Testing

4.7.1 Hypothesis One

There is no significance difference between students' skills achievement mean scores in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies.

The data for testing hypothesis one is contained in Table 12.

Table 12: Analysis of Covariance for the test of Significance Difference Between Students' Skills Achievement Mean Scores in EIMW When Taught Using Glencoe's and Rusbult's Problem-Solving Strategies

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	834.17[a]	2	417.08	223.48	.000
Intercept	4014.83	1	401.83	215.92	.000
Pretest	598.62	1	598.62	320.76	.000
Group	18.15	1	18.15	9.72	.002*
Error	796.89	427	1.86		
Total	2730.00	430			
Corrected Total	1631.06	429			

a. R Squared = .511 (Adjusted R Squared = .509)

Table 12 above shows the F-calculated value for testing the significance difference between the skill achievement scores of students taught EIMW using Glencoe's and those taught using Rusbult's problem-solving strategies. The F-calculated value of 9.72 was obtained with associated exact Significant Two Tailed (Sig. 2 tailed) value of 0.02. Since the associated Sig. 2 tailed value of 0.02 is less than the stated level of significance (0.05), the null hypothesis which stated that there is no significance difference between students' skills achievement mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies is rejected. Hence, there is significance difference between students' skills achievement mean scores in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies.

4.7.2 Hypothesis Two

There is no significance difference between students' cognitive achievement mean scores in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies. The data for testing hypothesis two is contained in Table 13

Table 13: Analysis of Covariance for the test of Significance Difference Between Students' Cognitive Achievement Mean Scores in EIMW When Taught Using Glencoe's and Rusbult's Problem-Solving Strategies

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1322.16[a]	2	661.082	896.60	.000
Intercept	197319.92	1	1973.92	2676.72	.000
Pretest	1007.36	1	1007.36	1366.26	.000
Group	281.02	1	281.02	381.14	.000*
Error	314.83	427	.737		
Total	25911.00	430			
Corrected Total	1636.998	429			

a. R Squared = .808 (Adjusted R Squared = .807)

Table 13 show the F-calculated value for testing the significance difference between the cognitive achievement scores of students taught EIMW using Glencoe's and those taught using Rusbult's problem-solving strategies. The F-calculated value of 381.14 was obtained with associated exact Sig. 2 tailed value of 0.00. Since the associated Sig. 2 tailed value of 0.00 is less than 0.05, the null hypothesis which stated that there is no significance difference between students' cognitive achievement mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies is rejected. This implied that, there is significance difference between students' cognitive achievement mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies.

4.7.3 Hypothesis Three

There is no significance difference between students interest mean scores in studying EIMW when taught using Glencoe's and the Rusbult's problem-solving strategies.

The data for testing hypothesis three is contained in Table 14.

Table 14: Analysis of Covariance for the test of Significance Difference Between Students' Interest Mean Scores in EIMW When Taught Using Glencoe's and Rusbult's Problem-Solving Strategies

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1290.29[a]	2	6452.64	621.50	.000
Intercept	3568.82	1	3568.82	343.22	.000
Pretest	1.33	1	1.330	1.282	.258
Group	1285.42	1	1285.42	123.97	.000*
Error	443.22	427	1.038		
Total	22873.00	430			
Corrected Total	1334.51	429			

a. R Squared = .967 (Adjusted R Squared = .967)

Table 14 shows the F-calculated value for testing the significance difference between the interest scores of students taught EIMW using Glencoe's and those taught using Rusbult's problem-solving strategies. The F-calculated value of 123.97 was obtained with associated exact Sig. 2 tailed value of 0.00. Since the associated Sig. 2 tailed value of 0.00 is less than 0.05, the null hypothesis which stated that there is no significance difference between students' interest mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies is rejected. This implied that, there is significance difference between students' interest mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies.

4.7.4 Hypothesis Four

There is no significant difference between the mean scores of high, medium and low ability levels on the skills achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.

The data for testing hypothesis four is contained in Table 15.

Table 15: Analysis of Covariance for the test of Significance Difference Between the Mean Scores of High, Medium and Low Ability Levels on the Skills Achievement of Students Taught EIMW with Glencoe's and Rusbult's Problem-Solving Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1322.86[a]	3	440.95	609.50	.000
Intercept	1251.33	1	1251.33	1729.75	.000
Pretest	184.00	1	184.00	254.33	.000
Ability Levels	506.85	2	253.42	350.29	.000*
Error	308.19	426	.72		
Total	27300.00	430			
Corrected Total	1631.06	429			

a. R Squared = .811 (Adjusted R Squared = .810)

Table 15 show the F-calculated value for testing the significance difference between the mean scores of high, medium and low ability levels on the skill achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies. The F-calculated value of 350.29 was obtained with associated exact Sig. 2 tailed value of 0.00. Since the associated Sig. 2 tailed value of 0.00 is less than 0.05, the null hypothesis which stated that there is no significance difference between the mean scores of high, medium and low ability levels on the skill achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies is rejected. Hence, there is significance difference between the mean scores of high, medium and low ability levels on the skill achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies**.** In order to determine the ability level responsible for the significance difference, post hoc test was carried out as shown in Table 16.

Table 16: Post Hoc Test for the Significance Difference Between the Mean Scores of High, Medium and Low Ability Levels on the Skills Achievement of Students T0aught EIMW with Glencoe's and Rusbult's Problem-Solving Strategies

(I) ABILITY	(J) ABILITY	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
HIGH	LOW	4.8988*	.16100	.000	4.5033	5.2943
	MEDI	4.7369*	.16697	.000	4.3268	5.1470
L0 W	HIGH	-4.8988*	.16100	.000*	-5.2943	-4.5033
	MEDI	-.1619	.11239	.355	-.4380	.1142
MEDI	HIGH	-4.7369*	.16697	.000*	-5.1470	-4.3268
	LOW	.1619	.11239	.355	-.1142	.4380

Key: HIGH = High Ability Level, LOW = Low Ability Level, MEDI = Medium Ability Level

Table 16 above reveals Sig. 2 Tailed value = 0.00 for skill achievement mean score of high ability level students when compared with the skill achievement mean scores of medium and low ability level students. This indicated that, the skill achievement mean score of high ability level students is responsible for the significant difference between the skill achievement mean scores of high, medium and low ability levels of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.

4.7.5 Hypothesis Five

There is no significant difference between the mean scores of high, medium and low ability levels on the cognitive achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.

The data for testing the hypothesis is contained in Table 17.

Table 17: Analysis of Covariance for the test of Significance Difference Between the Mean Scores of High, Medium and Low Ability Levels on the Cognitive Achievement of Students Taught EIMW with Glencoe's and Rusbult's Problem-Solving Strategies

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1217.09[a]	3	405.70	411.59	.000
Intercept	6729.52	1	6729.52	6827.30	.000
Pretest	126.57	1	126.57	128.41	.000
Ability Levels	175.96	2	87.98	89.25	.000*
Error	419.89	426	.986		
Total	25911.00	430			
Corrected Total	1636.99	429			

a. R Squared = .743 (Adjusted R Squared = .742)

Table 17 show the F-calculated value for testing the significance difference between the mean scores of high, medium and low ability levels on the cognitive achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies. The F-calculated value of 89.25 was obtained with associated exact Sig. 2 tailed value of 0.00. Since the associated Sig. 2 tailed value of 0.00 is less than 0.05, the null hypothesis which stated that there is no significance difference between the mean scores of high, medium and low ability levels on the cognitive achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies is rejected. Hence, there is significance difference between the mean scores of high, medium and low ability levels on the cognitive achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies**.** In order to determine the ability level responsible for the significance difference, post hoc test was carried out as shown in Table 18.

Table 18: Post Hoc Test for the Significance Difference Between the Mean Scores of High, Medium and Low Ability Levels on the Skills Achievement of Students Taught EIMW with Glencoe's and Rusbult's Problem-Solving Strategies

(I) ABILITY	(J) ABILITY	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
HIGH	LOW	4.7884*	.16964	.000	4.3717	5.2051
	MEDI	4.6447*	.17594	.000	4.2125	5.0768
LOW	HIGH	-4.7884*	.16964	.000*	-5.2051	-4.3717
	MEDI	-.1437	.11843	.480	-.4346	.1472
MEDI	HIGH	-4.6447*	.17594	.000*	-5.0768	-4.2125
	LOW	.1437	.11843	.480	-.1472	.4346

Table above reveals Sig. 2 Tailed value = 0.00 for cognitive achievement mean score of high ability level students when compared with the cognitive achievement mean scores of medium and low ability level students. This indicated that, the cognitive achievement mean score of high ability level students is responsible for the significant difference

4.7.6 Hypothesis Six

There is no significant difference between the mean scores of high, medium and low ability levels on the interest of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.

The data for testing the hypothesis is contained in Table 19. between the cognitive achievement mean scores of high, medium and low ability levels of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.

Table 19: Analysis of Covariance for the test of Significance Difference Between the Mean Scores of High, Medium and Low Ability Levels on the Interest of Students Taught EIMW with Glencoe's and Rusbult's Problem-Solving Strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	663.48[a]	3	221.16	7.42	.000
Intercept	4830.93	1	4830.93	162.23	.000
Pretest	67.06	1	67.06	2.25	.134
Ability Levels	613.61	2	306.80	10.30	.000*
Error	12685.02	426	29.77		
Total	22873.00	430			
Corrected Total	13348.51	429			

A. R Squared = .050 (Adjusted R Squared = .043)

Table 19 shows the F-calculated value for testing the significance difference between the mean scores of high, medium and low ability levels on the interest of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies. The F-calculated value of 10.30was obtained with associated exact Sig. 2 tailed value of 0.00. Since the associated Sig. 2 tailed value of 0.00 is less than 0.05, the null hypothesis which stated that there is no significance difference between the mean scores of high, medium and low ability levels on the interest of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies is rejected. Hence, there is significance difference between the mean scores of high, medium and low ability levels on the interest of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies**.** In order to determine the ability level responsible for the significance difference, post hoc test was carried out as shown in Table 20.

Table 20: Post Hoc Test for the Significance Difference Between the Mean Scores of High, Medium and Low Ability Levels on the Interest of Students Taught EIMW with Glencoe's and Rusbult's Problem-Solving Strategies

(I) ABILITY	**(J) ABILITY**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval Lower Bound**	**Upper Bound**
LOW	HIGH	3.5880*	.81948	.000	1.5750	5.6009
	MEDI	3.3386*	.84989	.001	1.2510	5.4262
HIGH	LOW	-3.5880*	.81948	.000*	-5.6009	-1.5750
	MEDI	-.2494	.57208	.909	-1.6546	1.1559
MEDI	LOW	-3.3386*	.84989	.001*	-5.4262	-1.2510
	HIGH	.2494	.57208	.909	-1.1559	1.6546

The above table reveals Sig. 2 Tailed value = 0.00 for interest mean score of low ability level students when compared with the interest mean scores of high and medium ability level students. This indicated that, the interest mean score of low ability level students is responsible for the significant difference between the interest mean scores of high, high and medium levels of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.

4.13 Findings of the Study

1. Rusbult's and Glencoe's problem-solving strategies are effective in improving students skill achievement in EIMW but Rusbult's problem-solving strategy is more effective than Glencoe's problem-solving strategy.
2. Glencoe's and Rusbult's problem-solving strategies are effective in improving students cognitive achievement in EIMW but Glencoe's problem-solving strategy is more effective in student cognitive achievement than Glencoe's problem-solving strategy
3. Rusbult's and Glencoe's problem-solving strategies are effective in improving students interest in EIMW but Rusbult's problem-solving strategy is more effective in student interest in EIMW than Glencoe's problem-solving strategy.
4. The ability levels are effective in improving students skill achievement but Low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean skill achievement score than high and medium ability students.
5. The ability levels are effective in improving students skill achievement but Low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean cognitive achievement score than high and medium ability students.
6. The ability levels are effective in improving students skill achievement but Low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean interest score than high and medium ability students.
7. There was significant difference between students' skills achievement mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies.

8. There was significant difference between students' cognitive achievement mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies.
9. There was significant difference between students' interest mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies.
10. There was significant difference between the mean scores of high, medium and low ability levels on the skills achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.
11. There was significant difference between the mean scores of high, medium and low ability levels on the cognitive achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.
12. There was significant difference between the mean scores of high, medium and low ability levels on the interest of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies.

4.14 Discussion of Findings

Findings on the effects of Glencoe's and Rusbult's problem-solving strategies on students' skill achievement in EIMW revealed that the students taught using Rusbult's problem-solving strategy had higher mean skill achievement scores than students taught using Glencoe's problem-solving strategy. This indicated that, the students taught EIMW using Rusbult's problem-solving strategy performed better in the skill achievement test than the students taught using Glencoe's problem-solving strategy. The finding is similar to the findings of Nekang (2011) on differential effects of Reda's and Rusbult's problem-solving strategies on male and female students' achievement and interest in trigonometry in Cameroon that revealed students exposed to Rusbult's problem-solving strategies achieved higher in trigonometry achievement test than those exposed to conventional problem solving strategy.

The positive effect of Rusbult's problem-solving strategy on the students' skill achievement in EIMW could be attributed to the distinctive features of the technique that allow students to take action in solving the problem and also ensure whether the problem has been properly solved. Nwaodo (2016) stated that, the skill achievement of students can be enhanced using problem-solving strategy such as Rusbult's problem-solving strategy. The educational implication of this finding is that, the students' skill achievement can be enhanced using Rusbult's problem-solving strategy to teach EIMW and other practical oriented courses.

Furthermore, the test for significance difference between students' skills achievement mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies revealed statistical significance. This entailed that, there is much difference between the skills achievement mean scores of students taught EIMW using Glencoe's and those taught using Rusbult's problem-solving strategies. The finding is similar to the finding of Bawa (2011) on the effects of problem solving instructional strategy on academic achievement and retention in ecology among secondary school students in Zaria educational zone that revealed significant difference between the posttest mean scores of the experimental and control group of recall variable in favour of the experimental group. The finding implied that, substantial improvement in the skill achievement of students is obtainable if they are taught EIMW using Rusbult's problem-solving strategy.

Findings on the effects of Glencoe's and Rusbult's problem-solving strategies on students' cognitive achievement in EIMW revealed that the **s**tudents taught EIMW using Glencoe's problem-solving strategy had higher mean cognitive achievement scores than students taught using Rusbult's problem-solving strategy. The finding clearly showed that, students' cognitive achievement in EIMW is more enhanced using Glencoe's problem-solving strategy than Rusbult's problem-solving strategy. The finding is similar to the findings of Mandina and Ochonogor (2018) on the comparative effect of two problem-solving instructional strategies on students' achievement in Zimbabwe that revealed Glencoe's problem-solving strategy is more effective in improving the cognitive achievement of students in Stoichiometry than Reda's problem-solving strategy.

The effectiveness of Glencoe's problem-solving strategy in improving the cognitive achievement of students in EIMW could be attributed to the exploration and planning phases of the Glencoe's problem-solving strategy that demand students to brainstorm the problem properly in order to understand and identify the basic facts and materials needed for solving the problem. These two phases of Glencoe's problem-solving strategy are responsible for triggering the cognitive functions capable of enhancing the cognitive achievement of students (Nwoke, 2015). This implied that, the exploration and planning phases could be responsible for the effectiveness of Glencoe's problem-solving strategy over Rusbult's problem-solving strategy in enhancing students' cognitive achievement in EIMW.

Contrary to the null hypothesis on the significant difference between students' cognitive achievement mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies, the test result revealed statistical significance. The statistical significance recorded is an indication that, there is substantial difference between the mean cognitive achievement scores of students taught EIMW using Glencoe's problem-solving strategy is much higher than that of students taught using Rusbult's problem-solving strategy. However, based on the above findings Nwaodo (2016), in his finding revealed statistical significant difference between the academic achievements mean scores of students taught metal work using Reda and Rubult problem solving models in technical colleges in Enugu State, Nigeria. The finding implied that, Glencoe's problem-solving strategy clearly illustrated the capability of causing major difference in the cognitive achievement scores of students in EIMW.

Findings on the effects of Glencoe's and Rusbult's problem-solving strategies on students' interest in EIMW revealed that, the students taught EIMW using Rusbult's problem-solving strategy had higher mean interest scores than students taught using Glencoe's problem-solving strategy. The finding provided a clearer understanding that, the interest of students in learning EIMW is stimulated using Rusbult's problem-solving strategy than using Glencoe's problem-solving strategy. The finding is also in-line with the findings of Ogumah *et al.* (2019) on the **e**ffect of guided inquiry teaching method on students' academic performance and interest in EIMW in technical colleges in Gombe State that revealed guided inquiry significantly impacted the interest of students.

However, the characteristics of Rusbult's problem solving strategy that allows the teacher to give detailed explanation and procedures to students at every stage of problem solving where necessary could be the stimulus responsible for arousing the students' interest in EIMW. Shadreck (2018) confirmed that, the distinctive features of Rusbult's problem solving strategy that allows students' engagement and participation in the learning processes is capable of arousing interest. The finding revealed an interesting fact that, interest among students can be stimulated using Rusbult's problem solving strategy. This implied that, stimulating the interest of students in learning EIMW can be achieved using Rusbult's problem solving strategy.

Similarly, finding on the test for significance difference between the students' interest mean scores in EIMW when taught using Glencoe's and those taught using Rusbult's problem-solving strategies revealed statistical significant. The revealed statistical significant difference show the great extent to which Rusbult's problem-solving strategy stimulates students' interest in EIMW especially, when compared with Glencoe's problem-solving strategy. Literarily, the finding is in harmony with the finding of Akinwumi *et al.,* (2018) that revealed statistical significant difference between the interest of students taught Biology using problem–solving teaching strategy and their counterparts taught using the conventional method. The finding is particularly important to stakeholders in education at technical college level as it provide a basis for using Rusbult's problem-solving strategy to stimulate the interest of students in EIMW.

Findings on the effects of ability level on the skills achievement of students' in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies revealed that, the low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean score on skill achievement score than the medium ability students. The finding shows that, Glencoe's and Rusbult's problem-solving strategies are effective in enhancing the skill achievement of low ability students in EIMW. The finding is in concordance with the finding of Olaniyan and Omosewo (2015) that revealed enhanced academic performance of low scoring level male students on the effects of a target-task problem-solving model on senior secondary school students' performance in Physics. In other words, the finding also revealed that, Glencoe's and Rusbult's problem-solving strategies have taken care of the difference that existed between the low and high ability students taught EIMW in the skill achievement test.

Nevertheless, the students' centered nature of Glencoe's and Rusbult's problem-solving strategies that engages the students both cognitively and practically in solving educational problems could be responsible for their ability to have taken care of the difference that existed between the low and high ability students. According to Nwaodo (2016), the engagement of students in the various stages of solving complex educational problems as displayed in Glencoe's and Rusbult's problem-solving strategies is capable of broadening their understanding as well as their practical skill in technical oriented subject such as EIMW. The educational importance of the finding is that, the skill achievement of low ability students in EIMW can be enhanced using Glencoe's and Rusbult's problem-solving strategies.

Finding on the test for significant difference between the mean scores of high, medium and low ability levels on the skills achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies revealed statistical significant. The statistical significant difference was traced to the scores of high ability level students taught EIMW using Glencoe's and Rusbult's problem-solving strategies. The finding entailed that, there was no significance difference between the skill achievement scores of low and medium ability level students taught EIMW using Glencoe's and Rusbult's problem-solving strategies. The finding is similar to the finding of Shadreck (2018) that revealed that, low ability students taught Chemistry in Zimbabwe using problem-solving instructional strategy performed significantly better than their high and medium ability counterparts. Thus, Glencoe's and Rusbult's problem-solving strategies significantly enhanced the skill achievement of low ability students taught EIMW.

Findings on the effects of ability level on the cognitive achievement of students in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies revealed that, the low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean cognitive achievement score than high and medium ability students. The finding indicated that, the cognitive achievement of low ability students is better enhanced than that of high and medium ability students when taught EIMW using Glencoe's and Rusbult's problem-solving strategies. The finding is in-line with the findings of Shodeinde (2013) on the effect of cognitive mind mapping on the achievement of electrical and electronic trades students in technical colleges in Ogun state that revealed mind mapping instructional strategy was superior to the conventional method in enhancing low ability students' cognitive achievement in abstract contents.

The finding also implied that, exposing the low ability students to the processes involved in problem solving impacted positively on their cognitive achievement. This could be due to educational flexibility and adaptability associated with the Glencoe's and Rusbult's problem-solving strategies. In support of the finding, Kurumeh *et al.* (2016) stated that, the cognitive achievement of low ability students could be improved using teaching technique that directly engage the mental functions of individual as well as the physical activities such as Glencoe's and Rusbult's problem-solving strategies. This finding is particularly important in bridging the cognitive achievement gap between the low and high ability students in EIMW.

Finding on the test for the significant difference between the mean scores of high, medium and low ability levels on the cognitive achievement of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies revealed statistical significant. The revealed statistical significant was traced to the cognitive achievement mean scores of high ability level students. This signified that, significance difference between the cognitive achievement scores of low and medium ability level students taught EIMW using Glencoe's and Rusbult's problem-solving strategies do not exist. The finding is related to the finding of Akinwumi *et al.* (2018) that revealed statistical significant difference between the mean achievement scores of high and low ability levels students taught Biology using problem-solving teaching approach in Senior Secondary School.

Thus, Glencoe's and Rusbult's problem-solving strategies significantly enhanced the cognitive achievement of low ability students taught EIMW.

Findings on the effects of ability level on the interest of students' in EIMW when taught using Glencoe's and Rusbult's problem-solving strategies revealed that, the low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean interest score than high and medium ability students. This clearly indicated that, the Glencoe's and Rusbult's problem-solving strategies are more effective in stimulating the interest of the low ability level students than that of high and medium ability students when taught EIMW using Glencoe's and Rusbult's problem-solving strategies. The finding is in agreement with the finding of Olaniyan and Omosewo (2015) that revealed target-task problem-solving model was more effective than conventional teaching method in stimulating the interest of senior secondary school students in Physics. The finding implied that, the interest of the low ability students exposed to the processes involved in problem solving stimulated their interest in EIMW. This could be due to fascinating features of interaction associated with the Glencoe's and Rusbult's problem-solving strategies. In support of the finding, Rusbult (1989) suggested that the process of translating educational problem into a clear idea as contained in Glencoe's and Rusbult's problem-solving strategies stimulates sense of interest in students. This finding is particularly important in compensating the difference between the interest of the low and high ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies.

Furthermore, the test for significant difference between the mean scores of high, medium and low ability levels on the interest of students taught EIMW with Glencoe's and Rusbult's problem-solving strategies revealed that there is significant difference. The revealed statistical significant was traced to the interest mean scores of high ability level students. This signified that, the significance difference between the interest scores of low and medium ability level students taught EIMW using Glencoe's and Rusbult's problem-solving strategies was taken care of. The finding is related to the finding of Olaniyan and Omosewo (2015) that revealed statistical significant difference between the mean interest scores of high and low ability levels senior secondary school students taught Physics using target-task problem-solving model. Hence, the interest of low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies was significantly stimulated.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the findings of the study, insights on the effects of Glencoe's and Rusbult's Problem-Solving Strategies on students' achievement and interest in Electrical Installation and Maintenance Works (EIMW) in technical colleges was provided. The study found out that: students taught EIMW using Rusbult's problem-solving strategy had higher mean skill achievement and interest scores while students taught EIMW using Glencoe's problem-solving strategy had higher mean cognitive achievement scores. The study also revealed that low ability students taught EIMW using Glencoe's and Rusbult's problem-solving strategies had higher mean cognitive and skill achievement and interest scores than high and medium ability students. The educational implication of the findings is that, the adoption of Glencoe's and Rusbult's problem-solving strategies hold the potential to enhance students' cognitive and skill achievements as well as stimulate interest in EIMW. Nevertheless, the findings are limited to the contents of EIMW at technical college level in North-Central Nigeria. Therefore, it is concluded that, Glencoe's and Rusbult's problem-solving strategies had positive effects on students' cognitive and skill achievement as well as interest in EIMW.

5.2 Recommendations

Based on the findings from the study, the following recommendations were made:

1. Electrical Installation and Maintenance Works teachers should adopt the use of Rusbult's problem-solving strategy to enhance students' skill achievement and interest; and Glencoe's problem-solving strategy to enhance students' cognitive achievement.

2. Science and Technical Schools Board should encourage sensitization and training of Electrical Installation and Maintenance Works teachers on the use of Glencoe's and Rusbult's problem-solving strategies in order to enhance students' cognitive and skill achievements as well as stimulate students interest.
3. Administrators of technical colleges should encourage the teaching of Electrical Installation and Maintenance Works using Glencoe's and Rusbult's problem-solving strategies in order to enhance students' cognitive and skill achievements as well as stimulate their interest.
4. Electrical Installation and Maintenance Works students should be introduced to learn through the use of Glencoe's and Rusbult's problem-solving strategies in order to enhance their cognitive, ability level and skill achievements as well as stimulate their interest.

5.3 Contribution to Knowledge

1. The study has established that with the use of Glencoe's and Rusbult's problem-solving instructional strategies are effective instructional strategies that can be used to enhance students' cognitive and skill achievement and interest in Electrical Installation and Maintenance Works. However, Rusbult's problem-solving instructional strategies is more effective than Glencoe's problem-solving instructional strategies in improving students skill achievement in Electrical Installation and Maintenance Works. In the same vein Rusbult's problem-solving instructional strategies also more effective in stimulating students interest in Electrical Installation and Maintenance Works.
2. The study also established that Glencoe's and Rusbult's problem-solving strategies are effective in improving students ability level in Electrical Installation and Maintenance Works. However, Rusbult's problem-solving instructional strategies is

more effective than Glencoe’s problem-solving instructional strategies in improving students ability level

5.4 Suggestions for Further Study

Based on the findings from the study, the following suggestions for further study were made:

1. Effects of Glencoe’s and Rusbult’s problem-solving strategies on students' motivation in Electrical Installation and Maintenance Works in technical colleges in North-Central, Nigeria.
2. Perception of teachers on the adoption of Glencoe’s and Rusbult’s problem-solving strategies in teaching Electrical Installation and Maintenance Works in technical colleges in North-Central, Nigeria.
3. Strategies for the utilization of Glencoe’s and Rusbult’s problem-solving strategies among teachers in teaching Electrical Installation and Maintenance Works in technical colleges in North-Central, Nigeria.
4. Development of a framework for training Electrical Installation and Maintenance Works teachers on the use of Glencoe’s and Rusbult’s problem-solving strategies in technical colleges in North-Central, Nigeria.

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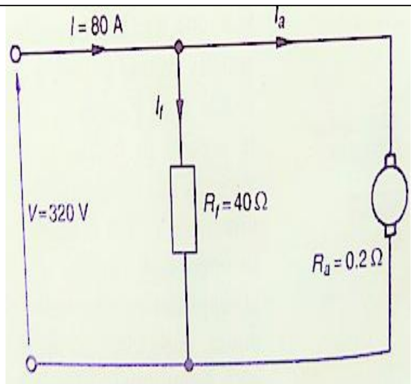
APPENDIX A

GLENCOE PROBLEM SOLVING LESSON PLAN

LESSON ONE
Topic: Cell and Battery Circuits
Duration: 45 minutes
Class: NTC II
Behavioural Objectives: At the end of the lesson, the students should be able to:

- Define the terms e.m.f and internal resistance, R of a cell
- Differentiate between a cell and a battery
- Perform simple calculations using V = E – IR
- Determine the total e.m.f and total internal resistance for cells connected in series and parallel
- Distinguish between primary and secondary cell

Entry Behaviour: students have been taught Ohms law
Instructional Resources: Batteries, charts, cells and posters
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
EMF and Internal Resistance	Definition of an e.m.f, E and internal resistance of a cell	 Teacher present the circuit diagram a voltmeter connected to a circuit as shown above. Teacher ask the students to study and draw the circuit diagram Teacher guide the students as the draw the circuit diagram Teacher guide the students to define electromotive force (emf), E of a cell as potential difference between its terminals when it is not connected to a load and it is measured by using a high resistance voltmeter connected in parallel with the cell.	Students study the circuit diagram and explain the relationship among R, r, E and V in the circuit. Students define electromotive force (e.m.f) Students discover that the terminals of a cell falls when a load is connected, caused by internal resistance when no loads: V = E and when R is connected, a current I flows which causes voltage drop in the cell given by IR. The potential difference across the cell terminal V = IR	Exploration

		Teacher guide the students to discover the terminals of a cell falls when a load is connected. This is caused by the internal resistance of the cell which is the opposition of the material of the cell to the flow of current. Teacher presents the circuit diagram of a cell of e.m.f E volts and internal resistance r, and XY represent the terminals. Teacher asks the students to study the circuit diagram and explain the relationship between the symbols in the circuits. Teacher guide the students to discover that when a load R is not connected, no current flows and terminal potential difference, V = E. When R is connected, a current I flows which causes a voltage drop in the cell given by IR. The potential difference across the cell terminal is given by V = E – Ir. $r = \frac{E-V}{I}$ where V = potential difference at terminal E = e.m.f of the cell I = current flowing through the cell r = internal resistance of the cell		

	Connection of cell in battery	Teacher guide the students to discover that a battery is a combination of more than one cell. a) For cells in series: Total e.m.f = sum of cells e.m.f Total internal resistance = sum of cells internal resistance b) For cells connected in parallel Total e.m.f = e.m.f of one cell Total internal resistance of n cells = $\frac{1}{n}\times$ internal resistance of one cell	Students discover that a battery is a combination of cell Students discover the methods of calculating the total e.m.f and internal resistance of cell when connected in series and parallel	Exploration
Simple problems on cell and battery	A cell has an internal resistance of 0.02Ω and an e.m.f 2.0V. Calculate its terminal potential difference if it delivers (a) 5A (b) 50A	Teacher write the question on the whiteboard and asks the students to study it carefully and identify the facts needed for solving the problem	Students write the questions in their notebook Students study the question carefully and identify the facts to be used in solving the problem	Exploration
		Teacher asks the students to identify the parameters needed for solving the problem	Students identify the parameters Terminal potential difference V = E – Ir where E = e.m.f of cell I = current flowing and r = internal resistance of cell	Planning
		Teacher asks the students to solve the problem Teacher guides the students as they solve the problem	Students solve the problem a) when the current is 5A	Solve

			E = 2.0V, I = 5A and r = 0.02Ω V = E – Ir Hence, V = 2.0 – (5 × 0.02) = 2.0 – 0.1 = 1.9V b) when the current is 50A E = 2.0V, I = 50A and r = 0.02Ω V = E – Ir Hence, V = 2.0 – (50 × 0.02) = 2.0 – 1.0 = 1.0V	
		Teacher asks the students to examine if their answers are correct Teacher guides the students as they examining their answer	Students examine their answers a) 1.9V = 2.0 – 5(0.02) 1.9V = 2 – 0.1 1.9V = 1.9V b)1.0 = 2.0 – 1.0 1.0 = 1.0	Examine
	Differences between primary and secondary cells	Teacher guide the students to discover that primary cells cannot be recharged i.e. conversion of chemical energy is irreversible and the cell cannot be used once the chemicals are exhausted. Secondary cells can be recharged after use i.e. the conversion of chemical energy to electrical energy is reversible and the cell may be used many	Students discover that primary cells are not rechargeable while secondary cells are rechargeable	Exploration

		times.		
Evaluation	Define the term e.m.f? what is the difference between the primary and secondary cells?	Teacher ask questions on the lesson he just concluded.	Students answer the questions.	
Assignment	The potential difference at a terminal of a battery is 25V when no load is connected and 25V when a load taking 10A is connected. Determine the internal resistance of the battery	Teacher copy the question on the whiteboard and asks the students to copy it in their notebooks	Students copy the assignments in their notebooks	

LESSON TWO

Topic: Constant Voltage Battery Charging Method

Duration: 45 minutes

Class: NTC II

Behavioural Objectives: At the end of the lesson, the students should be able to:

- Explain the process of charging a battery
- Describe the process of constant voltage method of charging a battery
- Explain that the charging current in constant voltage method depends on the difference between charging voltage and total e.m.f of the cells.

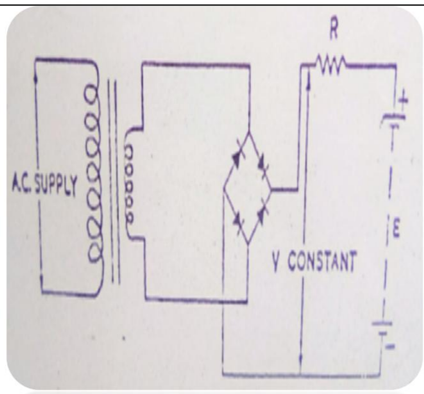
  $I = \frac{V - E}{R}$

1. Perform simple problems on constant voltage battery charging

Entry Behaviour: students have been taught on cell and battery circuits

Instructional Resources: Batteries, charts, charger and posters

Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
Battery charging	Constant charging process	 Constant Voltage Charger Teacher present the circuit diagram of a constant voltage battery charging process as shown above Teacher asks the students to study it and brainstorm Teacher asks the students to describe the battery charging processes Teacher explains that batteries	Students study and draw the circuit diagrams Students brainstorm and explore and describe the process of battery charging as passing direct current through cells connected in series from negative terminal to positive terminal	Exploration

		are charged by passing direct current through them from positive to negative terminals. The cells are usually connected in series to maintain the same charging current and correct division between currents.		
		Teacher allows students to brainstorm on the using of constant voltage method which allows maintenance of constant voltage at a value slightly in excess of the fully charged cell multiplied by the number of cells connected in series When using this method $I = \frac{V-E}{R}$ Where V = charging voltage E = total e.m.f of cells R = total internal resistance	Students brainstorm and describe the process of constant voltage method	Exploration
Problems on constant voltage charging method	Thirty, lead acid secondary cells are to be charged at a constant volatage. The e.m.f of each cells at the beginning and the end of charge is 1.9V and 2.7V respectively, and the internal resistance of each cell is 0.1 ohms. Calculate: (a) The mimimum charging voltage required. (b)	Teacher copy the problem on the whiteboard Teacher asks the students to copy it in their notebooks Teacher asks the students to identify the facts to be used in solving the problem Teacher guides the students as they identifies the facts needed for solving the problem	Students write the question in their notebooks Students carefully study the question and identify the facts required to solve the problem	Exploration

	The initial charging current.			
		Teacher asks the students to identify the parameters that are needed and available in the question	Students identify the parameters needed that are available in the question $V = E - Ir$, $V = 1.9V$, $E = 2.7V$, $r = 0.1\Omega$	Planning
		Teacher asks the students to solve the problem Teacher guides students as they solve the problems	Students solve the problem Since $V = E - IR$ No. of cells = 30 a) $V = 30 \times 2.7 = 81V$ b) $I = \frac{V-E}{R} = \frac{81-(30 \times 1.9)}{30 \times 0.1}$ $I = 8A$	Solve
		Teacher asks the students to examine if their answer is correct Teacher guides the students as they examine their answers	Students check if their answers are correct or not a) Since each cell is 2.7V, 30 cells = $30 \times 2.7V = 81V$ $V = E - Ir$ $V = 81 - 8(30 \times 0.1)$ $V = 57V$ $E = V + Ir$ $E = 57 + 8(30 \times 0.1)$ $81 = 57 + 24$ $81 = 81$	Examine

Evaluation	Identify the common constant charging process we have?	The teacher ask students question on the just concluded lesson.	Students answer the questions.	Further explaination
Assignment	Eight cells, each with an internal resistance of 0.2 Ω and an e.m.f of 2.2 V are connected a) in series b) in parallel. Determine the e.m.f and the internal resistance of the batteries so formed	Teacher copy the question on the whiteboard Teacher asks the students to copy the question in their notebooks	Students copy the question in their notebooks	

LESSON THREE

Topic: Constant Current Battery Charging Method

Duration: 45 minutes

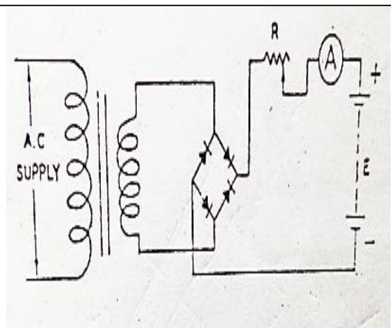
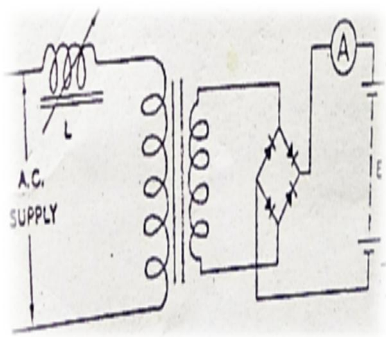
Behavioral Objective: At the end of the lesson, the students should be able to:

A. Describe the process constant current battery charging
B. Differentiate between constant voltage and constant current methods of charging battery
C. Appreciate that the charging current in constant voltage method depends on the difference between charging voltage and total emf of the cell
D. Perform simple problem on battery charging entry behavior students have been taught cells and battery cell

Entry Behavior: students have already been taught on constant voltage or charging types

Instructional Resources: Batteries, cells, charts and posters

Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Student Activities	Instructional Strategies
Battery charging	Constant current charging process of charging batteries	 (A) Rheostat control  (B) Inductor control	Students draw the circuit diagram in their notebooks. Student study the diagram. Students explore, brainstorm and describe the process of charging batteries with constant-current charging method. Students observed that rheostat is used to maintain constant current. Students study the second circuit and the discovered variable is used to maintain constant current required for the charging of the battery.	Exploration

		Teacher present the circuit diagrams of the constant current charging using rheostat or inductor control process of charging batteries on the white board. Teacher asks the students to study the circuit diagram. Teacher asks student to explore and explain the process of constant –current charging method, of charging batteries. Teacher asks the student to study the second circuits where an inductor is connected in series with A.C input.		
	Differences between constant voltage and constant current methods of charging batteries	Teacher guides the students to identify the differences between constant voltage and constant current charging methods. In constant voltage method, the charging voltage is maintained constant at a value slightly on excess of e.m.f of a fully charged multiplied by the number of cells connected in series while in constant current method, the current flowing through the rheostat or inductor depends on its setting and on the potential difference between its terminals which is also the difference between output voltage of the rectifier and voltage required to charge the cells	Teacher identify the difference between constant voltage and constant current method as guided by the teacher	Exploration
Problem on constant current method of charging	Thirty lead acid secondary cells are to be charged using constant current method. The e.m.f of each cell at the beginning and	Teacher writes the question on the whiteboard and asks the students to carefully study it. Teacher asks the students to identify the facts needed for solving the problem Teacher guides the students as they identifies the fact needed to solve the problem	Students write the question in their notebooks Students study the question carefully Students identify the facts needed for solving the problem	Exploration

	end of charge are 1.9V and 2.7V respectively. The output voltage of the rectifier used in the charger is 157v. (a) The value in ohms to which the rheostat must be set to give an initial charging current of 5A. (b) The current at the end of the charge if the rheostat is left at this setting.			
		Teacher asks the students to identify the parameters for solving the problem Teacher guides the students as they identifies the parameter needed to solve the problem	Students identify the parameters for solving the problem E = V – Ir V = 1.9V, E = 2.2V I = 5A	Planning
		Teacher asks students to solve the problem Teacher guides the students as they as they solve the problem	Students solve the problem a) potential difference across rheostat at commencement of charge = 157 – (30 × 1.9) = 100V Rheostat setting in ohms $R = \frac{V}{I} = \frac{100}{5}$ R = 20Ω b) potential difference across rheostat at the end of charge = 157 – (30 × 2.7) =	Solve

			76V Current at end of charge $I = \frac{V}{R} = \frac{76}{20} = 3.8A$	
		Teacher ask the students to check if their answer is correct Teacher guides the students as they examining their answer	Students examine their answer if they are correct 100V = 157 – 30(1.9) 100V = 100V Since R = 20 Ω and I = 5A V = IR 100V = 5 × 20 100 = 100 76V = 157 – 30(2.7) 76V = 76V Since R = 20 Ω, I = 3.8 V = IR = 3.8 × 20 76 = 76	Examine
Evaluation	Explain the constant current charging process? and what is the problem on constant current method of charging?	Teacher ask students question based on the concluded lesson	Students answer the teacher question.	Teacher give more explaination.
Assignment	A cell has an internal resistance of 0.02 Ω and an e.m.f. of 2.0V. calculate its terminal p.d. if it delivers (a) 5A, (b) 50A.	Teacher copy the assignment on the whiteboard Teacher asks the students to copy the assignment in the notebooks	Students copy the assignment in their notebooks	

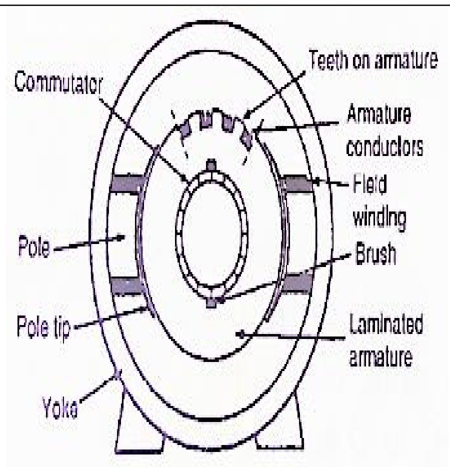
LESSON FOUR
Topic: DC Machines
Duration: 45 minutes
Class: NTC II
Behavioural Objectives: At the end of the lesson, the students should be able to:

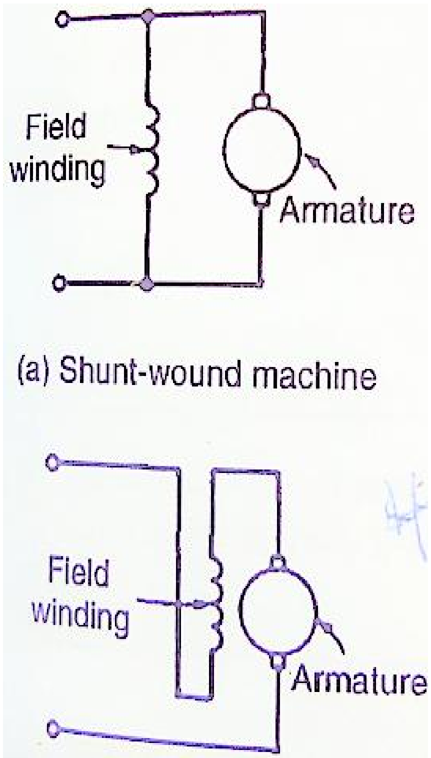
2. Distinguish between the function of a motor and a generator
3. Describe the construction of a DC machine
4. Distinguish between wave and lap windings
5. Understand shunt, series and compound winding of DC machine
6. Calculate generated e.m.f in an amateur winding using $E = \frac{2P\phi nZ}{a}$

Entry Behaviour: The students have been taught machines

Instructional Resources: Charts, posters, DC electric motors and generator

Instructional Procedure

Content Developme nt	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
Dc Motors and Generators	Function of motor and generator	Teacher guides the students to describe motor as an electrical machine that convert electrical energy to mechanical energy while generator converts mechanical energy to electrical energy	Students describe motor and generator as guided by the teacher and write down notes in their notebooks	Exploration
	DC machine construction	 Teacher draw the diagram of a DC machine with all its features or parts as shown above. Teacher asks students to study the diagram properly Teacher guide the students as they state the functions of each part (I) stator – yoke, poles and field windings (II) armature –	Students study the diagram Students state the functions of the various parts in a DC machine	Exploration

		core, armature winding and commutator		
	Wave and Lap windings	Teacher guides the students to know that armature winding can be divided into two – wave winding and lap winding Teacher guides the students as they explain the meaning of wave and lap windings	Students describe the meaning of wave and lap windings	Exploration
	Shunt series and compound windings	 (a) Shunt-wound machine b. series wound machine Teacher present the circuit diagrams of the various windings Teacher asks the students to study the circuit diagrams Teacher guides the students as they study the circuit diagrams of various windings Teacher guide the students to discover that in shunt the field winding is connected in parallel with the armature. In series, the field winding is connected in series with the armature while a compound has combination of series and shunt	Students draw the circuit diagrams and study them properly. Student describe shunts, series and compounds windings Students state the differences among the three windings	

	Armature reaction	Teacher guide the students to describe armature reactions as the effects that magnetic field produced by armature current has on the magnetic field produced by the field system. In generator, it reduces output voltage. In motor, it increases speed.	Students describe the armature and state its effects on motor and generator	Exploration
	E.m.f generated in armature winding	Teacher guides the students to discover the following parameters Let Z = number of armature conductors ϕ = useful flux per pole in webs P = number of pairs of poles and n = armature speed in rev/s E.m.f generated by the armature = e.m.f generated by one of the parallel parts. Each conductor passes ZP pole per revolution and this cut ZPϕwebers of magnetic flux per revolution. Hence flux by one conductor per second = 2Pϕn wb and conductor is given by E = 2Pϕn volts (1 volt = 1 weber per second) Let C = no of parallel paths through the winding between positive and negative brushes C = 2 for a ware winding C = 2P for lap winding The no of conductors in series in each path = $\frac{Z}{C}$ The total e.m.f between brushes = average e.m.f conductors (no of conductors in series per path) =2Pϕn $\frac{Z}{C}$ Therefore generated e.m.f, E = $\frac{2P\phi nZ}{C}$ volts Generated e.m.f E and ϕw	Students discover the parameters and derive the formular for calculating e.m.f generated in armature winding	Exploration
Problems on	An 8-pole, wave-	Teacher write problem on the	Students write the question	Exploration

generated e.m.f in armature winding	connected armature has 600 conductors and is driven at 625 rev/min. if the flux per pole is 20 mWb, determine the generated e.m.f.	whiteboard. Teacher asks the students to study the problem carefully. Teacher asks the students to identify the fact needed to solve the problem	in their notebooks Students identify the facts required for solving the problem	
		Teacher asks the students to identify the parameters needed for solving the problem	Students identify the parameters needed for solving the problem Z = 600, C = 2 (for a wave winding) P = 4 pairs N = 625 rev/min ϕ = 200mWb	Planning
		Teacher asks students to solve the problem Teacher guides the students as they as they solve the problem	Students solve the problem $n = \frac{625}{60}$rev/s, $\phi = 20\times10^{-3}$wb Generated e.m.f $E = \frac{2P\phi nZ}{C} = \frac{2(4)(20\times10^{-3}(\frac{625}{60}\times600}{2}$ = 500V	Solve
		Teacher Examine the students to check if their answer is correct Teacher guides the students as they examining their answer	Students examine their answer if they are correct $500 = \frac{2(4)(20\times10-3)(\frac{625}{60})600}{2}$	Examine

Evaluation	Identify the difference between the shunt series and compound windings?	Teacher ask students questions on the concluded lesson.	Students answer teacher question.	Teacher explain further.
Assignment	A 4-pole generator has a lap-wound armature with 50 slots with 16 conductors per slot. The useful flux per pole is 30 mWb. Determine the speed at which the machine must be driven to generate an e.m.f. of 240V.	Teacher copy the assignment on the whiteboard Teacher asks the students to copy the assignment in the notebooks	Students copy the assignment in their notebooks	

LESSON FIVE

Topic: DC Generator

Class: NTC II

Duration: 60 minutes

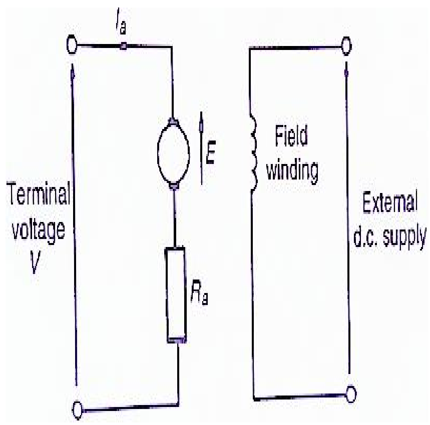
Behavioral Objective: At the end of the lesson, the students should be able to:

1. Describe types of D.C generators
2. Calculate generated e.m.f for a generator using $E = V + I_aR_a$
3. Describe the characteristics of separately secured generator
4. State typical applications of dc generators
5. Calculate the efficiency of a dc generator

Entry Behavior: student have already been taught on generator types.

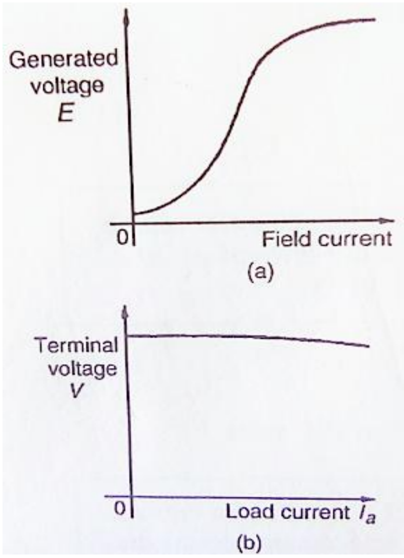
Instructional Resources: dc generators, dynamos, charts and posters

Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Student Activities	Instructional Strategies
DC generator	Description of DC generators	Teacher guides the students to classify generators according to their field excitation i) separately excited generators- the field is connected directly to a source of supply ii) self-excited generators – field winding receives its supply from the armature (shunt, series, compound wound generators)	Students classify generators into separately and self- excited generators Students write down notes in their notebooks	Exploration
	Types of DC generator and their characteristics Separately excited generator	Teacher present the circuit diagrams of a separately excited generator to the students as shown below.  Teacher asks the students to study it carefully. Teacher asks the students to derive	Students study the circuit diagram carefully, Students draw the circuit diagram in their notebooks Students derive the formular for calculating terminal voltage ($V = E - I_aR_a$) or generated e.m.f ($E = V + I_aR_a$)	Exploration

		the formular for calculating terminal voltage ($V = E - I_aR_a$) or generated e.m.f ($E = V + I_aR_a$)		
Problem on DC generators	A separately-excited generator develops a no-load e.m.f. of 150 V at an armature speed of 20 rev/s and a flux per pole of 0.10 Wb. Determine the generated e.m.f. when (a) the speed increases to 25 rev/s and the pole flux remains unchanged, (b) the speed remains at 20 rev/s and the pole flux is decreased to 0.08 Wb, and (c) the sped increases to 24 rev/s and the pole flux is decreased to 0.07 Wb.	Teacher write the problem on the whiteboard Teacher asks the students to study it carefully and identify the facts needed for solving the problem	Students write the question in their notebooks Students study the question carefully and identify the facts required for solving the problem	Exploration
		Teacher asks the students to identify the parameters for solving the problem Teacher guide the students as they identify the parameters for solving the problem	Students identify the parameters needed for solving the problem a) generated e.m.f E and ϕn $E_1 = 150V$, $\phi_1 =$ O.1Wb, $n_1 =$ 20rev/sec $E_2 = ?$, $n_2 = 25$rev/sec, , $\phi_2 = 0.1$Wb b) $E_1 = 150V$, ϕ_1 = O.1Wb, $n_1 =$	Planning

			20rev/sec E_3= ?, n_3 = 20rev/sec, , ϕ_3 = 0.08Wb c) E_1 = 150V, ϕ_1 = O.1Wb, n_1 = 20rev/sec E_4= ?, n_4 = 24rev/sec, , ϕ_4 = 0.07Wb	
		Teacher asks the students to solve the problem Teacher guides the students as they solve the problem	Students solve the problem Since $\frac{E_1}{E_2} = \frac{\phi_1 n_1}{\phi_2 n_2}$ a) Hence $\frac{150}{E_2} = \frac{(0.10)(20)}{0.10 \times 25}$ $E_2 = \frac{150 \times 0.10 \times 25}{0.10 \times 20}$ = 187.5V b) $\frac{150}{E_3} = \frac{0.10 \times 20}{0.08 \times 20}$ $E_3 = \frac{150 \times 0.08 \times 20}{0.10 \times 20}$ = 120V c) $\frac{150}{E_4} = \frac{0.10 \times 20}{0.07 \times 24}$ $E_4 = \frac{150 \times 0.07 \times 24}{0.10 \times 20}$ = 126V	Solving the problem
		Teacher examine the students to check if their answer is correct	Students examine their answer a) 150×0.1×20 = 187×0.1×20 375 = 375 b) 150×0.08×20 = 120×0.1×20 240 = 240 c) 150×0.07×24 = 126×0.1×20	Examine

			252 = 252	
		Teacher guides the students to study the graph of separately excited characteristics a) a typical separately excited generator open circuit b) load characteristics 	Students study the graphs in order to differentiate between open-circuit and load characteristics of separately excited generators	Exploration
Evaluation	Mention the common types of dc generator and their advantage and disadvantage over each other?	Teacher ask students question on the current lesson.	Students answer the teacher questions.	More explanation by the teacher
Assignment	A generator is connected to a 60Ω load and a current of 8 A flows. If the armature resistance is 1Ω. Determine (a) the terminal voltage, and (b) the generated e.m.f.	Teacher guides the students to state the applications, advantages and disadvantages of separately excited generators	Students state the applications, advantages and disadvantages of separately excited generators.	

LESSON SIX

Topic: DC Generator Characteristics

Duration: 45 minutes

Class: NTC II

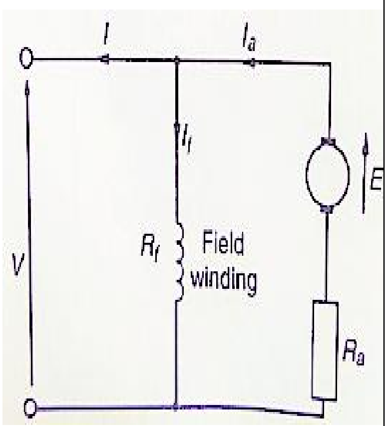
Behavioral Objectives: At the end of the lesson, the students should be able to:

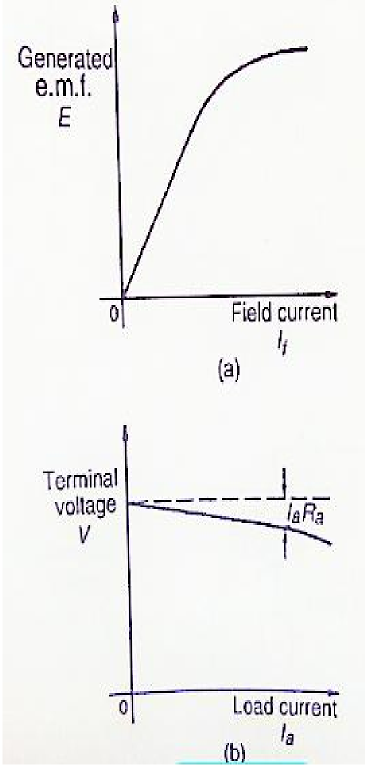
6. Describe shunt-wound generator
7. Describe the characteristics of shunt-wound generators
8. State the applications, advantages and disadvantages of shunt-wound generator
9. Describe the series-wound generator
10. Describe the characteristics of series-wound generator
11. State the application of series-wound generator
12. Solve simple problems on shunt-wound and series-wound generators

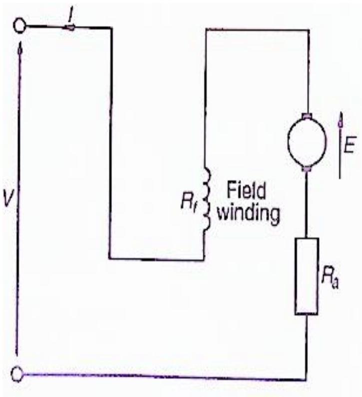
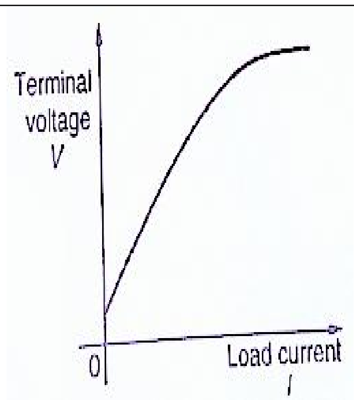
Previous Knowledge: The students have been taught DC machines

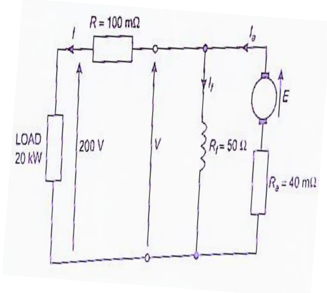
Instructional Resources: dc generators, dynamos, charts and posters

Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Student Activities	Instructional Strategies
Characteristic of Dc generator	Shunt- wound generator	Teacher present circuit diagram of shunt-wound generator on the whiteboard Teacher asks the students to study the circuit diagram  Teacher guide the students to study the circuit diagram of shunt-wound generator above. Teacher guides the students to discover that in shunt-wound generator, the field winding is connected in parallel with the armature.	Students study the circuit diagram Students explore, brainstorm and discover that in shunt-wound generator, the field winding is connected in parallel with armature	Exploration

		In the circuit above, $V = E - I_aR_a$ $E = V + I_aR_a$ $I_a = I_f + I$ (from Kirchhoff's current law where I_a = armature current I_f = field current $I_f = \frac{V}{RF}$ I = load current		
	Characteristics of shunt-wound generator	 Teacher present the graphs of shunt-wound generator on the whiteboard Teacher asks the students to study the graphs to discover the relationship that exist between (i) generated e.m.f and field current (ii) terminal voltage and load current in shunt-wound generator Teacher guide the students as they establish the relationship	Students draw the graphs Students study the graphs Students establish the relationship between (i) generated e.m.f and field current (ii) terminal voltage and load current in shunt-wound generator	Exploration

	Applications, advantages and disadvantages of shunt-wound generators	Teacher guides the students to state the applications, advantages and disadvantages of shunt-wound generators	Students state the applications, advantages and disadvantages of shunt-wound generators	Explorati on
Series-wound generator	Series-wound generator	 Teacher draw the circuit diagram of series-wound generator on the whiteboard Teacher asks the students to study the circuit diagram Teacher guide the students as they study the circuit diagram Teacher guide the students to discover that in series-wound generators, the field winding are connected in series with the armature	Students draw the circuit diagrams in their notes Students study the circuit diagram Students discover that the field winding are connected in series with the armature in series-wound generators	Explorati on
	Characteristics of series – wound generator	 Teacher present the graph of series-wound generator on the whiteboard to establish its characteristics Teacher asks the students to study the graph to establish the relationship that exist	Students draw the graphs of series-wound generator characteristics Students study the graph and establish the relationship that exist between terminal voltage and load current	Explorati on

		between terminal voltage and load current		
	Applications, advantages and disadvantages of series-wound generators	Teacher guides the students to state the applications, advantages and disadvantages of series-wound generators	Students state the applications, advantages and disadvantages of series-wound generators	Explorati on
Problem on shunt-wound and series-wound generators	A shunt generator supplies a 20KW load at 200V through cables of resistance, R = 100m Ω. If the field winding resistance, R_f =50 Ω and the armature resistance, R_a = 40m Ω, determine (a) the terminal voltage, and (b) the e.m.f. generated in the armature.	Teacher writes the problem on the whiteboard Teacher asks the students to study the problem Teacher asks the students to identify the facts that are required for solving the problem Teacher guides the students as they identify the facts needed for solving the problem	Students write the problem in their notebooks. Students indentify the facts needed for solving the problem	Explorati on
		Teacher asks the students to identify the parameters that are needed in solving the problem. Teacher asks the students to draw the circuit diagram. Teacher guide the students as they draw the circuit diagram	 Students draw the circuit diagram. Students identify the parameters needed for solving the problem P = 20KW, supply V = 200V R = 100mΩ, R_f = 50Ω R_a = 40mΩ	Planning
		Teacher asks the students to solve the problems	Students solve the problem	Solve

		Teacher guides the students as they solve the problem	a) Load current $I = \frac{20000}{200}$ = 100A Volt drop in the cables to the load = IR = $100 \times 100 \times 10^{-3}$ = 10V Hence terminal voltage V = 200+10 = 20V b) Armature current $I_a = I_f + I$ field current $I_f = \frac{V}{R_f} = \frac{210}{50}$ = 4,2A Hence, $I_a = I_f + I$ = 4.2 + 100 = 104.2A Generated e.m.f $E = V + I_aR_a$ = 210 + ($104.2 \times 40 \times 10^{-3}$) = 210 + 4.16 = 214.17V	
		Teacher asks the students to examine their answers to know if they are correct or not Teacher guide the students as they examining their answers to know if they are correct or not	Teacher examine their answers to see if they are correct or not $V = E - I_aR_a$ = 214.17– ($104.2 \times 40 \times 10^{-3}$) = 214.17-4.168 = 210V	Examine
Evaluation	State where the shunt and series generator are applicable and their advantage and disadvantages.	Teacher ask students questions based on concluded lesson.	Students answer the teacher question.	Teacher explain more.
Assignment	Determine the internal voltage of a generator which develops an e.m.f of 200V and has an armature current of 30A on load.	Teacher write the assignment on the whiteboard Teacher asks the students to copy the assignment in their notebook	Students copy their assignment in their notebooks	

	Assume the armature resistance is 0.30 Ω			

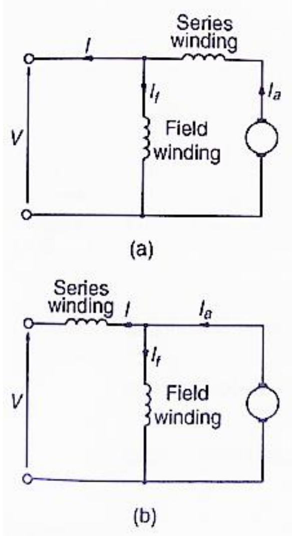
LESSON SEVEN
Topic: DC Generator Characteristics II

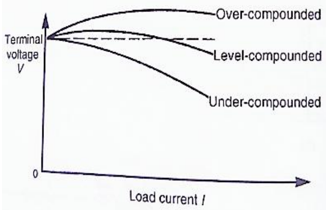
Duration: 45 minutes
Class: NTC II
Behavioral Objectives: At the end of the lesson, the students should be able to:

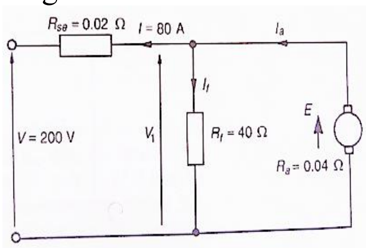
13. Describe Compound-wound generator
14. Describe the characteristics of compound-wound generator
15. State the applications, advantages and disadvantages of compound-wound generator
16. List DC machine losses
17. Solve simple problem on compound-wound generator
18. Calculate the efficiency of a DC generator

Previous Knowledge: The students have been taught shunt-wound and series-wound generators
Instructional Resources: dc generators or dynamos, charts and posters

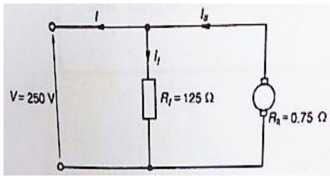
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Student Activities	Instructional Strategies
Compound wound generator	Description of compound-wound generator	 Teacher present the circuit diagram of compound-wound generators on the whiteboard Teacher asks the students to study the circuit diagram. Teacher guides the students to discover that a compound wound generator is a combination of series wound and shunt-wound generators	Students draw the circuit diagrams in their notebooks. Students study the circuit diagrams Students discover that compound-wound generator is a combination of series-wound and shunt-wound generators	Exploration

	Characteristics of compound-wound generator	 Teacher draw the graph of compound-wound generator on the whiteboard Teacher asks the students to study the graph and establish the relationship that exists between terminal voltage, V and load current, I in compound-wound generator Teacher guide the students as they establish the relationship that exist between terminal voltage V and load current, I in compound-wound generator	Students draw the graphs in their notebooks Students study the graph and establish the relationship that exists between the terminal voltage V and load current I in compound-wound generator	Exploration
	Application of compound-wound generator	Teacher guide the students to state the applications, advantages and disadvantages of compound-wound generator	Students state the applications, advantages and disadvantages of compound-wound generator	Exploration
Losses in Dc machine	DC machine losses	Teacher guides the students to identify the losses in DC machine i) copper loss ii) iron (core) loss iii) friction and windage loss iv) brush contact loss	Students identify the losses in DC machines	Exploration
Problem on Dc machine	A short – shunt compound generator supplies 80A at 2000V. If the field resistance, Rf = 40ohms,	Teacher write the problem on the whiteboard Teacher asks the students to study the problem and identify the facts that are needed in solving the problem.	Students write the problem in their notebooks. Students study the problem and identify the facts that are required for solving the problem	Planning

	the series resistance, Rsc = 0.02 and the armature resistance, Ra = 0.04, determine the e.m.f generated	Teacher guides the students as they identify the facts = that are required in solving the problem		
		Teacher asks the students to identify the parameters that are needed for solving the problems Teacher asks the students to draw the circuit diagram. Teacher guide the students as they draw the circuit diagram Teacher guides the students as they identify the parameters	Students identify the parameters needed for solving the problem I = 80A, V = 200V Rf = 40Ω, *RSc = 0.02*Ω $R_a = 0.04\ \Omega$ Students draw the circuit diagram 	Planning
		Teacher asks the students to solve the problem Teacher guides the students as they solve the problem	Voltage drop in series winding = IR_{SC} = 80×0.02 = 1.6V Potential difference across the field winding = potential difference across armature = V_1 = 200+1.6 = 201.6V Field current $I_f = \frac{V_1}{R_f} = \frac{201.6}{40}$ = 5.04A Armature current $I_a = I + I_F$ = 80+5.04 = 85.05A Armature current, $I_a = I+I_F$ = 80+5.04 = 85.04A Generated e.m.f, $E = V_1 + I_aR_a$ = 201.6 + (85.04×0.04) = 201.6 + 3.4016	Solve

			=205V	
		Teacher asks the students to examine their answer if it is correct or not Teacher guides the students as they examining their answer if it is correct or not	Students examine their answer to check if it is correct or not $E = V_1 + I_aR_a$ $201.6 = 20 -(85.04\times0.04)$ $201.6 = 205 – 3.4016$ $201.6V = 201.6V$	Examine
Dc generator Efficiency	Efficiency of a DC generator	Teacher solve the students to define efficiency of an electrical machine as the ratio of the output power to the input power and usually expressed in percentage Efficiency, ŋ = $\frac{output\ power}{input\ power} \times 100\%$ Efficiency, ŋ = $\frac{VI}{VI \times IaRa + I_fV + C} \times 100$ The efficiency of a generator is maximum when the load is such that $I^2_aR_a = VI_f + C$ Teacher guides the students as they study the DC general efficiency formular	Students defined efficiency as the ratio of output power to the input power and usually express in % Students study the formular for calculating efficiency of a generator. Students write the definition and formular in their notebooks	Exploration
Problem on efficiency	A 10KW shunt generator having an armature circuit resistance of 0.75 Ω and a field resistance of 125 Ω, generates a terminal voltage of	Teacher write the problem on the whiteboard Teacher asks the students to study the problem and identify facts that are needed in solving the problems	Students study the problem and identify the facts that are needed in solving the problem Students copy the problem in their notebook	Exploration

	250V at full load. Determine the efficiency of the generator at full load, assuming the iron, friction and windage losses amount to 600 W.			
		Teacher asks the students to identify the parameter that are needed in solving the problem Teacher guide the students as they identify the parameters needed in solving the problems Teacher guide the students to draw the circuit diagram	Students identify the parameter needed in solving the problem Students draw the circuit diagram  P = 10kw, R_a = 0.75**Ω**, R_f = 12.5 **Ω**, V = 250 **Ω**, losses = 600W	Planning
		Teacher asks the students to solve the problem Teacher guides the students as they solve the problem	Students solve the problem Output power = 10000W = VI Load current, I = $\frac{10000}{V}$ = $\frac{10000}{250}$ = 40A Field current, I_f = $\frac{V}{R_f}$ = $\frac{250}{125}$ = 2A Armature current, I_a = I_f + I = 2+40 = 42A Efficiency, ŋ = $\frac{VI}{VI \times I^2aRa + I_fV + C} \times 100\%$ = $\frac{10000}{10000 + (42^2 \times 0.75) + (2 \times 250) +}$ = $\frac{10000}{12423} \times 100\%$ = 80.50%	Solving the problem

		Teacher asks the students to examine if their answer is correct or not Teacher guides the students as they examining if their answer is correct or not	Students examining their answer to ascertain whether it is correct or not Efficiency, ŋ = $\frac{output\ power}{input\ power} \times 100\%$ Output power = 10000W Input power = 12423W Ŋ = $\frac{10000}{12423} \times 100\%$ = 80.50%	Examine
Evaluation	State the application of compound wind generator and its advantage and disadvantage	Teacher ask students questions.	Students answer teacher questions.	Frther explanation by the teacher.
Assignment	A generator is connected to a 60 Ω load and a current of 8A flows. If the armature resistance is 1 Ω. Determine (a) the terminal voltage, and (b) the generated e.m.f.	Teacher asks the students to write the assignment in their notebooks	Students write the assignment in their notebooks	

LESSON EIGHT
Topic: DC Motor
Duration: 45 minutes

Class: NTC II

Behavioural Objectives: At the end of the lesson, the students should be able to:

- Define Back e.m.f of a dc motor
- Derive the formular for calculating torque in a DC machine
- Describe shunt-wound motor and their characteristics
- State the application of shunt-wound motor
- Solve simple problems on shunt-wound motor
- Describe series-wound motor and their characteristics
- State the applications of series-wound motor
- Solve simple problems on series-wound motor

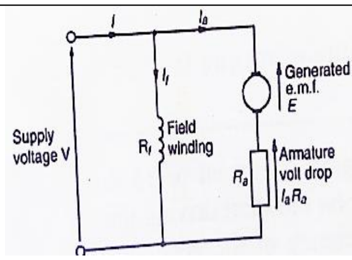
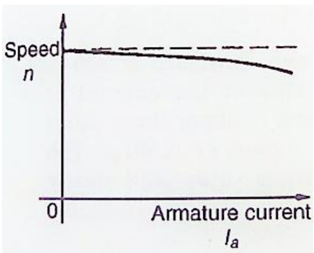
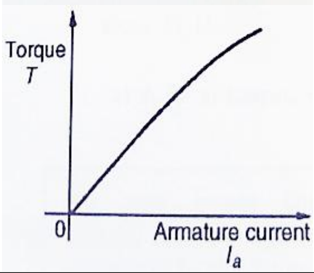
Previous Knowledge: The students have been taught dc generators

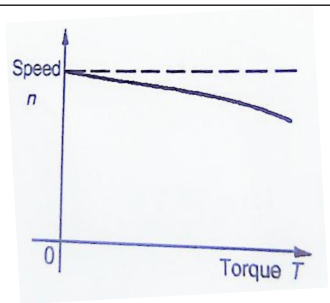
Instructional Resources: dc motors, charts and posters

Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
Back emf	Definition of Back e.m.f	Teacher guide the students to define back e.m.f as an e.m.f induced in the armature of a rotating motor. Back e.m.f, $V = E + I_aR_a$ or $E = V - I_aR_a$	Students define back e.m.f as an e.m.f inducted in the armature of a rotating motor $V = E + I_aR_a$ or $E = V - I_aR_a$ Students write down the definition in their notebooks	Exploration
DC Machine torque	Torque of a DC machine	Teacher guides the students to derive the formular for calculating torque of a DC machine. In a DC motor, the supply voltage, $V = E + I_aR_a$ $VI_a = EI_a + I^2{}_aR_a \times$ byI_a VI_a = power supplied to armature EI_a = mechanical power developed by the armature I_aR_a = loss due to armature resistance If T = torque in NM, then mechanical power developed is given by TW Watts Hence, $TW = 2\pi nT = EIa$	Students derive the formular for determining torque of a DC motor Students write the derivation in their notebooks	Exploration

		Torque, T = $\frac{EI_a}{2\pi n}$ Newton meter		
Problems on torque	Determine the torque developed by a 350V d.c. motor having an armature resistance of 0.5 Ω and running at 15 rev/s. the armature current is 60A.	Teacher write the problem on the whiteboard Teacher asks the students to identify the facts that are needed on solving the problem. Teacher guide the students as they identify the facts needed for solving the problem.	Students identify the facts that are needed for solving the problem. Students write the problem in their notebooks	Exploration
		Teacher asks the students to identify the parameters for solving the problems. Teacher guides the students as they identify the parameters	Students identify the parameters for solving the problems V = 350V, I_a = 0.5Ω, n = 15, Ia = 60A	Planning
		Teacher asks the students to solve problems Teacher guides the students as they solve problems	Students solve the problem Back e.m.f = E = V - IaRa = 350 – 60 × 0.5 = 320V Torque, T = $\frac{EI_a}{2\pi n}$ = $\frac{320 \times 60}{2\pi \times 15}$ = 203.7µm	Solve
		Teacher asks the students to examine their answers if correct or not Teacher guides the students as they examining their answers if correct or not	Students examine their answers V = E + IaRa = 320 + (60×0.5) = 320+30 = 350V	Examine
Shunt-wound motor	Shunt-wound motor description	Teacher draw the circuit diagram on the whiteboard	Students draw the circuit diagram in their notebooks Students study the circuit diagram and discover that the field winding is in parallel with the	Exploration

		 Teacher asks the students to draw and study the circuit diagram Teacher guides the students to discover that in shunt-wound motor, the field winding is in parallel with the armature Supply voltage, V = E + IaRa Generated e.m.f, E = V – IaRa Supply current, I = Ia + If from Kirchhoff's current law	armature in shunt-wound motor	
Shunt-wound motor characteristics	Characteristics of shunt-wound motor	Teacher draws the characteristic graphs of the shunt-wound motor on the whiteboard.  	Students draw the characteristics graphs of the shunt-wound motor on the whiteboard Students study the characteristics of shunt-wound motor	Exploration

		 i) The theoretical torque/armature current characteristics can be derived from expression T α ϕIa ii) E α ϕn, hence n = $\frac{E}{\Phi}$ speed of rotation, n α $\frac{E}{\Phi}$ α $\frac{V - IaRa}{\phi}$		
Problems shunt-wound motor	A 240V shunt motor takes a total current of 30A. If the field winding resistance R_f = 150 Ω and the armature resistance Ra = 0.4V. Determine (a) the current in the armature, and (b) the back e.m.f.	Teacher write the problem on the whiteboard Teacher asks the students to study the problem and identify the facts that are needed in solving the problems Teacher guides the students as they identify the facts needed to solve the problem	Students write the problems in their notebooks Students study the problem and identify the facts needed in solving the problem	Exploration
		Teacher asks the students to identify the parameters available in the problem. Teacher guides the students as they identify the parameters	Students identify the parameters that are needed for solving the problem V = 240V, I = 30A, Rf = 150Ω, Ra = 0.4Ω	Planning
		Teacher asks the students to solve the problems Teacher guides the students as they solve the problem	Students solve the problem a) field current I_f = $\frac{V}{Rf} = \frac{240}{150}$ = 1.6A supply current I = I_a	Solve

			$- I_f$ = 30-1.6 = 28.4A b) Back e.m.f, E = V-IaRa =240 – (28.4×0.4) = 240 – 11.36 = 228.64V	
		Teacher asks the students to examine if their answer is correct Teacher guides the students as they examining their answer	Students examine their answers to ascertain whether it is correct or not $I = I_a + I_f$ 30 = 28.4 + 1.6, 30 = 30 V = E + IaRa, 240 = 228.64 + (28.4×0.4) 240 = 228.64 + 11.36 240 = 240	Examine
	Applications of shunt-wound DC motor	Teacher guide the students to state the applications of shunt-wound motor to include driving the machine, lines of shaft, fans, conveyor belts, pumps, compressor, driving machines, etc	Students state the applications of shunt-wound DC motor Students write the applications of shunt-wound DC motor in their notebooks	Exploration
Evaluation	state the applications of shunt-wound motor and how can one solve simple problem of compound wind motors.	Teacher ask students questions based on the concluded lesson	Student gives answer to teacher questions	Teacher explain further.
Assignment	A 100V d.c. generator supplies a	Teacher asks the students to copy the assignment in their notebooks	Students copy the assignment in their notebooks	

	current of 15 A when running at 1500 rev/min. if the torque on the shaft driving the generator is 12Nm, determine (a) the efficiency of the generator and (b) the power loss in the generator.			

LESSON NINE

Topic: Series-wound and Compound-wound Motors

Duration: 60 minutes

Class: NTC II

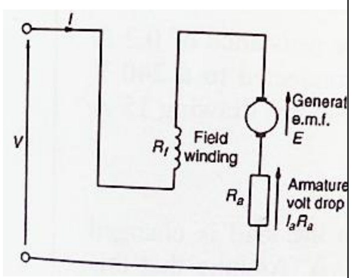
Behavioural Objectives: At the end of the lesson, the students should be able to:

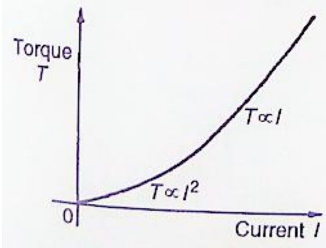
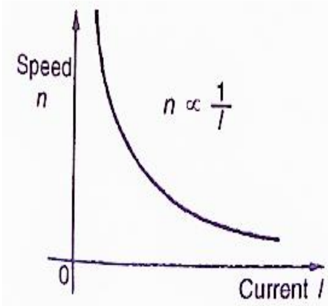
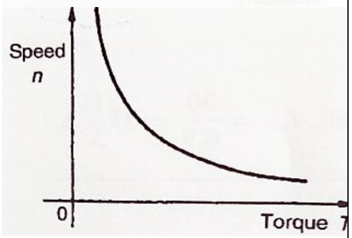
- Describe series-wound motor
- Describe the characteristics of series-wound motor
- State the applications of series-wound motor
- Describe compound-wound motor
- Describe the characteristics of compound-wound motor
- State the application of compound-wound motor
- Derive the formular for calculating efficiency of DC motor
- Solve simple problems on series-wound motor
- Solve simple problems on efficiency of a dc motor

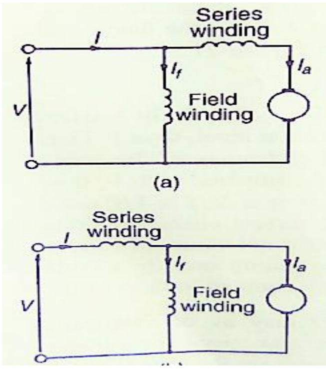
Entry Behaviour: Students have been taught shunt-wound DC motor

Instructional Resources: charts, posters, dc motor

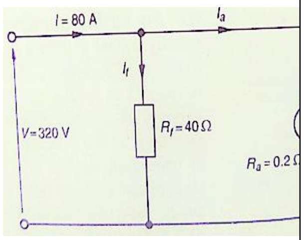
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
Series-wound dc motor	Description of series-wound DC motor	Teacher draw the circuit diagram of a series-wound motor on the whiteboard  Teacher asks the students to study the circuit diagram Teacher guides the students to discover that in series-wound motor, field winding is in series with the armature Supply voltage V = E + (Ra + Rf) or generated e.m.f, E = V – I(Ra + Rf)	Students draw the circuit diagram of a series-wound motor DC motor in their notebooks. Students study the circuit diagram of a series-wound motor	Exploration
Series-wound motor characterist	Characteristics of a series-wound dc motor		Students draw the graph in their notebooks Students study the	Exploration

ics		   Teacher draws the graph of the characteristics of a series-wound motor. Teacher asks the students to study the graphs and establish the relationship that exist between torque and current, speed and current and speed and torque in series-wound motor i) ϕ α I, I α I^2 and T α I ii) n α $\frac{(V - IaRa)}{\phi}$, n α $\frac{V-IR}{I}$, n α $\frac{V}{I}$ α $\frac{I}{I}$ Teacher guide the students as they study the graph and establish the relationship	graph and establish the relationship between i) torque and current ii) speed and current iii) current and speed	
	Applications of series-wound motor	Teacher guide the students to state the applications of series-wound motor – train, milk delivery vehicles, driving fans, crane,	Students state the application of series-wound motor	Exploration

		hoists, nbzVSA9Retc		
Dc compound-wound motor	Description of compound-wound motor	Teacher draw the circuit diagram of compound-wound motor  Teacher asks the students to study the circuit diagram Teacher guides the students to discover the types of compound-wound motor i) cumulative compound-wound motor ii) differential compound-wound motor iii) long-shunt compound-wound motor iv) short-shunt compound-wound motor	Students draw the circuit diagram of compound-wound motor in their notebooks Students study the circuit diagrams Students discovered the types of compound-wound motors	Planning
charact eristics	Characteristics of a compound-wound motor	Teacher guide the students to discover that compound-wound motor had both series and shunt field winding. The characteristics similar in shape to a series wound motor	Students discovered that the characteristics of compound-wound motor is similar to that of series-wound motor	Exploration
	Applications of compound-wound motor	Teacher guide the students to state the applications of compound-wound motor. It is used where heavy load may occur such as for driving plunger pumps, presses, gear lift,	Students state the applications of compound-wound motor	Exploration

		conveyors, hoists, etc		
Dc motor efficiency	Efficiency of a DC motor	Efficiency, ŋ = $\frac{output\ power}{input\ power}$ × 100% Total losses = I^2aRa + IfV + C (shunt motor) where C = sum of Iron , friction and windage losses Input power = VI, output power = VI – losses = VI – I^2Ra – IfV – C Hence, Efficiency ŋ = $\frac{VI - I^2aRa - IfV - C}{VI}$ × 100% The efficiency of a motor is maximum when the load is such that I^2aRa + IfV + C	Students study the former for determining Efficiency in a DC motor Students write the formular in their notebooks	Exploration
Problems on Efficiency	A 320V shunt motor takes a total current of 80A and runs at 1000 rev/min. If the iron, friction and windage losses amount to 1.5KW, the shunt field resistance is 40 Ω and the armature resistance is 0.2 Ω, determine the overall efficiency of the motor.	Teacher write the problem on the whiteboard Teacher asks the students to study the problem and identify the facts that are needed to solve the problem. Teacher guides the students as they identify the facts needed	Students write the problems in their notebooks Students study the problems and identify the facts that are required to solve the problem	Exploration
		Teacher asks the students to identify the parameters available in the problem that can be used to solve the problem	Students identify the parameters required for solving the problem Students draw the	Planning

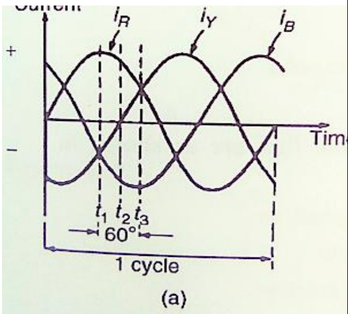
		Teacher guides the students as they identify the parameter	circuit diagrams  V = 320V, I = 80A, n = 1000revolutions, C = 1.5kW, Rf = 40Ω, Ra = 0.2Ω	
		Teacher asks the students to solve the problem. Teacher guides the students as they solve the problem	Students solve the problem Field current, If = $\frac{V}{Rf} = \frac{320}{40}$ = 8A Armature current Ia = I – If = 80 – 8.72A C = Iron, friction and windage losses = 1500W Efficiency ŋ = $\frac{VI - I^2 aRa - IfV - C}{VI} \times$ 100% = $\frac{(3020 \times 80) - (12^2 \times 0.2) - (8 \times 3200 - 1500}{320 \times 80}$ × 100% = $\frac{25600 - 1036.8 - 2560 - 1500}{25600} \times 10$ 0% = $\frac{20503.2}{25600} \times 100\%$ = 80.1%	Solve
		Teacher asks the students to examining if their answer is correct or not	Students examine their answer 80.1% = $\frac{801}{1000}$ = $\frac{20503.2}{25600}$ = $\frac{0.8008}{10.000}$ = 81.1%	Examine
Evaluation	Describe the	Teacher ask students	Students answer	Teacher

	common characteristic of series wind motor and state the common problems associated with series wind motors	questions based on concluded lesson.	teacher questions	give further explanations
Assignment	A 250V series motor draws a current of 40A. The armature resistance is 0.15 Ω and the field resistance is 0.05 Ω. Determine the maximum efficiency of the motor.	Teacher write the assignment on the whiteboard Teacher asks the students to copy the assignment in their notebooks.	Students copy the assignment in their notebooks.	

LESSON TEN
Topic: Alternating Current Motor
Duration: 45 minutes
Class: NTC II
Behavioural Objectives: At the end of the lesson, the students should be able to:

- Describe how a rotating magnetic field is produced
- State the synchronous speed, n_S of a three phase induction motor
- Describe the operation of a three phase induction motor
- State the advantages of a three phase induction motor
- Understand and calculate slip
- State the application of induction motor

Previous Knowledge: Students have been taught DC Motors
Instructional Resources: charts, posters, AC motor
Instructional Procedures

Content Developme nt	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
AC motor	Description of how a rotating magnetic field is produces	Teacher present the sine-wave of a three single-loop conductor, one for each phase to explain how magnetic field is produced by a rotating conductor  Teacher asks the students to study the sine wave Teacher guides the students as they study the sine wave	Students draw the sine wave of a three single loop conductor to explain how magnetic field is produced Students explain how magnetic field is produced	Exploration
	Synchronous speed	Teacher guides the students to discover that synchronous speed $n_S = \frac{f}{p}$ rev/sec where f = frequency and p = pairs of pole	Students discovered that synchronous speed $n_S = \frac{f}{p}$ rev/sec	Exploration
Problems	A three-phase two-	Teacher writes the	Students write	Exploration

on synchronous speed	pole induction motor is connected to a 50 Hz supply. Determine the synchronous speed of the motor in rev/min.	problem on the whiteboard Teacher asks the students to study the problems and identify the facts needed in solving the problem Teacher guides the students as they identify the facts	the problem in their notebooks Students study the problem and identify the facts that are needed for solving the problem	
		Teacher asks the students to identify the parameters that can be used to solve the problem Teacher guides the students as they identify the parameters	Students identify the parameters for solving the problem P = no of pairs of pole = 1 F = 50 $n_S = \frac{f}{p}$	Planning
		Teacher asks the students to solve the problem Teacher guides the students as they solve the problem	Students solve the problem $n_S = \frac{f}{p} = \frac{50}{1} =$ 50rev/s = 50×60rev/min = 3000rev/min	Solve
		Teacher asks the students to examine if their answer is correct	Students examine their answer $F = n_S \times p$ F = 50×1 = 50Hz	Examine
	Principle of operation of a three phase induction motor	Teacher guides the students to understand the principle of operation of a three phase induction motor	Students listen at the end of explaining the principle of operation of a three-phase induction motor	Exploration
	Slip	Teacher guides the students to understand that the difference between the rotor speed,	Students explain slip, S as $\frac{(n_s - n_r)}{n_s} \times 100\%$	Exploration

		n_r and the synchronous speed, n_S is called slip speed = n_S - n_r rev/s The ratio $\frac{(n_s - n_r)}{n_s}$ is called fractional slip or just the slip, S and usually expressed in percentage. Thus, slip, S = $\frac{(n_s - n_r)}{n_s} \times 100\%$	Students write the formular in their notebooks	
Problem on slip	The stator of a 3-phase, 4-pole induction motor is connected to a $50H_Z$ supply. The rotor runs at 1455 rev/min at full load. Determine (a) the synchronous speed and (b) the slip at full load.	Teacher write the problem on the whiteboard Teacher asks the students to study the problem and identify facts that are needed in solving problem Teacher guide the students as they solve the problem	Students write the problem in their notebooks Students study the problem and identify facts that are needed in solving the problem	Exploration
		Teacher asks the students to identify the parameters for solving the problem Teacher guides the students as they identify the parameters	Students identify the parameters for solving the problem No of par of pole, P = $\frac{4}{2}$ = 2 F = 50Hz, n_r = 1453revolutions	Planning to solve the problems
		Teacher asks the students to solve the problem Teacher guides the students as they solve the problem	Student solve the problem a) Synchronous speed, $n_r = \frac{f}{p} = \frac{50}{2}$ = 25rev/s b) Motor speed, $n_r = \frac{1453}{60}$ = 24.25rev/s b) the slip, S = $\frac{(n_s - n_r)}{n_s} \times 100\%$ =	Solve

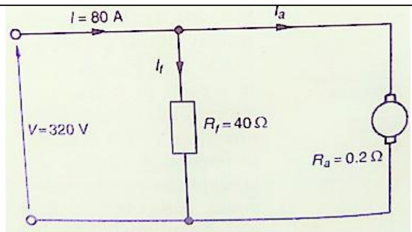
			$\frac{25-24.25}{25} \times 100$ $= 3\%$	
		Teacher asks the students to examining if their answer is correct or not	Students examine their answer $F = n_s \times p = 25 \times 2 = 50Hz$ $N_r = 60 \times 2 \times 25 = 1455 rev/min$	Examine
Three-phase induction motor	Advantages of induction motor	Teacher guide the students to state the advantages of induction motor i) squirrel-cage induction motors ii) wound rotor induction motors iii) double-cage induction motors	Students state the advantages of induction motor i) squirrel-cage induction motors ii) wound rotor induction motors iii) double-cage induction motors	Exploration
	Application of three-phase induction motor	Teacher guide the students to state the application of a three-phase induction motor	Students state the application of a three-phase induction motor – tools, pumps and mill motors	Exploration
Evaluation	What is the difference between synchronous and un- synchronous speed ac motor	Teacher ask students questions.	Students answer the teacher questions	Explanation by the teacher.
Assignment	The frequency of the supply to the stator of an 8-pole induction motor is $50H_Z$ and the rotor frequency is $3H_Z$. Determine (a) the slip, and (b) the rotor speed.	Teacher write the problem on the whiteboard Teacher asks the students to copy the problem in their notebooks	Students copy the problems in their notebooks	

APPENDIX B
RUSBULT PROBLEM SOLVING LESSON PLAN

LESSON ONE
Topic: Cell and Battery Circuits
Duration: 45 minutes
Class: NTC II
Behavioural Objectives: At the end of the lesson, the students should be able to:

- Define the terms e.m.f and internal resistance, r of a cell
- Differentiate between a cell and a battery
- Perform simple calculations using V = E – Ir
- Determine the total e.m.f and total internal resistance for cells connected in series and parallel
- Distinguish between primary and secondary cell

Entry Behaviour: students have been taught Ohms law
Instructional Resources: Batteries, charts, cells and posters
Instructional Procedure

Content Developme nt	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
EMF and Internal Resistance	Definition of an e.m.f, E and internal resistance of a cell	 Teacher present the circuit diagram a voltmeter connected to a circuit as shown above. Teacher explains the circuit to the student to study and draw the circuit diagram. Teacher establish the relationship among the voltmeter, current and the voltage in the circuit. Teacher define electromotive force (emf), E of a cell as potential difference between its terminals when it is not connected to a load and it is measured by using a high resistance voltmeter connected in parallel with the cell. Teacher guide the students to	Students study the circuit diagram and explain the relationship among R, r, E and V in the circuit. Students define electromotive force (e.m.f) Students listen to teacher explanation and define (emf) as electromotive force (emf), E of a cell as potential difference between its terminals when it is not connected to a load and it is measured by using a high resistance voltmeter	Orientation

		discover the terminals of a cell falls when a load is connected. This is caused by the internal resistance of the cell which is the opposition of the material of the cell to the flow of current. Teacher presents the circuit diagram of a cell of e.m.f E volts and internal resistance r, and XY represent the terminals. Teacher asks the students to study the circuit diagram and explain the relationship between the symbols in the circuits. Teacher guide the students to discover that when a load R is not connected, no current flows and terminal potential difference, V = E. When R is connected, a current I flows which causes a voltage drop in the cell given by IR. The potential difference across the cell terminal is given by V = E – Ir. $r = \frac{E-V}{I}$ where V = potential difference at terminal E = e.m.f of the cell I = current flowing through the cell r = internal resistance of the cell	connected in parallel with the cell. V = E and when R is connected, a current I flows which causes voltage drop in the cell given by IR. The potential difference across the cell terminal V = IR	
	Difference between cell and battery	Teacher explains to the students that a battery is a combination of more than one cell. a) For cells in series: Total e.m.f = sum of cells e.m.f Total internal resistance = sum of cells internal resistance b) For cells connected in parallel Total e.m.f = e.m.f of one cell Total internal resistance of n cells = $\frac{1}{n}\times$ internal resistance of	Students discover that a battery is a combination of one cell Students listen to teacher explanation on those methods of calculating the total e.m.f and internal resistance of cell when connected	Orientation

		one cell	in series and parallel Student write it down in their note	
Simple problems on cell and battery	A cell has an internal resistance of 0.02Ω and an e.m.f 2.0V. Calculate its terminal potential difference if it delivers (a) 5A (b) 50A	Teacher writes the question on the whiteboard and asks the students to study it carefully and identify the facts needed for solving the problem. Teacher explains the procedure for solving the problem	Students write the questions in their notebook Students study the question carefully and identify the facts to be used in solving the problem	Orientation
		Teacher identify and explain the parameters needed for the problem. Terminal potential difference V = E – Ir where E = e.m.f of cell I = current flowing and r = internal resistance of cell	Students listen to teacher explanation and identify the parameters Terminal potential difference V = E – Ir where E = e.m.f of cell I = current flowing and r = internal resistance of cell	Planning
		Teacher explain the procedure for solving the problem Teacher asks the students to start doing their plan by solving the problem	Students take action by solving the problem a) when the current is 5A E = 2.0V, I = 5A and r = 0.02Ω V = E – Ir Hence, V = 2.0 – (5 ×	Action

			0.02) = 2.0 – 0.1 = 1.9V b) when the current is 50A E = 2.0V, I = 50A and r = 0.02Ω V = E – Ir Hence, V = 2.0 – (50 × 0.02) = 2.0 – 1.0 = 1.0V	
		Teacher asks the students to check if their answer is correct Teacher explains the process of checking the answer.	Students listens to teacher explanation and check their answers a) 1.9V = 2.0 – 5(0.02) 1.9V = 2 – 0.1 1.9V = 1.9V b)1.0 = 2.0 – 1.0 1.0 = 1.0	Check
	Differences between primary and secondary cells	Teacher explain to students that primary cells cannot be recharged i.e. conversion of chemical energy is irreversible and the cell cannot be used once the chemicals are exhausted. Secondary cells can be recharged after use i.e. the conversion of chemical energy to electrical energy is reversible and the cell may be used many times.	Students listen to teachers explanation and write down note.	Orientation
Evaluation	What is the difference	Teacher ask students question based on the just concluded	Students give answer to	Teacher give further

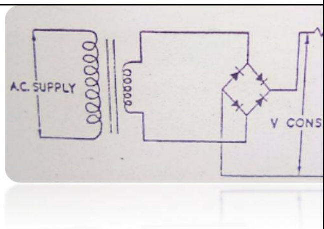
	between cell and battery? What is the Differences between primary and secondary cells	lesson.	teacher question.	explanation
Assignment	The potential difference at a terminal of a battery is 25V when no load is connected and 25V when a load taking 10A is connected. Determine the internal resistance of the battery	Teacher copy the question on the whiteboard and asks the students to copy it in their notebooks	Students copy the assignments in their notebooks	

LESSON TWO
Topic: Constant Voltage Battery Charging
Duration: 45 minutes
Class: NTC II
Behavioural Objectives: At the end of the lesson, the students should be able to:

- Describe the process of charging a battery
- Describe the process of constant voltage method of charging a battery
- Appreciate that the charging current in constant voltage method depends on the difference between charging voltage and total e.m.f of the cells.
  $I = \frac{V-E}{R}$

7. Perform simple problems on constant voltage battery charging

Entry Behaviour: students have been cells and battery circuits
Instructional Resources: Battery cells, charts, charger and posters
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
Battery charging	Constant charging process	 Constant Voltage Charger Teacher present the circuit diagram of a constant voltage battery charging process as shown above Teacher explains the process of constant voltage battery charging to the student. Teacher asks the students to describe the battery charging processes Teacher explains that batteries are charged by passing direct current through them from positive to negative terminals. The cells are	Students study and draw the circuit diagrams Students listen to teacher explanation and write down note. Student explains the process of constant voltage battery charging Student write down note	Orientation

		usually connected in series to maintain the same charging current and correct division between currents.		
		Teacher explains that constant voltage battery charging allows maintenance of constant voltage at a value slightly in excess of the fully charged cell multiplied by the number of cells connected in series When using this method $I = \frac{V-E}{R}$ Where V = charging voltage E = total e.m.f of cells R = total internal resistance	Students listen to the teacher explanation and describe the process of constant voltage method Student write down note.	Orientation
Problems on constant voltage charging method	Thirty, lead acid secondary cells are to be charged at a constant volatage. The e.m.f of each cells at the beginning and the end of charge is 1.9V and 2.7V respectively, and the internal resistance of each cell is 0.1 ohms. Calculate: (a) The mimimum charging voltage required. (b) The initial charging current.	Teacher copy the problem on the whiteboard Teacher asks the students to copy it in their notebooks Teacher explains the problem to the student Teacher identify and explain the facts that are needed for solkving the problem	Students write the question in their notebooks Students listen to teacher explanation and identify the facts required to solve the problem	Exploration
		Teacher asks the students to identify the parameters that are needed and available in the question.	Students identify the parameters needed that are available in the question.	Planning

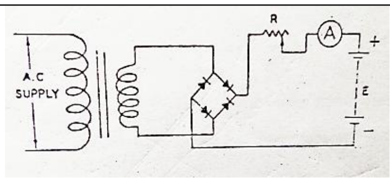
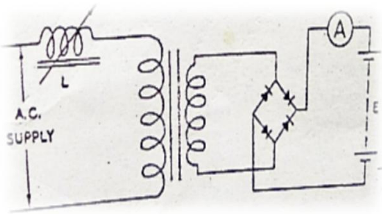
			V = E – Ir, V = 1.9V, E = 2.7V, r = 0.1Ω	
		Teacher explains the procedures for solving the problem Teacher asks the students to take action by doing their plans and solve the problem.	Students take action by solving the problem. Since V = E – IR No. of cells = 30 a) V = 30 × 2.7 = 81V b) I = $\frac{V-E}{R}$ = $\frac{81-(30\times1.9)}{30\times0.1}$ I = 8A	Action
		Teacher asks the students to check if their answer is correct Teacher explains the process of checking their answer.	Students listen to teacher explanation check if their answers are correct or not a) Since each cell is 2.7V, 30 cells = 30 ×2.7V = 81V V = E – Ir V = 81 – 8(30 ×0.1) V = 57V E = V + Ir E = 57 + 8(30×0.1) 81 = 57 + 24 81 = 81	Check
Evaluation	What are the problems of constant voltage battery charging method?	Teacher ask students question on the concluded lesson.	Students answer teacher question	Teacher give explanation further
Assignment	Eight cells, each with an internal resistance	Teacher copy the question on the	Students copy the question in	

	of 0.2 Ω and an e.m.f of 2.2 V are connected a) in series b) in parallel. Determine the e.m.f and the internal resistance of the batteries so formed	whiteboard Teacher asks the students to copy the question in their notebooks	their notebooks	

LESSON THREE
Topic: Constant Current Battery Charging
Duration: 45 minutes
Behavioral Objective: At the end of the lesson, the students should be able to:

i. Describe the process constant current charging battery
ii. Differentiate between constant voltage and constant current methods of charging battery
iii. Appreciate that the charging current in constant voltage method depends on the difference between charging voltage and total emf of the cell
iv. Perform simple problem on battery charging entry behavior students have been taught cells and battery cell

Instructional Resources: Batteries, cells, charts and posters
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Student Activities	Instructional Strategies
Battery charging	Constant current charging process of charging batteries	 (A) Rheostat control  (B) Inductor control Teacher present the circuit diagrams of the constant current charging using rheostat or inductor control process of charging batteries on the white board. Teacher asks the students to study the CCT diagram. Teacher explain the process of constant–current battery charging method using rheostat or inductor.	Students draw the circuit diagram in their notebooks. Student study the diagram. Students listen to teacher explanation and write down note.. Students explains the process of constant current charging method using rheostat or inductor.	Orientation

	Differences between constant voltage and constant current methods of charging batteries	Teacher identify the differences between constant voltage and constant current charging methods. Teacher ask the student to identify the differences between constant voltage and constant current charging methods. In constant voltage method, the charging voltage is maintained constant at a value slightly on excess of e.m.f of a fully charged multiplied by the number of cells connected in series while in constant current method, the current flowing through the rheostat or inductor depends on its setting and on the potential difference between its terminals which is also the difference between output voltage of the rectifier and voltage required to charge the cells	Student listen to teacher explanation and identify the difference between constant voltage and constant current method as guided by the teacher	Orientation
Problem on constant current method of charging	Thirty lead acid secondary cells are to be charged using constant current method. The e.m.f of each cell at the beginning and end of charge are 1.9V and 2.7V respectively. The output voltage of the rectifier used in the charger is 157v. (a) The value in	Teacher writes the question on the whiteboard and asks the students to carefully study it. Teacher identify the facts for solving the problem. Teacher explain the problem to the student	Students write the question in their notebooks Students study the question carefully Students listens to teacher explanation on procedure and identify the fact needed for solving the problem.	Orientation

	ohms to which the rheostat must be set to give an initial charging current of 5A. (b) The current at the end of the charge if the rheostat is left at this setting.			
		Teacher identify the parameters for solving the problem Teacher asks the student to identify the parameters Teacher explains the process of solving the problem.	Students listens to teacher explanation on the process of solving the problem and identifying the parameters. E = V – Ir V = 1.9V, E = 2.2V I = 5A	Planning
		Teacher explains the procedure for solving the problem Teacher asks students to start doing their plan by solving the problem.	Students take action by solving the problem. a) potential difference across rheostat at commencement of charge = 157 – (30 × 1.9) = 100V Rheostat setting in ohms $R = \frac{V}{I} = \frac{100}{5}$ R = 20Ω b) potential difference across rheostat at the end of charge = 157 – (30 × 2.7) = 76V Current at end of charge	Action

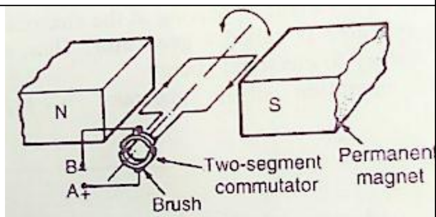
			$I = \frac{V}{R} = \frac{76}{20} =$ 3.8A	
		Teacher asks the students to check if their answer is correct Teacher guides the students as they check their answer	Students check their answer to ensure that they solve the problem. 100V = 157 – 30(1.9) 100V = 100V Since R = 20 Ω and I = 5A V = IR 100V = 5 × 20 100 = 100 76V = 157 – 30(2.7) 76V = 76V Since R = 20 Ω, I = 3.8 V = IR = 3.8 × 20 76 = 76	Check
Evaluation	What are the problems of constant currentbattery charging method?	Teacher ask students question on the concluded lesson.	Students answer teacher question	Teacher give explanation further
Assignment	A cell has an internal resistance of 0.02 Ω and an e.m.f. of 2.0V. Calculate its terminal p.d. if it delivers (a) 5A, (b) 50A.	Teacher copy the assignment on the whiteboard Teacher asks the students to copy the assignment in the notebooks	Students copy the assignment in their notebooks	

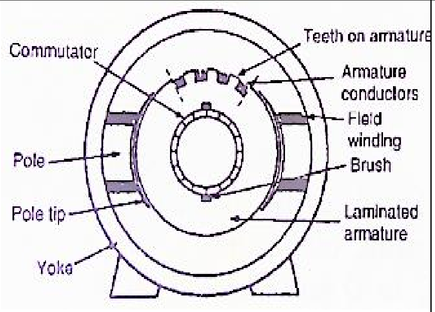
LESSON FOUR
Topic: DC Machines
Duration: 45 minutes
Class: NTC II
Behavioural Objectives: At the end of the lesson, the students should be able to:

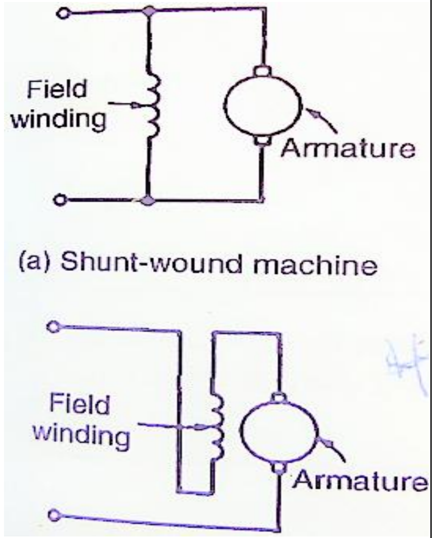
8. Distinguish between the function of a motor and a generator
9. Describe the action of a commutator
10. Distinguish between wave and lap windings
11. Understand shunt, series and compound winding pf DC machine
12. Calculate generated e.m.f in an amateur winding using $E = \frac{2P\phi nZ}{c}$

Previous Knowledge: The students have been taught battery charging

Entry Behaviour: students have been taught machines
Instructional Resources: Charts, posters, DC electric motors and generator
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
Dc Motors and Generators	Function of motor and generator	Teacher describes motor as an electrical machine that convert electrical energy to mechanical energy while generator converts mechanical energy to electrical energy	Students listens to teachers description and write down notes in their notebooks	Orientation
	Action of a commutator	 Teacher present the diagram of a single loop conductor mounted between permanent magnets as shown above Teacher asks the students to study the diagrams. Teacher explains that in an electric motor, conductors rotate in a uniform magnetic field Teacher explains that when a voltage is applied at point A and B in the figure above. A force acts on the loop due to the interaction of the magnetic field at the permanent magnets and	Students study the diagrams. Students listen to teacher explanation. Student writes down notes in their note books.	Exploration

		the magnetic field created by the current flowing in the loop. If the loop is free to rotate, then it has rotated through 180^0, the conductors are shown in figure 5.1(a) from D to C and from F to E. This apparent reversal in direction of current flow is called commutation.		
	DC machine construction	 Teacher draw the diagram of a DC machine with all its features or parts as shown above. Teacher asks students to study the diagram properly Teacher states the functions of each part (I) stator – yoke, poles and field windings (II) armature – core, armature winding and commutator Teacher ask the student to state each function of each part	Students study the diagram Students state the functions of the various parts in a DC machine	Orientation
	Wave and Lap windings	Teacher explains that armature winding can be divided into two – wave winding and lap winding Teacher explains the meaning of wave and lap windings	Students listen to teacher's explanation. Students explain the meaning of wave and lap windings.	Planning

	Shunt series and compound windings	 Teacher asks the students to study the circuit diagrams of various windings Teacher explains that in shunt the field winding is connected in parallel with the armature. In series, the field winding is connected in series with the armature while a compound has combination of series and shunt. Teacher ask the student to state the differences that exist among them	Students draw the circuit diagrams and study them properly. Student listens to teacher explanation on shunts, series and compounds windings Students state the differences among the three windings	Orientation
	Armature reaction	Teacher explains that armature reactions as the effects that magnetic field produced by armature current has on the magnetic field produced by the field system. In generator, it reduces output voltage. In motor, it increases speed.	Students listen to teachers explanation and write down notes in their note books.	Orientation
	E.m.f generated in armature winding	Teacher derive the formula for calculating e m f in armature winding Teacher asks the students to derive the formula for calculating e.m.f in armature winding Let Z = number of armature conductors ϕ = useful flux per pole in webs	Students derive the formular for calculating e.m.f generated in armature winding	Orientation

		P = number of pairs of poles and n = armature speed in rev/s E.m.f generated by the armature = e.m.f generated by one of the parallel parts. Each conductor passes ZP pole per revolution and this cut ZPϕwebers of magnetic flux per revolution. Hence flux by one conductor per second = 2Pϕn wb and conductor is given by E = 2Pϕn volts (1 volt = 1 weber per second) Let C = no of parallel paths through the winding between positive and negative brushes C = 2 for a ware winding C = 2P for lap winding The no of conductors in series in each path = $\frac{Z}{C}$ The total e.m.f between brushes = average e.m.f conductors (no of conductors in series per path) =2Pϕn $\frac{Z}{C}$ Therefore generated e.m.f, E = $\frac{2P\phi nZ}{C}$ volts Generated e.m.f E and ϕw		
Problems on generated e.m.f in armature winding	An 8-pole, wave-connected armature has 600 conductors and is driven at 625 rev/min. if the flux per pole is 20 mWb, determine the generated e.m.f.	Teacher write problem on the whiteboard. Teacher explain the procedure for solving the problem Teacher asks the students to study the problem carefully. Teacher asks the students to identify the fact needed to solve the problem	Students write the question in their notebooks Students identify the facts required for solving the problem	Orientation
		Teacher identify and explain the parameters needed for solving the problem	Students identify the parameters	Planning

		Teacher explain the procedure for solving the problem	needed for solving the problem Z = 600, C = 2 (for a wave winding) P = 4 pairs N = 625 rev/min ϕ = 200mWb	
		Teacher explains the procedure for solving the problem Teacher asks students to start doing their plan by solving the problem.	Students take action by solving the problem. $n = \frac{625}{60}$rev/s, $\phi = 20\times10^{-3}$wb Generated e.m.f $E = \frac{2P\phi nZ}{C} = \frac{2(4)(20\times10^{-3}(\frac{625}{60})\times600}{2}$ = 500V	Action
		Teacher asks the students to check if their answer is correct Teacher explains the process of checking their answer.	Students listen to teacher explanation and check if their answers are correct or not $500 = \frac{2(4)(20\times10^{-3}(\frac{625}{60})\times600}{2}$	Check
Evaluation	What is the difference between dc motor and dc generator?	Teacher ask students question on the concluded lesson.	Students answer teacher question	Teacher give explanation further
Assignment	A 4-pole generator has a lap-wound armature with	Students examine their answer if they are correct	Students copy the assignment in their notebooks	

	50 slots with 16 conductors per slot. The useful flux per pole is 30 mWb. Determine the speed at which the machine must be driven to generate an e.m.f. of 240V.	$2(4)(20\times10-3)$ $500 = \frac{(\frac{625}{60})600}{2}$		

LESSON FIVE

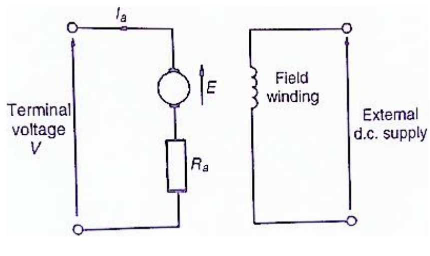
Topic: DC Generator

Class: NTC II
Duration: 45 minutes
Behavioral Objective: At the end of the lesson, the students should be able to:

19. Describe types of D.C generators
20. Calculate generated e.m.f for a generator using $E = V + I_aR_a$
21. Describe the characteristics of separately secured generator
22. State typical applications of dc generators
23. List dc machine losses
24. Calculate the efficiency of a dc generator

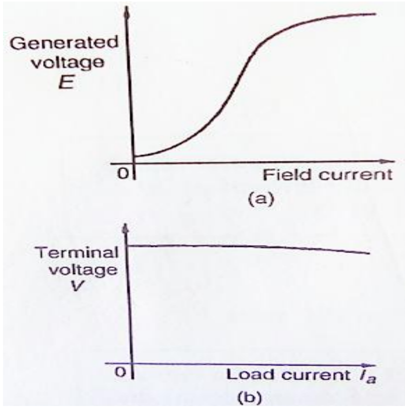
Entry Behaviour: students have been taught dc machines
Instructional Resources: dc generators, dynamos, charts and posters

Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Student Activities	Instructional Strategies
DC generator	Description of DC generators	Teacher explains and classifies generators according to their field excitation i) separately excited generators- the field is connected directly to a source of supply ii) self-excited generators – field winding receives its supply from the armature (shunt, series, compound wound generators)	Students listen to teacher explanation and classify generators into separately and self- excited generators Students write down notes in their notebooks	Orientation
	Types of DC generator and their characteristics Separately excited generator (fig 21.5, pg 357 and 358)	Teacher present the circuit diagrams of a separately excited generator to the students as shown below.  Teacher asks the students to study it carefully. Teacher asks the students to derive the formular for calculating terminal voltage ($V = E - I_aR_a$) or generated e.m.f ($E = V + I_aR_a$)	Students study the circuit diagram carefully, Students draw the circuit diagram in their notebooks Students derive the formular for calculating terminal voltage ($V = E - I_aR_a$) or generated e.m.f ($E = V + I_aR_a$)	Orientation

Problem on DC generators	A separately-excited generator develops a no-load e.m.f. of 150 V at an armature speed of 20 rev/s and a flux per pole of 0.10 Wb. Determine the generated e.m.f. when (a) the speed increases to 25 rev/s and the pole flux remains unchanged, (b) the speed remains at 20 rev/s and the pole flux is decreased to 0.08 Wb, and (c) the sped increases to 24 rev/s and the pole flux is decreased to 0.07 Wb.	Teacher write the problem on the whiteboard Teacher asks the students to study it carefully Teacher explains the problem to the student and identify the facts needed for solving the problem	Students write the question in their notebooks Students study the question carefully and identify the facts required for solving the problem	Orientation
		Teacher identify the parameter for solving the problem Teacher explain the parameter for solving the problem Teacher ask the student to identify the parameters for solving the problem	Students listens to teacher explanation and identify the parameters needed for solving the problem a) generated e.m.f E and ϕn E_1 = 150V, ϕ_1 = O.1Wb, n_1 = 20rev/sec E_2= ?, n_2 = 25rev/sec, , ϕ_2 = 0.1Wb b) E_1 = 150V, ϕ_1 = O.1Wb, n_1 = 20rev/sec E_3= ?, n_3 = 20rev/sec, , ϕ_3= 0.08Wb c) E_1 = 150V, ϕ_1 = O.1Wb, n_1 = 20rev/sec E_4= ?, n_4 = 24rev/sec, , ϕ_4 =	Planning

			0.07Wb	
		Teacher asks the students to take action by solving the problem. Teacher explain the procedure for solving the problem	Students listen to teacher explanation in the procedure for solving the problem Student take action by solving the problem. Since $\frac{E_1}{E_2} = \frac{\phi_1 n_1}{\phi_2 n_2}$ a) Hence $\frac{150}{E_2} = \frac{(0.10)(20)}{0.10 \times 25}$ $E_2 = \frac{150 \times 0.10 \times 25}{0.10 \times 20} =$ 187.5V b) $\frac{150}{E_3} = \frac{0.10 \times 20}{0.08 \times 20}$ $E_3 = \frac{150 \times 0.08 \times 20}{0.10 \times 20} =$ 120V c) $\frac{150}{E_4} = \frac{0.10 \times 20}{0.07 \times 24}$ $E_4 = \frac{150 \times 0.07 \times 24}{0.10 \times 20} =$ 126V	Action
		Teacher asks the students to check if their answer is correct	Students check their answer a) 150×0.1×20 = 187×0.1×20 375 = 375 b) 150×0.08×20 = 120×0.1×20 240 = 240 c) 150×0.07×24 = 126×0.1×20 252 = 252	Check
		Teacher explains the graph of separately excited characteristics	Students study the graphs. Student listens to	Orientation

		a) a typical separately excited generator open circuit b) load characteristics  Teacher asks the student to study the graphs and differentiate between open-circuit and load characteristics of separately excited generators	teacher explanation and differentiate between open-circuit and load characteristics of separately excited generators	
	Advantages and disadvantages of separately excited generators.	Teacher states the applications, advantages and disadvantages of separately excited generators	Students state the applications, advantages and disadvantages of separately excited generators.	Orientation
Evaluation	Identify the types of dc generator? And the common problems associated with them	Teacher ask students questions on the concluded lesson.	Students answer teacher question.	Teacher explain further.
Assignment	A generator is connected to a 60Ω load and a current of 8 A flows. If the armature resistance is 1Ω. Determine (a) the terminal voltage, and (b) the generated e.m.f.	Teacher writes the assignment on the chalkboard	Students copy their assignment in their note books	

LESSON SIX
Topic: DC Generator Characteristics
Duration: 45 minutes

Class: NTC II

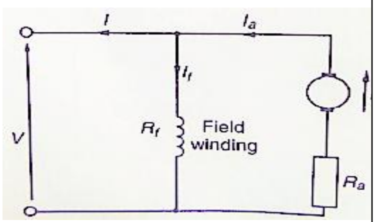
Behavioral Objectives: At the end of the lesson, the students should be able to:

25. Describe shunt-wound and series generator
26. Describe the characteristics of shunt-wound and series generators
27. State the applications, advantages and disadvantages of shunt-wound generator
28. State the application of series-wound generator
29. Solve simple problems on shunt-wound and series-wound generators

Previous Knowledge: The students have been taught DC generators

Instructional Resources: dc generators, dynamos, charts and posters

Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Student Activities	Instructional Strategies
Characteristic of Dc generator	Shunt- wound generator	Teacher present circuit diagram of shunt-wound generator on the whiteboard Teacher asks the students to study the circuit diagram  Teacher explain the circuit diagram of shunt-wound generator above to the students. Teacher explain that in shunt-wound generator, the field winding is connected in parallel with the armature. In the circuit above, $V = E - I_aR_a$ $E = V + I_aR_a$ $I_a = I_f + I$ (from Kirchhoff's current law where I_a = armature current I_f = field current $I_f = \frac{V}{RF}$ I = load current	Students study the circuit diagram Students listen to teacher explanation. Student write down note in their note books Student explain that in shunt-wound generator, the field winding is connected in parallel with armature	Orientation

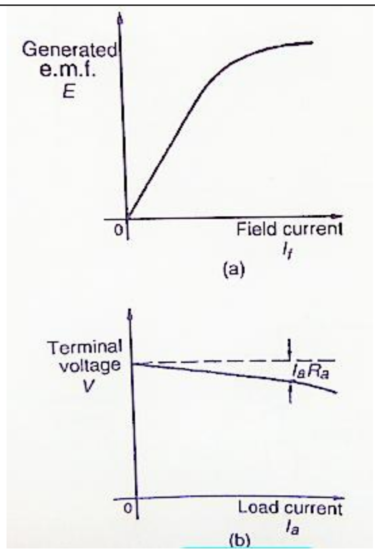
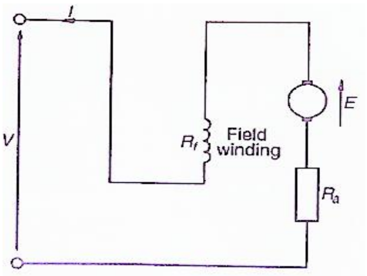
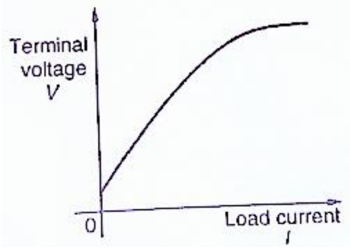
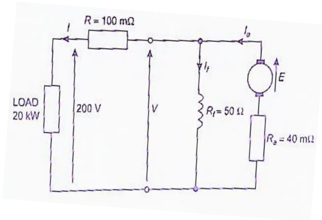
	Characteristics of shunt-wound generator	 Teacher present the graphs of shunt-wound generator on the whiteboard Teacher explain the relationship that exist between (i) generated e.m.f and field current (ii) terminal voltage and load current in shunt-wound generator Teacher asks the students as they establish the relationship	Students draw the graphs Students study the graphs Student listens to teacher explanation. Students establish the relationship between (i) generated e.m.f and field current (ii) terminal voltage and load current in shunt-wound generator	Orientation
	Applications, advantages and disadvantages of shunt-wound generators	Teacher states the applications, advantages and disadvantages of shunt-wound generators Teacher ask the student to states the applications, advantages and disadvantages of shunt-wound generators	Students state the applications, advantages and disadvantages of shunt-wound generators	Orientation
Series-wound generator	Series-wound generator	 Teacher draw the circuit	Students draw the circuit diagrams in their notes Students study the circuit diagram Students explains that the field winding are connected in series with the armature in series-	Orientation

		diagram of series-wound generator on the whiteboard Teacher asks the students to study the circuit diagram Teacher explains that in series-wound generators, the field winding are connected in series with the armature	wound generators	
	Characteristics of series –wound generator	 Teacher present the graph of series-wound generator on the whiteboard to establish its characteristics Teacher asks the students to study the graph. Teacher explain the relationship that exist between terminal voltage and load current.	Students draw the graphs of series-wound generator characteristics Students study the graph and explain the relationship that exist between terminal voltage and load current	Orientation
	Applications, advantages and disadvantages of series-wound generators	Teacher states the applications, advantages and disadvantages of series-wound generators Teacher ask the student to state the applications, advantages and disadvantages of series-wound generators	Students state the applications, advantages and disadvantages of series-wound generators	Orientation
Problem on shunt-wound and series-wound generators	A shunt generator supplies a 20KW load at 200V through cables of resistance, R = 100m Ω. If the field winding resistance, R_f	Teacher writes the problem on the whiteboard Teacher asks the students to study the problem Teacher explain the problem to the student and identify the fact required	Students write the problem in their notebooks. Students listen to teacher explanation and identify the facts needed for solving the problem	Orientation

	=50 Ω and the armature resistance, R_a = 40m Ω, determine (a) the terminal voltage, and (b) the e.m.f. generated in the armature.	for solving the problem Teacher asks the students to identify the facts that are required for solving the problem		
		Teacher explain the parameters that are needed in solving the problem. Teacher draw the circuit diagram.  P = 20KW, supply V = 200V R = 100mΩ, R_f = 50Ω R_a = 40mΩ Teacher ask the student to plan and solve the problem	Students draw the circuit diagram. Students identify the parameters needed and plan to solve the problem P = 20KW, supply V = 200V R = 100mΩ, R_f = 50Ω R_a = 40mΩ	Planning
		Teacher explain the process of solving the problem. Teacher ask the student to start doing their plan by solving the problem.	Students take action and solve the problem a) Load current I = $\frac{20000}{200}$ = 100A Volt drop in the cables to the load = IR = $100 \times 100 \times 10^{-3}$ = 10V Hence terminal voltage V = 200+10 = 20V b) Armature current $I_a = I_f + I$ field current $I_f = \frac{V}{R_f} = \frac{210}{50}$ = 4,2A Hence, $I_a = I_f + I$ = 4.2 + 100 = 104.2A Generated e.m.f E = V +	Action

			I_aR_a $= 210 + (104.2 \times 40 \times 10^{-3}) = 210 + 4.16 = 214.17V$	
		Teacher asks the students to check if their answers are correct or not	Student check their answers to see if they are correct or not $V = E - I_aR_a$ $= 214.17 - (104.2 \times 40 \times 10^{-3})$ $= 214.17 - 4.168$ $= 210V$	Check
Evaluation	What are some of the characteristics of shunt and series wound generator? And the common problems associated with them	Teacher ask students questions on the concluded lesson.	Students answer teacher question.	Teacher explain further.
Assignment	Determine the internal voltage of a generator which develops an e.m.f of 200V and has an armature current of 30A on load. Assume the armature resistance is 0.30 Ω	Teacher write the assignment on the whiteboard Teacher asks the students to copy the assignment in their notebook	Students copy their assignment in their notebooks	

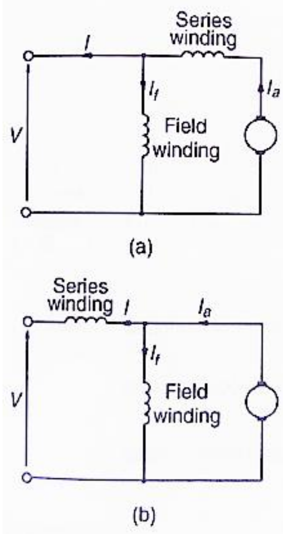
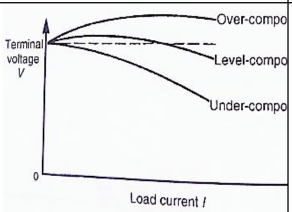
LESSON SEVEN
Topic: DC Generator Characteristics II
Duration: 45 minutes
Class: NTC II
Behavioral Objectives: At the end of the lesson, the students should be able to:

30. Describe Compound-wound generator
31. Describe the characteristics of compound-wound generator
32. State the applications, advantages and disadvantages of compound-wound generator
33. List DC machine losses

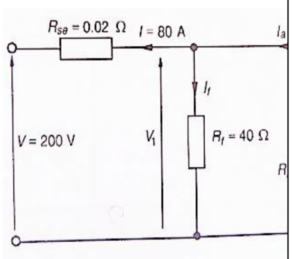
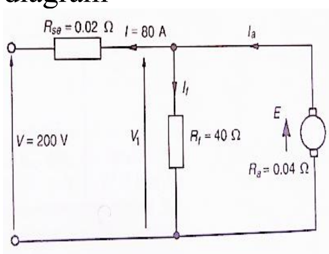
34. Solve simple problem on compound-wound generator
35. Calculate the efficiency of a DC generator

Previous Knowledge: The students have been taught shunt-wound and series-wound generators
Instructional Resources: dc generators or dynamos, charts and posters

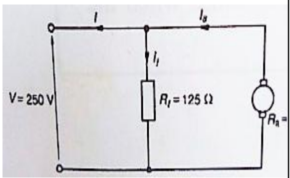
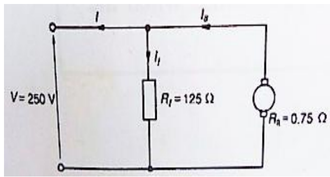
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Student Activities	Instructional Strategies
Compound wound generator	Description of compound-wound generator	 Teacher present the circuit diagram of compound-wound generators on the whiteboard Teacher asks the students to study the circuit diagram. Teacher explains that a compound wound generator is a combination of series wound and shunt-wound generators	Students draw the circuit diagrams in their notebooks. Students study the circuit diagrams Students explain that compound-wound generator is a combination of series-wound and shunt-wound generators	Orientation
	Characteristics of compound-wound generator	 Teacher draw the graph of compound-wound generator on the whiteboard	Students draw the graphs in their notebooks Students study the graph. Student listen to teachers explanation and establish the relationship that exists between the terminal voltage V and load current I in	Orientation

		Teacher asks the students to study the graph and establish the relationship that exists between terminal voltage, V and load current, I in compound-wound generator Teacher explains the relationship that exist between terminal voltage V and load current, I in compound-wound generator	compound-wound generator	
	Application of compound-wound generator	Teacher states the applications, advantages and disadvantages of compound-wound generator Teacher asks the student to state applications, advantages and disadvantages of compound-wound generator	Students state the applications, advantages and disadvantages of compound-wound generator	Orientation
Losses in Dc machine	DC machine losses	Teacher identifies and explain the losses in DC machine i) copper loss ii) iron (core) loss iii) friction and windage loss iv) brush contact loss Teacher asks the student to identifies and explain the losses in DC machine i) copper loss ii) iron (core) loss iii) friction and windage loss	Students listen to teachers explanation. Student explain and identify the losses in DC machines	Orientation

		iv) brush contact loss		
Problem on Dc machine	A short –shunt compound generator supplies 80A at 2000V. If the field resistance, Rf = 40ohms, the series resistance, Rsc = 0.02 and the armature resistance, Ra = 0.04, determine the e.m.f generated	Teacher write the problem on the whiteboard Teacher ask the student to study the problem. Teacher explains the problem and identifies the facts that are needed in solving the problem.	Students write the problem in their notebooks. Students study the problem. Student listens to teacher explanation and identify the facts that are required for solving the problem	Orientation
		Teacher identifies and explains the parameters for solving the problems. Teacher asks the students to identify the parameters that are needed for solving the problem  Teacher asks the students to draw the circuit diagram. Teacher guide the students as they draw the circuit diagram	Students identify the parameters needed for solving the problem I = 80A, V = 200V Rf = 40Ω*, RSc = 0.02*Ω *R_a = 0.04* Ω Students draw the circuit diagram 	Planning
		Teacher asks the students to start doing their plan by solving the problem	Student take action by solving the problem Voltage drop in series winding = IR_{SC} =	Action

			$80 \times 0.02 = 1.6V$ Potential difference across the field winding = potential difference across armature = V_1 = $200+1.6 = 201.6V$ Field current $I_f = \frac{V_1}{R_f} = \frac{201.6}{40} = 5.04A$ Armature current $I_a = I + I_F = 80+5.04 = 85.05A$ Armature current, $I_a = I+I_F = 80+5.04 = 85.04A$ Generated e.m.f, $E = V_1 + I_aR_a$ $= 201.6 + (85.04 \times 0.04)$ $= 201.6 + 3.4016$ $=205V$	
		Teacher asks the students to check their answer if it is correct or not	Students check their answer to check if it is correct or not $E = V_1 + I_aR_a$ $201.6 = 20 -(85.04 \times 0.04)$ $201.6 = 205 - 3.4016$ $201.6V = 201.6V$	Check
Dc generator Efficiency	Efficiency of a DC generator	Teacher define efficiency of an electrical machine as the ratio of the output power to the input power and usually expressed in percentage Efficiency, $\eta = \frac{output\ power}{input\ power} \times 10$ Efficiency, $\eta = \frac{VI}{VI \times IaRa + I_fV + C} \times 1$ The efficiency of a generator is maximum when the load is such	Students defined efficiency as the ratio of output power to the input power and usually express in % Students study the formular for calculating efficiency of a generator. Students write the definition and formular in their notebooks	Orientation

		that $I^2_a R_a = VI_f + C$		
Problem on efficiency	A 10KW shunt generator having an armature circuit resistance of 0.75 Ω and a field resistance of 125 Ω, generates a terminal voltage of 250V at full load. Determine the efficiency of the generator at full load, assuming the iron, friction and windage losses amount to 600 W.	Teacher write the problem on the whiteboard Teacher explains the problem to the student. Teacher identify the facts that are needed in solving the problems Teacher ask the student to identify the fact required for solving the problem	Students study the problem. Student listens to teacher explanation and identify the facts that are needed in solving the problem Students copy the problem in their notebook	Orientation
		Teacher explains the parameters needed for solving the problem. Teacher asks the students to identify the parameter Teacher also draw the circuit diagram  P = 10kw, R_a = 0.75Ω, R_f = 12.5 Ω, V = 250 Ω, losses = 600W	Students identify the parameter needed in solving the problem Students draw the circuit diagram  P = 10kw, R_a = 0.75Ω, R_f = 12.5 Ω, V = 250 Ω, losses = 600W	Planning
		Teacher explains the process of solving the problem Teacher asks the students to start doing their plan by solving the problem.	Students take action and solve the problem Output power = 10000W = VI Load current, I = $\frac{10000}{V} = \frac{10000}{250}$ = 40A	Action

			Field current, $I_f = \frac{V}{R_f} = \frac{250}{125} = 2A$ Armature current, $I_a = I_f + I = 2+40 = 42A$ Efficiency, ŋ = $\frac{VI}{VI \times I^2aRa + I_fV+C} \times 100\%$ $= \frac{10000}{10000+(42^2 \times 0.75)+(2\times 250)}$ $= \frac{10000}{12423} \times 100\% =$ 80.50%	
		Teacher asks the students to check if their answer is correct or not	Students check their answer to ascertain whether it is correct or not Efficiency, ŋ = $\frac{output\ power}{input\ power} \times 100\%$ Output power = 10000W Input power = 12423W ŋ = $\frac{10000}{12423} \times 100\% =$ 80.50%	Check
Evaluation	What are some of the characteristics of compound wound generator? And the common problems associated with it	Teacher ask students questions on the concluded lesson.	Students answer teacher question.	Teacher explain further.
Assignment	A generator is connected to a 60 Ω load and a current of 8A flows. If the armature resistance is 1 Ω. Determine (a) the terminal voltage, and (b) the generated e.m.f.	Teacher asks the students to write the assignment in their notebooks	Students write the assignment in their notebooks	

LESSON EIGHT

Topic: DC Motor

Duration: 45 minutes

Class: NTC II

Behavioural Objectives: At the end of the lesson, the students should be able to:

- Define Back e.m.f of a dc motor
- Derive the formular for calculating torque in a DC machine
- Describe shunt-wound motor and their characteristics
- State the application of shunt-wound motor
- Solve simple problems on shunt-wound motor
- Describe series-wound motor and their characteristics
- State the applications of series-wound motor

- Solve simple problems on series-wound motor

Previous Knowledge: The students have been taught dc generators
Instructional Resources: dc motors, charts and posters
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
Back emf	Definition of Back e.m.f	Teacher defines and explain back e.m.f as an e.m.f induced in the armature of a rotating motor. Back e.m.f, $V = E + I_aR_a$ or $E = V - I_aR_a$ Teacher ask the student to define and explain back e.m.f	Students define back e.m.f as an e.m.f inducted in the armature of a rotating motor $V = E + I_aR_a$ or $E = V - I_aR_a$ Students write down the definition in their notebooks	Orientation
DC Machine torque	Torque of a DC machine	Teacher derives the formular for calculating torque of a DC machine. In a DC motor, the supply voltage, $V = E + I_aR_a$ $VI_a = EI_a + I^2{}_aR_a \times$ byI_a VI_a = power supplied to armature EI_a = mechanical power developed by the armature I_aR_a = loss due to armature resistance If T = torque in NM, then mechanical power developed is given by TW Watts Hence, $TW = 2\pi nT = EIa$ Torque, $T = \frac{EI_a}{2\pi n}$ Newton meter	Students derive the formular for determining torque of a DC motor Students write the derivation in their notebooks	Orientation
Problems on torque	Determine the torque developed by a 350V d.c. motor having an armature resistance	Teacher write the problem on the whiteboard Teacher explain the problem and identify the fact required for solving the problem Teacher asks the students to	Students listen to the explanation and identify the facts that are needed for solving the problem. Students write the problem in their	Orientation

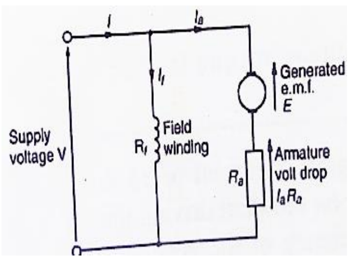
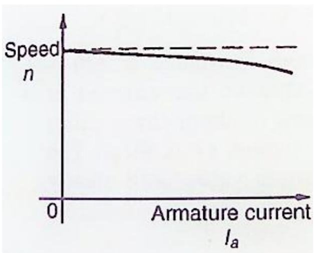
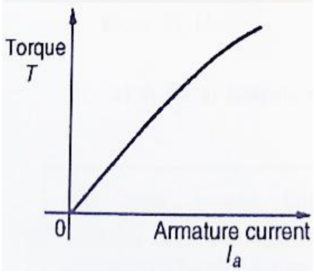
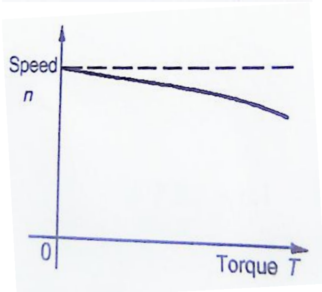
	of 0.5 Ω and running at 15 rev/s. the armature current is 60A.	identify the facts that are needed on solving the problem.	notebooks	
		Teacher explains the parameter for solving the problem. Teacher asks the students to identify the parameters for solving the problems.	Students identify the parameters for solving the problems V = 350V, I_a = 0.5Ω, n = 15, Ia = 60A	Planning
		Teacher explains the process of solving the problem Teacher asks the students to start doing their plan by solving the problems	Student listen to the process of solving the problem Students take action and solve the problem Back e.m.f = E = V - IaRa = 350 – 60 × 0.5 = 320V Torque, T = $\frac{EI_a}{2\pi n}$ = $\frac{320 \times 60}{2\pi \times 15}$ = 203.7μm	Action
		Teacher asks the students to check their answers if correct or not	Students check their answers V = E + IaRa = 320 + (60×0.5) = 320+30 = 350V	Check
Shunt-wound motor	Shunt-wound motor description	Teacher draw the circuit diagram on the whiteboard  Teacher asks the students to draw and study the circuit	Students draw the circuit diagram in their notebooks Student listens to teacher explanation and write down note in their note book Students study the circuit diagram and discover that the field winding is in	Orientation

		diagram Teacher explains that in shunt-wound motor, the field winding is in parallel with the armature Supply voltage, $V = E + IaRa$ Generated e.m.f, $E = V – IaRa$ Supply current, $I = Ia + If$ from Kirchhoff's current law	parallel with the armature in shunt-wound motor	
Shunt-wound motor characteristics	Characteristics of shunt-wound motor	Teacher draws the characteristic graphs of the shunt-wound motor on the whiteboard. Teacher explains the characteristic of the graph to the students    i) The theoretical torque/armature current characteristics can be derived from expression T α	Students draw the characteristics graphs of the shunt-wound motor on the whiteboard Students study the characteristics of shunt-wound motor Student listens to teacher explanations and write down note in their note books	Orientation

		ϕIa ii) E α ϕn, hence n = $\frac{E}{\Phi}$ speed of rotation, n α $\frac{E}{\Phi}$ α $\frac{V-IaRa}{\Phi}$		
Problems shunt-wound motor	A 240V shunt motor takes a total current of 30A. If the field winding resistance R_f = 150 Ω and the armature resistance Ra = 0.4V. Determine (a) the current in the armature, and (b) the back e.m.f.	Teacher write the problem on the whiteboard Teacher explains the problem to the students. Teacher identifies the parameters needed for solving the problem Teacher asks the students to study the problem and identify the facts that are needed in solving the problems	Students write the problems in their notebooks Students listens to teacher explanation Students study the problem and identify the facts needed in solving the problem	Orientation
		Teacher explain and identifies the parameters required for solving the problems Teacher asks the students to identify the parameters available in the problem.	Students listen to teacher explanation and identify the parameters that are needed for solving the problem V = 240V, I = 30A, Rf = 150Ω, Ra = 0.4Ω	Planning
		Teacher explains the proves of solving the problem Teacher asks the students to start doing their plan by solving the problems	Students take action and solve the problem a) field current I_f = $\frac{V}{Rf}$ = $\frac{240}{150}$ = 1.6A supply current I = I_a – I_f = 30-1.6 = 28.4A b) Back e.m.f, E =	Action

			V-IaRa =240 – (28.4×0.4) = 240 – 11.36 = 228.64V	
		Teacher asks the students to check if their answer is correct Teacher guides the students as they check their answer	Students check their answers to ascertain whether it is correct or not $I = I_a + I_f$ 30 = 28.4 + 1.6, 30 = 30 V = E + IaRa, 240 = 228.64 + (28.4×0.4) 240 = 228.64 + 11.36 240 = 240	Check
	Applications of shunt-wound DC motor	Teacher state the applications of shunt-wound motor to include driving the machine, lines of shaft, fans, conveyor belts, pumps, compressor, driving machines, etc Teacher asks the student to state Applications of shunt-wound DC motor	Students state the applications of shunt-wound DC motor Students write the applications of shunt-wound DC motor in their notebooks	Orientation
Evaluation	State where shunt and series woundmotors are applicable and some of the common problems associated with them	Teacher ask students questions on the concluded lesson.	Students answer teacher question.	Teacher explain further.
Assignment	A 100V d.c. generator supplies a	Teacher asks the students to copy the assignment in their notebooks	Students copy the assignment in their notebooks	

	current of 15 A when running at 1500 rev/min. if the torque on the shaft driving the generator is 12Nm, determine (a) the efficiency of the generator and (b) the power loss in the generator.			

LESSON NINE

Topic: Series-wound and Compound-wound Motors

Duration: 45 minutes

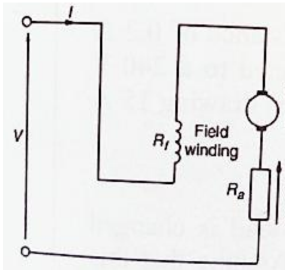
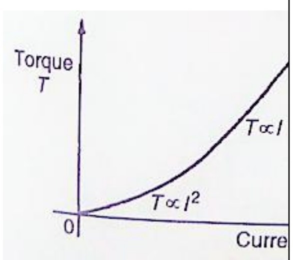
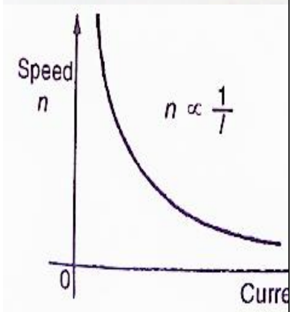
Class: NTC II

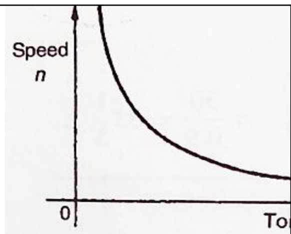
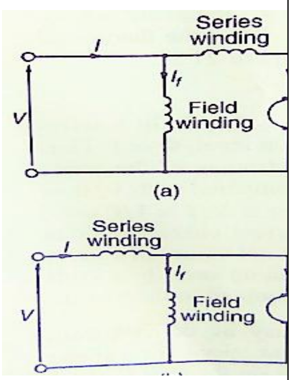
Behavioural Objectives: At the end of the lesson, the students should be able to:

- Describe series-wound motor
- Describe the characteristics of series-wound motor
- State the applications of series-wound motor
- Describe compound-wound motor
- Describe the characteristics of compound-wound motor
- State the application of compound-wound motor
- Derive the formular for calculating efficiency of DC motor
- Solve simple problems on series-wound motor

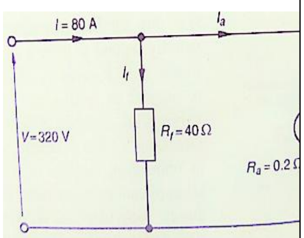
- Solve simple problems on efficiency of a dc motor

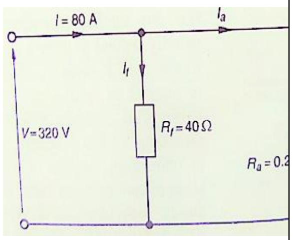
Entry Behaviour: Students have been taught shunt-wound DC motor
Instructional Resources: charts, posters, dc motor
Instructional Procedure

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
Series-wound dc motor	Description of series-wound DC motor	Teacher draw the circuit diagram of a series-wound motor on the whiteboard  Teacher asks the students to study the circuit diagram Teacher explains that in series-wound motor, field winding is in series with the armature Supply voltage V = E + (Ra + Rf) or generated e.m.f, E = V – I(Ra + Rf)	Students draw the circuit diagram of a series-wound motor DC motor in their notebooks. Students study the circuit diagram of a series-wound motor Student listen to teacher explanation and write down notes in their notebooks	Orientation
Series-wound motor characteristics	Characteristics of a series-wound dc motor	  	Students draw the graph in their notebooks Students study the graph and explain the relationship between i) torque and current ii) speed and current iii) current and speed	Orientation

		 Teacher draws the graph of the characteristics of a series-wound motor. Teacher asks the students to study the graphs and explain the relationship that exist between torque and current, speed and current and speed and torque in series-wound motor i) $\phi \; \alpha \; I$, $I \; \alpha \; I^2$ and $T \; \alpha \; I$ ii) $n \; \alpha \; \frac{(V - IaRa)}{\phi}$, $n \; \alpha \; \frac{V - IR}{I}$, $n \; \alpha \; \frac{V}{I} \; \alpha \; \frac{I}{I}$		
	Applications of series-wound motor	Teacher state the applications of series-wound motor – train, milk delivery vehicles, driving fans, crane, hoists, etc	Students state the application of series-wound motor	Orientation
Dc compound-wound motor	Description of compound-wound motor	Teacher draw the circuit diagram of compound-wound motor  	Students draw the circuit diagram of compound-wound motor in their notebooks Students study the circuit diagrams Students listen to teachers explanation and explain the types of compound-wound motors	Orientation

		Teacher asks the students to study the circuit diagram Teacher explain types of compound-wound motor i) cumulative compound-wound motor ii) differential compound-wound motor iii) long-shunt compound-wound motor iv) short-shunt compound-wound motor		
charact eristics	Characteristics of a compound-wound motor	Teacher explains that compound-wound motor had both series and shunt field winding. The characteristics similar in shape to a series wound motor	Students listen to teacher explanation and explain the characteristics of compound-wound motor is similar to that of series-wound motor	Orientation
	Applications of compound-wound motor	Teacher state the applications of compound-wound motor. It is used where heavy load may occur such as for driving plunger pumps, presses, gear lift, conveyors, hoists, etc	Students state the applications of compound-wound motor	Orientation
Dc motor efficiency	Efficiency of a DC motor	Efficiency, ŋ = $\frac{output\ power}{input\ power} \times$ 100% Total losses = $I^2aRa + IfV + C$ (shunt motor) where C = sum of Iron , friction and	Students study the formula for determining Efficiency in a DC motor Students write the formular in their notebooks	Orientation

		windage losses Input power = VI, output power = VI – losses = VI – I^2Ra – IfV – C Hence, Efficiency ŋ = $\frac{VI - I^2 aRa - IfV - C}{VI} \times$ 100% The efficiency of a motor is maximum when the load is such that I^2aRa + IfV + C		
Problems on Efficiency	A 320V shunt motor takes a total current of 80A and runs at 1000 rev/min. If the iron, friction and windage losses amount to 1.5KW, the shunt field resistance is 40 Ω and the armature resistance is 0.2 Ω, determine the overall efficiency of the motor.	Teacher write the problem on the whiteboard Teacher explain the problem to the students Teacher asks the students to study the problem and identify the facts that are needed to solve the problem.	Students write the problems in their notebooks Students listen to teacher explanation Students study the problems and identify the facts that are required to solve the problem	Orientation
		Teacher identify and explain the parameters required for solving the problem Teacher asks the students to identify the parameters available in the problem that can be used to solve the problem Teacher draw the circuit diagram and ask the student to do	Students listen to teacher explanation and identify the parameters required for solving the problem Students draw the circuit diagrams  V = 320V, I = 80A, n	Orientation

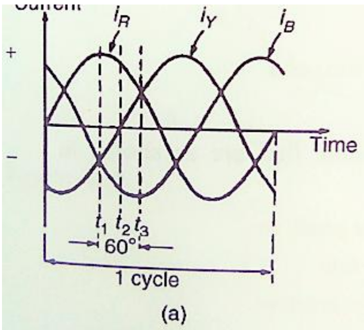
		so 	= 1000revolutions, C = 1.5kW, Rf = 40Ω, Ra = 0.2Ω	
		Teacher asks the students to start doing their plan by solving the problems.	Students take action and solve the problem Field current, If = $\frac{v}{Rf}$ = $\frac{320}{40}$ = 8A Armature current Ia = I – If = 80 – 8.72A C = Iron, friction and windage losses = 1500W Efficiency ŋ = $\frac{VI-I^2 aRa-IfV-C}{VI} \times$ 100% = $\frac{(3020\times 80)-(12^2\times 0.2) - (8\times 3200-1500}{320\times 80}$ × 100% = $\frac{25600-1036.8-2560-1500}{25600} \times 100\%$ = $\frac{20503.2}{25600} \times 100\%$ = 80.1%	Action
		Teacher asks the students to check if their answer is correct or not	Students check their answer 80.1% = $\frac{801}{1000}$ = $\frac{20503.2}{25600}$ = $\frac{0.8008}{10.000}$ = 81.1%	Check
Evaluation	State where compound wound	Teacher ask students questions on the	Students answer teacher question.	Teacher explain

	motors are applicable and some of the common problems associated with it	concluded lesson.		further.
Assignment	A 250V series motor draws a current of 40A. The armature resistance is 0.15 Ω and the field resistance is 0.05 Ω. Determine the maximum efficiency of the motor.	Teacher write the assignment on the whiteboard Teacher asks the students to copy the assignment in their notebooks.	Students copy the assignment in their notebooks.	

LESSON TEN
Topic: Alternating Current Motor
Duration: 45 minutes
Class: NTC II
Behavioural Objectives: At the end of the lesson, the students should be able to:

- Describe how a rotating magnetic field is produced
- State the synchronous speed, n_S of a three phase induction motor
- Describe the operation of a three phase induction motor
- State the advantages of a three phase induction motor
- Understand and calculate slip
- State the application of induction motor

Previous Knowledge: Students have been taught DC motors winding
Instructional Resources: charts, posters, AC motor
Instructional Procedures

Content Development	Subject Matter	Teacher Activities	Students Activities	Instructional Strategies
AC motor	Description of how a rotating magnetic field is produces	Teacher present the sine-wave of a three single-loop conductor, one for each phase to explain how magnetic field is produced by a rotating conductor  Teacher asks the students to study the sine wave	Students draw the sine wave of a three single loop conductor to explain how magnetic field is produced Students explain how magnetic field is produced	Orientation
	Synchronous speed	Teacher explain that synchronous speed $n_S = \frac{f}{p}$ rev/sec where f = frequency and p = pairs of pole	Students listen to teacher explanation that synchronous speed $n_S = \frac{f}{p}$ rev/sec	Orientation
Problems on synchronous speed	A three-phase two-pole induction motor is connected to a 50 Hz supply. Determine the synchronous speed of the motor in rev/min.	Teacher writes the problem on the whiteboard Teacher explains the problem. Teacher asks the students to study the problems and identify the facts needed in solving the problem	Students write the problem in their notebooks Students listen to teacher explanation. Students study the problem and identify the facts that are needed for solving the problem	Orientation
		Teacher identify and explain the parameters required for solving the problems Teacher asks the students to identify the parameters that	Students listen to teacher explanation and identify the parameters for	Planning

		can be used to solve the problem P = no of pairs of pole = 1 F = 50 $n_S = \frac{f}{p}$	solving the problem P = no of pairs of pole = 1 F = 50 $n_S = \frac{f}{p}$	
		Teacher explains the process of solving the problems Teacher asks the students to start doing their plan by solving the problem	Students listen to teacher explanation Students take action and solve the problem $n_S = \frac{f}{p} = \frac{50}{1} =$ 50rev/s = 50×60rev/min = 3000rev/min	Action
		Teacher asks the students to check if their answer is correct	Students check their answer $F = n_S \times p$ F = 50×1 = 50Hz	Check
	Principle of operation of a three phase induction motor	Teacher explains the principle of operation of a three phase induction motor	Students listen to teacher explanation and also explain the principle of operation of a three-phase induction motor	Orientation
	Slip	Teacher explain the difference between the rotor speed, n_r and the synchronous speed, n_S is called slip speed = $n_S - n_r$ rev/s The ratio $\frac{(n_s-n_r)}{n_s}$ is called fractional slip or just the slip, S and usually expressed in percentage. Thus, slip, S = $\frac{(n_s-n_r)}{n_s} \times 100\%$	Students listen to the explanation and also explain that slip, S as $\frac{(n_s-n_r)}{n_s} \times 100\%$ Students write the formular in their notebooks	Orientation

Problem on slip	The stator of a 3-phase, 4-pole induction motor is connected to a 50Hz supply. The rotor runs at 1455 rev/min at full load. Determine (a) the synchronous speed and (b) the slip at full load.	Teacher write the problem on the whiteboard Teacher explain the problem to the students Teacher identifies the parameter required for solving the problem Teacher asks the students to study the problem and identify facts that are needed in solving problem	Students write the problem in their notebooks Students listen to teacher explanation Students study the problem and identify facts that are needed in solving the problem	Orientation
		Teacher identify and explain the parameter required for solving the problems Teacher asks the students to identify the parameters for solving the problem No of par of pole, P = $\frac{4}{2}$ = 2 F = 50Hz, n_r = 1453revolutions	Students listen to teacher explanation and identify the parameters for solving the problem No of pair of pole, P = $\frac{4}{2}$ = 2 F = 50Hz, n_r = 1453revolutions	Planning
		Teacher explain the process or procedures for solving the problems Teacher asks the students start doing their plan by solving the problem	Student take action and solve the problem a) Synchronous speed, $n_r = \frac{f}{p} = \frac{50}{2}$ = 25rev/s b) Motor speed, $n_r = \frac{1453}{60}$ = 24.25rev/s b) the slip, S = $\frac{(n_s - n_r)}{n_s} \times 100\%$ = $\frac{25-24.25}{25} \times 100\%$ = 3%	Action

		Teacher asks the students to check if their answer is correct or not	Students check their answer $F = n_s \times p = 25\times2 = 50Hz$ $N_r = 60\times2\times25 = 1455rev/min$	Check
Three-phase induction motor	Advantages of induction motor	Teacher state the advantages of induction motor i) squirrel-cage induction motors ii) wound rotor induction motors iii) double-cage induction motors	Students state the advantages of induction motor i) squirrel-cage induction motors ii) wound rotor induction motors iii) double-cage induction motors	Orientation
	Application of three-phase induction motor	Teacher state the application of a three-phase induction motor	Students state the application of a three-phase induction motor – tools, pumps and mill motors	Orientation
Evaluation	State the function of slip ring? Ans state some of the common problems associated with the synchronous speed motors	Teacher ask students questions on the concluded lesson.	Students answer teacher question.	Teacher explain further.
Assignment	The frequency of the supply to the stator of an 8-pole induction motor is 50Hz and the rotor frequency is 3Hz. Determine	Teacher write the problem on the whiteboard Teacher asks the students to copy the problem in their notebooks	Students copy the problems in their notebooks	

	(a) the slip, and (b) the rotor speed.			

APPENDIX C

ELECTRICAL INSTALLATION AND MAINTANANCE WORK ACHIEVEMENT TEST (EIMWAT)

Instruction: Answer all questions. **Time**: 50 minutes

Each question is followed by five options lettered A-D

Identify the correct option for each question and write on the answer sheet provided the letter that bears the same answer of option you have chosen.

i. Active materials of a lead-acid cell is:

A. lead peroxide

B. sponge lead

C. dilute sulphuric

D. all the above

ii. A cell has an internal resistance of 0.02 Ω and an e.m.f. of 2.0V. calculate its terminal p.d. if it delivers 50A.

A. 10V

B. 1.0V

C. 0.1V

D. 0.5V

3. During the charging of a lead-acid cell:

A. its cathode becomes dark chocolate brown in colour

B. its voltage increases

C. it gives out energy *d*

D. specific gravity of H_2SO_4 is decreased

4. The capacity of a cell is measured in:

A. watt hours

B. watts

C. amperes

D. ampere-hours

5. Twelve cells, each with an internal resistance of 0.24 Ω and an e.m.f. of 1.5V are connected in series. Determine the e.m.f.

A. 18V

B. 6V

C. 24V

D. 12V

f. A cell has an internal resistance of 0.03 Ω and an e.m.f. of 2.2V. calculate its terminal p.d. if it deliver 20 A

A. 3.5V

B. 2.7V

C. 4.9V

D. 1.6V

g.The p.d. at the terminal of a battery is 16 V when no load is connected and 14 V when a load taking 8 A is connected. Determine the internal resistance of the battery.

A. 0.15Ω

B. 0.25Ω

C. 5.25Ω

D. 4.9Ω

h. A battery of e.m.f. 20 V and internal resistance 0.2 Ω supplies a load taking 10 A. Determine the p.d. at the battery terminals

A. 20V

B. 30V

C. 25V

D. 18V

i. Eight cells, each with an internal resistance of 0.2Ω and an e.m.f. of 2.2V are connected in parallel. Determine the e.m.f.

A. 22V

B. 0.22V

C. 2.2V

D. 2.4V

j. Ten 2.2V cells, each having an internal resistance of 0.1 Ω are connected in series to a load of 21 Ω. Determine the p.d. at the battery terminals.

A. 23V

B. 21V

C. 12V

D. 1.2V

k. Am 8-pole, wave-connected armature has 600 conductors and is driven at 625 rev/min. if the flux per pole is 20 m Wb, determine the generated e.m.f.

A. 200V

B. 800V

C. 400V

D. 500V

l. A cell has an internal resistance of 0.03 Ω and an e.m.f. of 2.2V. calculate its terminal p.d. if it deliver 50 A

A. 0.7V

B. 0.10V

C. 0.5V

D. 1.0V

m. An 8-pole, lap-wound armature has 1200 conductors and a flux per pole of 0.03 Wb. Determine the e.m.f. generated when running at 500 rev/min

A. 0.O3V

B. 0.07V

C. 300V

D. 500V

n. Ten 1.5V cells, each having an internal resistance of 0.2 Ω, are connected in series to a load of 58 Ω. Determine the p.d. at the battery terminal

A. 1.45V

B. 0.145V

C. 14.5V

D. 14.9V

o. Secondary cells are often referred to as

A. Gibbsan cells

B. Leclanche cells

C. Mercury cells

D. Accumulator

p... As compared to shunt and compound motors, series motor has the highest torque because of its comparatively…………..at the start. lower armature resistance

A. stronger series Field

B. fewer series turns

C. larger armature current.

q. A series motor is best suited for driving

A. lathes

B. cranes and hoists

C. shears and punches

D. machine tools

r. A 220 V shunt motor develops a torque of 54 N-m at armature current of 10 A. The torque produced When the armature current is 20 A, is

A. 54 N-m- — —

B . 8 1 N - m

C. 108 N-m----

D. None of the above

s. The d.c. series motor should never be switched on at no load because

A. the field current is zero
B. the machine does not pickup
C. The speed becomes dangerously high
D. it will take too long to accelerate,

t. Sulphation in a lead-acid battery occurs due to:

A. trickle charging

B. incomplete charging

C. heavy discharging

D. fast charging

21. A cell has an internal resistance of 0.02 Ω and an e.m.f. of 2.0V. calculate its terminal p.d. if it delivers 5A.

A. 1.7V
B. 1.8V
C. 1.9V
D. 0.19V

22. Three-phase alternators are invariably Y-connected because

A. magnetic losses are minimized
B. less turns of wire are required
C. smaller conductors can be used
D. higher terminal voltage is obtained.

23. The harmonic which would be totally eliminated from the alternator e.m.f. using a fractional pitch

A. 3^{rd}

B. 7^{th}

C 5^{th}

'D. 9th.

24. The insulation for commutator is

A. Rubber

B. Mica

C. Silicon

D. Pvc

25. Regarding distribution factor of an armature winding of an alternator which statement is false?

A. it decreases as the distribution of coils (slots/ pole) increases

B. higher its value, higher the induced e.m.f. per phase

C. it is not affected by the type of winding either lap, or wave

D. it is not affected by the number of turns per coil.

26. When speed of an alternator is changed from 3600 r.p.m. to 1800 r.p.m,, the generated e.m.f./ phases will become

A. one-half

B. twice

C. four times

D. one-fourth.

27. A d.c. motor operates from a 240 V supply. The armature resistance is 0.2 Ω. Determine the back e.m.f. when the armature current is 50 A.

A. 0.32V

B. 2.30V

C. 700V

D. 230V

28. The armature of a d.c. machine has a resistance of 0.25 Ω and is connected to a 300 V supply. Calculate the e.m.f. generated when it is running as a generator giving 100 A

A. 2.35V

B. 325V

C. 504V

D. 375V

29. The active materials of a nickel-iron battery are.

A. nickel hydroxide

B. powdered iron and its oxides

C. 21% solution of caustic potash

D. all of the above.

30. During the charging and discharging of a nickel iron cell:

A. Its e.m.f. remains constant

B. water is neither formed nor absorbed

C. corrosive fumes are produced

D. nickel hydroxide remains unsplit

31. A battery of e.m.f. 20 V and internal resistance 0.2 Ω supplies a load taking 10 A. Determine the resistance of the load.

A. 1.8Ω

B. 2.8Ω

C. 19Ω

D. 0.8Ω

32. A 240 V shunt motor takes a total current of 30 A. if the field winding resistance R_f = 150Ω and the armature resistance R_a = 0.4 Ω. Determine the current in the armature.

A. 4.28A

B. 792A

C. 641A

D. 28.4A

33. As compared to a lead-acid cell, the efficiency of a nickel-iron cell is less due to its

A. lower e.m f

B. smaller quantity of eletrolyte used v

C. higher internal resistance

D. compactness.

34. A machine which converts mechanical energy into electrical energy is referred to as

A. Generator

B. motor

C. Electric Iron

D. Transformer

35. A generator is connected to a 60Ω load and a current of 8 A flows. If the armature resistance is 1 Ω determine the generated e.m.f.

A. 88.4V

B. 0.88V

C. 488V

D. 498V

36. Another name for an alternator is.

A. A.c Generator

B. commutator

C. D.c generator

D. A,c motor

37. An 8-pole, wave-wound armature has 1200 conductors and a flux per pole of 0.03 Wb. Determine the e.m.f. generated when running at 500 rev/min

A. 0.012V

B. 1200V

C. 4200V

D. 6000V

38. A d.c. series motor drives a load at 30 rev/s and takes a current of 10 A when the supply voltage is 400 V. If the total resistance of the motor is 2Ω and the iron, friction and wind age losses amount to 300 W, determine the efficiency of the motor.

A. 87.5%

B. 5.97%

C. 2.96%

D. 75.6%

39. Floating battery systems are widely used for :

A. power stations

B. emergency lighting

C. telephone exchange installation

D. all of the above

40. The two principal types of windings are

A. Lap/duplex

B. Lap/drum

C. Lap/wave

D. Lap/simplex

APPENDIX D

MARKING SCHEME

1 D	30 C
2 B	31 C
3 C	32B
4 A	33 B
5A	34 B
6 C	35 B
7 D	36 B
8 B	37 C
9 D	38 B
16 C	39 C
17 C	40C

18 D
19 C
20A
28 C
29 C

APPENDIX E

INTER RATERS SCORING GUIDE FOR ELECTRICAL INSTALLATION WORK PSYCHOMOTOR ACHIEVEMENT TEST (ELWAT)

	SKILLS TO BE OBSERVED AND ASSESSED	MARKS OBTAINABLE			
S/N	**FAULTS DETECTION ,REPAIR AND REPLACEMENT OF FAULTY CELLS IN A BATTERY**	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
1	Correct use of appropriate tools.	The right types of tools used	The use of tools is	The use of Very good	The use of tools is

		was very appropriate	appropriate	tools is inappropriate	highly inappropriate
2	Dismantling of battery	Battery dismantly very appropriate	Battery dismantly appropriate	Battery dismantly was rough	Dismantly was very rough
3	Neatness during removal of the battery	Component removal very neat	Component removal neatly	Component removal very rough	Component removal highly rough
4	Observation of safety precaution	Very good observation of safety precaution	Observance of safety was good	Observance of safety precautions poor	Observance of safety precautions very poor
5	Reading of the electromotive force	Reading of the multimeter taken very promptly	Reading of multimeter taken promptly	Reading of multimeter difficult	Reading of multimeter very difficult
6	Timely Use of appropriate instruments to trace faults	The right instruments are used to trace fault very quickly	The right instruments are used to trace fault quickly	The right instruments are used to trace fault after some time	The right instruments are not used to trace fault
7	Ability to identify faulty cells	Faulty cells are identify very promptly	Faulty cells are identify promptly	Faulty cells are identify after some time	Faulty cells cannot be identify at all
8	Time taken to complete the task of removing the faulty cells	Task completed within 10 minutes	**Task completed between 10-15 minutes**	**Tasks completed 15-20 minutes**	Task completed between 20-25 minutes
9	Correct replacement of the faulty cells	Very good replacement of the faulty cell	Good replacement of the faulty cell	Replacement of the faulty cell deceptive	Replacement of the faulty cell very deceptive
10	Neatness of the finished job.	The finished job is very nice devoid of leakage	The finished job is nice	The finished job is rough	The finished job is very rough
	TESTING OF ELECTRICAL MACHINE SPARKING ON LOAD	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
11	Use of appropriate tools to	Very accurate	Accurate	Inacurate	Very

	check				inacurate
12	Tracing of faults to check for short or open circuit using appropriate meters	Very skillful	Skillful	Unskillful	Highly unskillful
13	Creativeness in fault finding	Very innovative in finding fault	Innovative	Low innovativeness in finding fault	Very low innovativeness in finding fault
14	Ability to identify the tools to be carryout	Very good identification of the tools to be used	Good identification of the tools to be used	Fair knowledge of the tools to be used	Very poor identification 0f the tools to be used
15	Ability to identify the cause of sparking on load	Ability to identify the cause of sparking within 10 minutes	Ability to identify the cause of sparking within 10-15 minutes	Ability to identify the cause of sparking within 15-20 minutes	Ability to identify the cause of sparking within 15- 20 minutes 20-25 minutes
	INSTALLING A 3 PHASE MOTOR	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
16	Use of appropriate tools	Very prompt in selecting appropriate tools	prompt in selecting appropriate tools	Delay in selecting appropriating tools for sometime	selecting appropriate tools after a long time
17	Observation of safety precautions	Very high observance of safety precautions	High observance of safety precautions	Some safety precautions were observed	Safety precautions were not observed
18	Identification of appropriate cables	Very good identification of the cable size to be used	Good identification of the cable to be used	Very good identification of the cable size to be used	Very poor identification of the cable size to be used
19	Ability to install the motor	Ability to install the motor very skillfully	Ability to install the motor skillfully	Ability to install the motor unskillfully	Highly unskillful to install the motor
20	Ability to test installation resistance	The right testing instrument are used very timely	The right testing instrument are used timely	The right testing instrument are used after some	Wrong testing instrument are used to test installation resistance

				time delay	
21	Correctness of the installation	The installation done very accurately	The installation done accurately	The installation done not accurate	The installation very inaccurate
22	Time taken to complete the task	The task of installation completed less than ten(10) minutes	The task of installation completed within ten(10) to fifteen ((15) minutes	Tasks completed within fifteen (15)to twenty(20) minutes	The task of installation not completed at all
	MAINTENANCE OF ELECTRICAL MACHINES AND EQUIPMENT	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
23	Identify various types and grades of lubricants e.g. grease oil, coolant	Very good sense of identification of lubricants	Good sense of identification of Lubricants	identification of lubricants not adequate	Very bad identification of lubricants
24	Selection of appropriate tools mallets, hammers, cutters,pliers	The use of tools very appropriate	The use of tools appropriate	The use of tools inappropriate	The use of tools highly inappropriate
25	Ability to clean and blow dirt's	Very skillful	Skillful	Unskillful	Highly Unskillful
26	Tightening of loose nuts	Loose bolts are very well tightened	Loose bolts are well tightened	Loose bolts are not very tightened	Loose bolts
27	Ability to replace of worn-out parts	Very Innovative in replacing worn-out parts	Innovative in replacing worn out parts	low innovativeness in replacing worn out parts	Very low innovativeness in replacing worn out parts
28	Adjustment of belt tension	The correct test instruments are used to check belt tension very promptly	The correct test instruments are used to check belt tension promptly	The correct test instruments are used but delayed	Wrong testing instruments are not used to check belt tension
	DISMANTLING OF A MOTOR	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR The installation1**
29	Selection of appropriate tools e.g. hammers, mallets, pliers, insulating tapes etc.	Very good selection of appr0priate	Good selection of appropriate	Some selection of appropriate	Selection of appropriate tools not

		tools	tools	tools not very appropriate	appropriate
30	Composure during dismantling	Very calm and orderly	Calm and orderly	Not calm	Highly not calm
31	Identification of parts	Correctly done	Orderly done	Not calm	Highly calm
32	Extent of skills in the use of tools	Very skillful	Skillful	Unprofessional	Highly unprofessional
33	Time taken to complete the task	Task completed in less than ten(10) minutes	Task completed between 10(ten) to(15) fifteen minutes	Task completed between fifteen(15) to 20(twenty) minutes	Task not completed completely
	SKILLS TO BE OBSERVED	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
	BATTERY CHARGING				
34	Selection of appropriate charging tools	Very good selection of materials	Good selection of materials	Inappropriate selection	The selection of materials is very inappropriate
35	Selection of materials for battery charging	Very good selection of materials	Good selection of materials	Inappropriate selection	The selection of materials is very inappropriate
36	Preparing electrolyte observing necessary precautions	The use of tools is very appropriate	The use of tools is appropriate	The use of tools is inappropriate	The use of tools is highly inappropriate
37	Ability to identify battery terminals	Battery terminals are identify very promptly	Battery terminals are identify promptly	Battery terminals identification delayed after some time	Battery terminals cannot be identified
38	Ability to connect battery to a charger	Components are connected using the right probes very correctly	Components are connected using the right probes correctly	Components are connected using the right probes after some time	Components cannot be connected
39	Determine the specific gravity of an electrolyte using hydrometer	Determining the specific gravity very promptly	Determining the specific gravity promptly	Determining the specific gravity after some time	Cannot determine specific gravity

	TROUBLE SHOOTING TECHINQUES	EXCELLENT 4	GOOD 3	FAIR 2	POOR 1
40	Appropriate selection of tools and instruments	The use of tools is very appropriate	The use of tools is appropriate	The use of tools is inappropriate	The use of tools is highly inappropriate
41	Observations of safety precautions	Safety precaution highly observed	Safety precaution observed	Some Safety precautions not observed	Safety precautions not observed at all
42	procedure when carrying out the tasks	The procedure for carrying out the task is highly professional	The procedure for carrying out the task is professional	The procedure for carrying out the task is inappropriate	The procedure is highly inappropriate
43	Ability to carry out trouble shooting task	Highly effective	Effective	Ineffective	highly ineffective
44	Skills in carrying out the task	Very skillful	Skillful	Unskillful	Highly unskillful
	MEASURING OF ELECTRICAL QUANTITIES	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
45	Selecting the function and range of instruments	Function and range of instrument appropriately selected very correctly	Function and range of instrument appropriately selected correctly	Function and range of instrument appropriately selected after some time	Very wrong function and range of instrument selected
46	Ability to connect meter probes	The meter probes are connected to positive and negative terminals very correctly	The meter probes are connected to positive and negative terminals correctly	The meter probes are connected to positive and negative terminals correctly after some time	The meter probes are connected to positive and negative terminals very wrongly
47	Accurate taking of the value of the quantity been measured (e.g. current, résistance ,p.d)	The value of quantity measured is taken very accurately	The value of quantity measured is taken accurately	The value of quantity measured is inaccurately taken	The value of quantity measured is very inaccurate

APPENDIX F

INTER RATERS SCORING GUIDE FOR ELECTRICAL INSTALLATION WORK PSYCHOMOTOR ACHIEVEMENT TEST (ELWAT)

	SKILLS TO BE OBSERVED AND ASSESSED	MARKS OBTAINABLE			
S/N	**FAULTS DETECTION ,REPAIR AND REPLACEMENT OF FAULTY CELLS IN A BATTERY**	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
1	Correct use of appropriate tools.				
2	Dismantling of battery				
3	Neatness during removal of the battery				
4	Observation of safety precaution				
5	Reading of the electromotive force				

6	Use of appropriate instruments to trace faults				
7	Ability to identify faulty cells				
8	Time taken to complete the task of removing the faulty cells				
9	Correct replacement or the faulty cells				
10	Neatness of the finished job.				
	TESTING OF ELECTRICAL MACHINE SPARKING ON LOAD	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
11	Use of appropriate tools to check				
12	Tracing of faults to check for short or open circuit using appropriate meters				
13	Creativeness or innovativeness in fault finding				
14	Ability to identify the tools to be carried out				
15	Ability to identify the cause of sparking				
	INSTALLING A 3 PHASE MOTOR	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
16	Use of appropriate tools				
17	Observation of safety precautions				
18	Identification /selection of appropriate cables				
19	Ability to install the motor				
20	Ability to test installation resistance				
21	Correctness of the installation				
22	Time taken to complete the task				
	MAINTENANCE OF ELECTRICAL MACHINES AND EQUIPMENT	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
23	Identify various types and grades of lubricants e.g. grease oil, coolant				
24	Selection of appropriate tools mallets, hammers,				

	cutters ,pliers				
25	Ability to clean and blow dirt's				
26	Tightening of loose nuts				
27	Ability to replace of worn-out parts				
28	Adjustment of belt tension				
	DISMANTLING OF A MOTOR				
29	Selection of appropriate tools e.g. hammers, mallets, pullers, insulating tapes etc.				
30	Composure during dismantling				
31	Identification of parts				
32	Extent of skills in the use of tools				
33	Time taken to complete the task				
	SKILLS TO BE OBSERVED	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
	BATTERY CHARGING				
34	Selection of appropriate charging tools				
35	Selection of materials for battery charging				
36	Preparing electrolyte observing necessary precautions				
37	Ability to identify battery terminals				
38	Ability to connect battery to a charger				
39	Determine the specific gravity of an electrolyte using hydrometer				
	TROUBLE SHOOTING TECHINQUES	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
40	Appropriate selection of tools and instruments				
41	Observations of safety precautions				
42	Sequence or procedure when				

	carrying out the tasks				
43	Ability to carry out the task				
44	Skills in carrying out the task				
	MEASURING OF ELECTRICAL QUANTITIES	**EXCELLENT 4**	**GOOD 3**	**FAIR 2**	**POOR 1**
45	Selecting the function and range of instruments				
46	Ability to connect meter probes				
47	Accurate taking of the value of the quantity been measured (e.g. current, résistance ,p.d)				

APPENDIX G
EIMW INTEREST INVENTORY (EIMWII)

Sex: Male ( ) Female ( )

Instruction: Below is a list of statements to ascertain your disposition towards Radio, Television and Electronic works (EIMW) as one of the Electrical/Electronicscourse in Technical Colleges.

Please respond to whether you strongly Agree (SA), Agree (A) Disagree (D) and Strongly Disagree (SD)

S/N	**Statement**	**SA (4)**	**A (3)**	**D (2)**	**SD (1)**
1	Electrical Installation and Maintenance (EIMW) work trade lessons are very interesting				
2	I hate EIMW lessons because they involve simple calculations				
3	When I hear the word EIMW, I have a feeling of calculations.				
4	EIMW is a trade I enjoying studying.				
5	I don’t feel at ease in EIMW test or Examination				
6	EIMW lesson is always dull.				
7	I hate EIMW because I have not been exposed to practical aspect of the trade.				
8	I am always afraid when studding EIMW.				

9	Non availability of practical materials in the workshop always discourages me from studying EIMW.				
10	The feeling I have towards EIMW is a good one.				
11	EIMW makes me feels uneasy and confused				
12	I feel at ease when studying EIMW and I like it very much.				
13	I do solve EIMW problems alone.				
14	I like to learn more about EIMW.				
15	I am not always attentive during EIMW lesson.				
16	I am excited when I solve EIMW problems				
17	I am always excited when I study EIMW notes and understand				
18	I like answering questions during EIMW lessons.				
19	Calculations in EIMW are very interesting.				
20	Practical lessons in EIMW are very interesting.				
21	I like answering questions during EIMW lessons.				
22	I do not encourage other students to attend EIMW lessons				
23	I spend my time talking and chatting during EIMW lessons.				
24	I sleep during EIMW lessons.				
25	I hate reading EIMW note.				
26	I do not spending my time doing EIMW.				
27	When I fail EIMW problem, I make no effort to get it.				
28	I always late to EIMW lessons.				
29	I always do corrections to the home work I failed in EIMW.				
30	I always spend my free time doing home work in EIMW.				
31	Winding process is simple to understand.				
32	Domestic installation is very interesting.				
33	Industrial installation is very interesting.				
34	I frequently ensure that electrical tools are in good Conditions				
35	I pay more attention to manipulation skills in EIMW lesson.				
36	I know that qualities that promote good working condition in EIMW.				
37	I do enjoy EIMW lesson.				
38	I don’t like going for EIMW lesson.				
39	If the EIMW teacher/instructor fails to come to the class on time, I can go to their office to call any of themwhose period is on.				
40	I know the commonest joint that are important in Electrical installation and wiring.				
41	I enjoying doing EIMW assignment at home				
42	I like staying in the front sit during EIMW Teacher is say during lesson.				
43	I don’t use to come late to EIMW Lesson				

44	I enjoy solving simple problems on EIMW				
45	I like the simple calculations that are EIMW curriculum				
46	I use to enjoy the company of my fellow EIMW student				
47	I don't like doing assignment on calculation aspect of the EIMW.				
48	I encourage any friends to develop interest in EIMW				
49	I notice that some skills are needed to make produce joint in electrical cables				
50	I always use the correct tools for the right job in EIMW				

APPENDIX H
EIMW STUDENTS AND TEACHERS POPULATION DISTRIBUTION IN ACCREDITED SCIENCE AND TECHNICAL COLLEGES IN NORTH CENTRAL STATES

S/N	SCHOOL	LOCATION	NO OF STUDENTS
1	Mbakuha Technical College, Lessel	Benue State	31
2	Elabor Technical College, Adoka	Benue State	36
3	St. Joseph Technical College, Markudi	Benue State	37
4	Government Technical College, Markudi	Benue State	45
5	Federal Science Technical College, Otukpo	Benue State	38
6	St. Jude's Technical College, Tse-Mker	Benue State	39
7	User Technical College, Adikpo	Benue State	42
8	Government Technical College, Ankpa	Kogi State	41
9	Government Technical College, Idah	Kogi State	36
10	Government Technical College, Mopa	Kogi State	31
11	Government Technical College, Oboroke	Kogi State	30
12	Government Technical College, AmoduAsamegbolu	Kwara State	25

13	Government Technical College, Erin-Ile	Kwara State	29
14	Government Technical College, EsieIludun	Kwara State	28
15	Government Technical College, Ilorin	Kwara State	30
16	Government Technical College, Pategi	Kwara State	34
17	Government Technical College, Mada Station	Nasarawa State	33
18	Government Technical College, Akwanga	Nasarawa State	35
19	Government Technical College, Asakio	Nasarawa State	30
20	Government Technical College, Eyagi-Bida	Niger State	34
21	Government Technical College, Kontagora	Niger State	35
22	Government Technical College, Minna	Niger State	40
23	Government Technical College, New Bussa	Niger State	37
24	Mamman Kontagora Technical College, Pandogari	Niger State	37
25	Suleiman Barau Technical College, Suleja	Niger State	37
26	Federal Science and Technical College, Shiroro	Niger State	32
27	Government Technical College, Bukuru	Plateau State	40
28	Government Science and Technical College, Garki	FCT-Abuja	35
29	Federal Science and Technical College, Orozo	FCT-Abuja	36
	Total		1013

APPENDIX I
VALIDATION LETTER

Department of Industrial and Technology Education
Federal University of Technology,
Minna.
Niger State
April 7, 2021.
.

Dear Sir / Madam

REQUEST FOR FACE AND CONTENT VALIDATION OF RESEARCH INSTRUMENTS

I am a Post Graduate student in the Department of Industrial and Technology Education, Federal University of Technology, Minna, currently undertaking a research work titled: Effects of Glencoe and

Rusbuit Problem solving Strategies on Students achievement and interest in Electrical Installation and Maintenance Work Trade in Technical Colleges in North Central states.

Attached is a draft of the instruments for the study titled: Effects of Glencoe and Rusbuit Problem solving Strategies on Students achievement and interest in Electrical Installation and Maintenance Work Trade in Technical Colleges in North Central states. You are please requested to go through the items vet their clarity, relevance and appropriateness for the stated purpose.

In addition, kindly make further suggestions that will improve the status and the quality of the instrument.

Your contribution to this work is highly appreciated.

Yours faithfully,
UMARU, Nathaniel Ndagana.
PHd/SSTE/ 2018/ 8611
08036841709

APPENDIX J

LETTER TO RESPONDENTS

Department of Industrial and Technology Education
Federal University of Technology,
Minna.
Niger State
April 7, 2021.

…………………………………..
…………………………………..
Dear Sir / Madam

REQUEST FOR COMPLETION OF QUESTIONAIRE

I am a Post Graduate student in the Department of Industrial and Technology Education, Federal University of Technology, Minna, currently undertaking a research work titled: Effects of Glencoe and

Rusbuit Problem solving Strategies on Students achievement and interest in Electrical Installation and Maintenance Work Trade in Technical Colleges in North Central states.

Attached is a draft of the instruments for the study titled: Effects of Glencoe and Rusbuit Problem solving Strategies on Students achievement and interest in Electrical Installation and Maintenance Work Trade in Technical Colleges in North Central states. You are please requested to respond to the question in the questionnaire. The exercise is purely an academic one and your responses will be treated with strict confidentiality.

Your contribution to this work is highly appreciated.

Yours faithfully,
UMARU, Nathaniel Ndagana.
PHd/SSTE/ 2018/ 8611
08036841709

APPENDIX K

ITEM ANALYSIS OF EIMWAT BASED ON CLASSICAL TEST THEORY USING EXCEL SPREAD SHEET

	PT	PB	DIFFICULTY INDEX		DISCRIMINATION INDEX		DECISION
scr01	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr02	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr03	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr04	4	3	0.175	VERY DIFFICULT	0.090909	POOR ITEM	REJECT
scr05	9	8	0.425	AVERAGE	0.090909	POOR ITEM	REJECT
scr06	6	8	0.35	AVERAGE	-0.18182	POOR ITEM	REJECT
scr07	10	8	0.45	AVERAGE	0.181818	POOR ITEM	REJECT
scr08	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr09	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN

scr10	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr11	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr12	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr13	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr14	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr15	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr16	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr17	8	5	0.325	AVERAGE	0.272727	MARGINALLY GOOD ITEM	RETAIN
scr18	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr19	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr20	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr21	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr22	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr23	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr24	9	6	0.375	AVERAGE	0.272727	MARGINALLY GOOD ITEM	RETAIN
scr25	6	7	0.325	AVERAGE	-0.09091	POOR ITEM	REJECT
scr26	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr27	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr28	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr29	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr30	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr31	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr32	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr33	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr34	8	5	0.325	AVERAGE	0.272727	MARGINALLY GOOD ITEM	RETAIN
scr35	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr36	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr37	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr38	5	5	0.25	AVERAGE	0	POOR ITEM	REJECT
scr39	7	7	0.35	AVERAGE	0	POOR ITEM	REJECT
scr40	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN

scr41	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr42	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr43	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr44	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr45	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr46	7	6	0.325	AVERAGE	0.090909	POOR ITEM	REJECT
scr47	7	7	0.35	AVERAGE	0	POOR ITEM	REJECT
scr48	8	6	0.35	AVERAGE	0.181818	POOR ITEM	REJECT
scr49	8	4	0.3	AVERAGE	0.363636	REASONABLY GOOD ITEM	RETAIN
scr50	9	6	0.375	AVERAGE	0.272727	MARGINALLY GOOD ITEM	RETAIN
scr51	7	5	0.3	AVERAGE	0.181818	POOR ITEM	REJECT
scr52	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr53	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr54	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr55	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr56	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr57	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr58	9	5	0.35	AVERAGE	0.363636	REASONABLY GOOD ITEM	RETAIN
scr59	5	8	0.325	AVERAGE	-0.27273	POOR ITEM	REJECT
scr60	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr61	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr62	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr63	8	4	0.3	AVERAGE	0.363636	REASONABLY GOOD ITEM	RETAIN
scr64	5	4	0.225	VERY DIFFICULT	0.090909	POOR ITEM	REJECT
scr65	7	7	0.35	AVERAGE	0	POOR ITEM	REJECT
scr66	9	6	0.375	AVERAGE	0.272727	MARGINALLY GOOD ITEM	RETAIN
scr67	6	5	0.275	AVERAGE	0.090909	POOR ITEM	REJECT
scr68	9	5	0.35	AVERAGE	0.363636	REASONABLY GOOD ITEM	RETAIN
scr69	2	4	0.15	VERY DIFFICULT	-0.18182	POOR ITEM	REJECT
scr70	3	4	0.175	VERY DIFFICULT	-0.09091	POOR ITEM	REJECT
scr71	7	5	0.3	AVERAGE	0.181818	POOR ITEM	REJECT
scr72	7	7	0.35	AVERAGE	0	POOR ITEM	REJECT
scr73	5	5	0.25	AVERAGE	0	POOR ITEM	REJECT
scr74	5	7	0.3	AVERAGE	-0.18182	POOR ITEM	REJECT
scr75	7	5	0.3	AVERAGE	0.181818	POOR ITEM	REJECT

scr76	8	3	0.275	AVERAGE	0.454545	VERY GOOD ITEM	RETAIN
scr77	9	7	0.4	AVERAGE	0.181818	POOR ITEM	REJECT
scr78	10	9	0.475	AVERAGE	0.090909	POOR ITEM	RETAIN
scr79	7	4	0.275	AVERAGE	0.272727	MARGINALLY GOOD ITEM	RETAIN
scr80	7	4	0.275	AVERAGE	0.272727	MARGINALLY GOOD ITEM	RETAIN
scr81	7	6	0.325	AVERAGE	0.090909	POOR ITEM	REJECT
scr82	7	5	0.3	AVERAGE	0.181818	POOR ITEM	REJECT
scr83	5	4	0.225	VERY DIFFICULT	0.090909	POOR ITEM	REJECT
scr84	7	5	0.3	AVERAGE	0.181818	POOR ITEM	REJECT
scr85	7	1	0.2	VERY DIFFICULT	0.545455	VERY GOOD ITEM	REJECT
scr86	11	0	0.275	AVERAGE	1	VERY GOOD ITEM	RETAIN
scr87	11	2	0.325	AVERAGE	0.818182	VERY GOOD ITEM	RETAIN
scr88	11	5	0.4	AVERAGE	0.545455	VERY GOOD ITEM	RETAIN
scr89	6	6	0.3	AVERAGE	0	POOR ITEM	REJECT
scr90	8	7	0.375	AVERAGE	0.090909	POOR ITEM	REJECT

APPENDIX L

DETERMINATION OF THE RELIABILITY OF 61 RETAINED ITEMS OF EIMWAT BASED ON KUDDER-RICHARDSON FORMULAR 20 IN EXCELL SPREADSHEET

Anova: Two-Factor Without Replication				
SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	61	59	0.967213	0.03224
Row 2	61	58	0.95082	0.047541
Row 3	61	59	0.967213	0.03224
Row 4	61	58	0.95082	0.047541
Row 5	61	56	0.918033	0.076503
Row 6	61	60	0.983607	0.016393
Row 7	61	56	0.918033	0.076503
Row 8	61	58	0.95082	0.047541
Row 9	61	57	0.934426	0.062295
Row 10	61	57	0.934426	0.062295
Row 11	61	57	0.934426	0.062295

Row 12	61	57	0.934426	0.062295
Row 13	61	54	0.885246	0.103279
Row 14	61	50	0.819672	0.150273
Row 15	61	39	0.639344	0.234426
Row 16	61	37	0.606557	0.242623
Row 17	61	40	0.655738	0.229508
Row 18	61	42	0.688525	0.218033
Row 19	61	40	0.655738	0.229508
Row 20	61	38	0.622951	0.238798
Row 21	61	41	0.672131	0.224044
Row 22	61	41	0.672131	0.224044
Row 23	61	36	0.590164	0.245902
Row 24	61	38	0.622951	0.238798
Row 25	61	36	0.590164	0.245902
Row 26	61	36	0.590164	0.245902
Row 27	61	23	0.377049	0.238798
Row 28	61	35	0.57377	0.248634
Row 29	61	33	0.540984	0.252459
Row 30	61	23	0.377049	0.238798
Row 31	61	19	0.311475	0.218033
Row 32	61	23	0.377049	0.238798
Row 33	61	22	0.360656	0.234426
Row 34	61	22	0.360656	0.234426
Row 35	61	20	0.327869	0.224044
Row 36	61	18	0.295082	0.211475
Row 37	61	10	0.163934	0.139344
Row 38	61	8	0.131148	0.115847
Row 39	61	7	0.114754	0.103279
Row 40	61	8	0.131148	0.115847
Column 1	40	23	0.575	0.250641
Column 2	40	25	0.625	0.240385
Column 3	40	30	0.75	0.192308
Column 4	40	23	0.575	0.250641
Column 5	40	25	0.625	0.240385
Column 6	40	30	0.75	0.192308
Column 7	40	23	0.575	0.250641
Column 8	40	25	0.625	0.240385
Column 9	40	30	0.75	0.192308
Column 10	40	23	0.575	0.250641
Column 11	40	25	0.625	0.240385
Column 12	40	30	0.75	0.192308
Column 13	40	27	0.675	0.225
Column 14	40	23	0.575	0.250641

Column 15	40	25	0.625	0.240385
Column 16	40	30	0.75	0.192308
Column 17	40	23	0.575	0.250641
Column 18	40	25	0.625	0.240385
Column 19	40	30	0.75	0.192308
Column 20	40	26	0.65	0.233333
Column 21	40	23	0.575	0.250641
Column 22	40	25	0.625	0.240385
Column 23	40	30	0.75	0.192308
Column 24	40	23	0.575	0.250641
Column 25	40	25	0.625	0.240385
Column 26	40	23	0.575	0.250641
Column 27	40	25	0.625	0.240385
Column 28	40	30	0.75	0.192308
Column 29	40	20	0.5	0.25641
Column 30	40	23	0.575	0.250641
Column 31	40	25	0.625	0.240385
Column 32	40	30	0.75	0.192308
Column 33	40	23	0.575	0.250641
Column 34	40	25	0.625	0.240385
Column 35	40	30	0.75	0.192308
Column 36	40	23	0.575	0.250641
Column 37	40	25	0.625	0.240385
Column 38	40	30	0.75	0.192308
Column 39	40	22	0.55	0.253846
Column 40	40	21	0.525	0.255769
Column 41	40	23	0.575	0.250641
Column 42	40	25	0.625	0.240385
Column 43	40	30	0.75	0.192308
Column 44	40	23	0.575	0.250641
Column 45	40	25	0.625	0.240385
Column 46	40	30	0.75	0.192308
Column 47	40	21	0.525	0.255769
Column 48	40	23	0.575	0.250641
Column 49	40	25	0.625	0.240385
Column 50	40	30	0.75	0.192308
Column 51	40	23	0.575	0.250641
Column 52	40	27	0.675	0.225
Column 53	40	18	0.45	0.253846
Column 54	40	18	0.45	0.253846
Column 55	40	25	0.625	0.240385
Column 56	40	30	0.75	0.192308
Column 57	40	19	0.475	0.255769
Column 58	40	16	0.4	0.246154

Column 59	40	23	0.575	0.250641
Column 60	40	25	0.625	0.240385
Column 61	40	30	0.75	0.192308

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	179.7045	39	4.607808	29.00639	1.0129E-169	1.404536
Columns	18.93525	60	0.315587	1.986639	1.26174E-05	1.323953
Error	371.7205	2340	0.158855			
Total	570.3602	2439				

$$K - R20 = 1 - \left(\frac{Mean\ of\ Squares\ Error}{Mean\ of\ Squares\ Rows}\right)$$

$$K - R20 = 1 - \left(\frac{0.158855}{4.607808}\right)$$

$$K - R20 = 1 - \left(\frac{0.158855}{4.607808}\right)$$

$$K - R20 = 1 - 0.0345$$

$$K - R20 = 0.966$$

APPENDIX M

LIST OF RANDOMLY SELECTED 50 ITEMS

S/No	ITEM No.
1	itm01
2	itm02
3	itm03
4	itm09
5	itm10
6	itm11
7	itm12
8	itm14
9	itm15
10	itm16
11	itm18
12	itm19
13	itm20

14	itm22
15	itm23
16	itm24
17	itm27
18	itm28
19	itm29
20	itm31
21	itm32
22	itm33
23	itm34
24	itm35
25	itm37
26	itm40
27	itm41
28	itm43
29	itm44
30	itm45
31	itm49
32	itm50
33	itm52
34	itm53
35	itm55
36	itm56
37	itm57
38	itm58
39	itm60
40	itm62
41	itm63
42	itm66
43	itm68
44	itm77
45	itm78
46	itm79
47	itm80
48	itm86
49	itm87
50	itm88

APPEDIX N
RELIABILITY OF 61 RANDOMLY SELECTED ITEMS OF EIMWAT BASED ON KUDDER-RICHARDSON FORMULAR 20 IN EXCELL SPREADSHEET

Anova: Two-Factor Without Replication				
SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	50	44	0.88	0.107755
Row 2	50	48	0.96	0.039184
Row 3	50	48	0.96	0.039184
Row 4	50	45	0.9	0.091837
Row 5	50	41	0.82	0.150612
Row 6	50	46	0.92	0.075102
Row 7	50	43	0.86	0.122857
Row 8	50	48	0.96	0.039184

Row 9	50	46	0.92	0.075102
Row 10	50	45	0.9	0.091837
Row 11	50	44	0.88	0.107755
Row 12	50	45	0.9	0.091837
Row 13	50	43	0.86	0.122857
Row 14	50	41	0.82	0.150612
Row 15	50	32	0.64	0.235102
Row 16	50	29	0.58	0.248571
Row 17	50	32	0.64	0.235102
Row 18	50	34	0.68	0.222041
Row 19	50	33	0.66	0.22898
Row 20	50	32	0.64	0.235102
Row 21	50	33	0.66	0.22898
Row 22	50	33	0.66	0.22898
Row 23	50	30	0.6	0.244898
Row 24	50	31	0.62	0.240408
Row 25	50	29	0.58	0.248571
Row 26	50	30	0.6	0.244898
Row 27	50	19	0.38	0.240408
Row 28	50	28	0.56	0.251429
Row 29	50	26	0.52	0.254694
Row 30	50	18	0.36	0.235102
Row 31	50	16	0.32	0.222041
Row 32	50	19	0.38	0.240408
Row 33	50	19	0.38	0.240408
Row 34	50	21	0.42	0.248571
Row 35	50	17	0.34	0.22898
Row 36	50	16	0.32	0.222041
Row 37	50	13	0.26	0.196327
Row 38	50	7	0.14	0.122857
Row 39	50	13	0.26	0.196327
Row 40	50	11	0.22	0.175102
Column 1	40	22	0.55	0.253846
Column 2	40	26	0.65	0.233333
Column 3	40	29	0.725	0.204487
Column 4	40	25	0.625	0.240385
Column 5	40	29	0.725	0.204487
Column 6	40	25	0.625	0.240385
Column 7	40	23	0.575	0.250641
Column 8	40	26	0.65	0.233333
Column 9	40	24	0.6	0.246154
Column 10	40	30	0.75	0.192308
Column 11	40	24	0.6	0.246154

Column 12	40	23	0.575	0.250641
Column 13	40	30	0.75	0.192308
Column 14	40	26	0.65	0.233333
Column 15	40	30	0.75	0.192308
Column 16	40	26	0.65	0.233333
Column 17	40	23	0.575	0.250641
Column 18	40	31	0.775	0.178846
Column 19	40	25	0.625	0.240385
Column 20	40	25	0.625	0.240385
Column 21	40	26	0.65	0.233333
Column 22	40	30	0.75	0.192308
Column 23	40	20	0.5	0.25641
Column 24	40	22	0.55	0.253846
Column 25	40	28	0.7	0.215385
Column 26	40	21	0.525	0.255769
Column 27	40	25	0.625	0.240385
Column 28	40	23	0.575	0.250641
Column 29	40	25	0.625	0.240385
Column 30	40	30	0.75	0.192308
Column 31	40	22	0.55	0.253846
Column 32	40	21	0.525	0.255769
Column 33	40	24	0.6	0.246154
Column 34	40	25	0.625	0.240385
Column 35	40	23	0.575	0.250641
Column 36	40	25	0.625	0.240385
Column 37	40	30	0.75	0.192308
Column 38	40	21	0.525	0.255769
Column 39	40	23	0.575	0.250641
Column 40	40	30	0.75	0.192308
Column 41	40	23	0.575	0.250641
Column 42	40	27	0.675	0.225
Column 43	40	18	0.45	0.253846
Column 44	40	25	0.625	0.240385
Column 45	40	30	0.75	0.192308
Column 46	40	19	0.475	0.255769
Column 47	40	16	0.4	0.246154
Column 48	40	20	0.5	0.25641
Column 49	40	25	0.625	0.240385
Column 50	40	29	0.725	0.204487

ANOVA							
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	
Rows	115.368	39	2.958154	16.711	1.06E-94	1.405712	

Columns	15.598	49	0.318327	1.798269	0.000643	1.360684	
Error	338.282	1911	0.177018				
Total	469.248	1999					

$$K - R20 = 1 - \left(\frac{Mean\ of\ Squares\ Error}{Mean\ of\ Squares\ Rows}\right)$$

$$K - R20 = 1 - \left(\frac{0.177018}{2.958154}\right)$$

$$K - R20 = 1 - 0.0598$$

$$K - R20 = 0.9402$$

Reliability for EIMWII

APPENDIX O

Reliability

Notes

Output Created		10-APR-2021 20:04:47
Comments		
Input	Data	C:\Users\DELL USER\Documents\SPSS JOBS\nathaniel\EIMWII.sav
	Active Dataset	DataSet2
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	40
	Matrix Input	

Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=item01 item02 item03 item04 item05 item06 item07 item08 item09 item10 item11 item12 item13 item14 item15 item16 item17 item18 item19 item20 item21 item22 item23 item24 item25 item26 item27 item28 item29 item30 item31 item32 item33 item34 item35 item36 item37 item38 item39 item40 item41 item42 item43 item44 item45 item46 item47 item48 item49 item50 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE SCALE HOTELLING ANOVA COCHRAN /SUMMARY=TOTAL.
Resources	Processor Time	00:00:00.06
	Elapsed Time	00:00:00.07

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	40	100.0
	Excluded[a]	0	.0
	Total	40	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.900	.869	50

Item Statistics

	Mean	Std. Deviation	N
item01	1.20	.516	40
item02	2.00	.320	40
item03	2.20	.758	40
item04	2.85	.483	40
item05	2.20	.758	40
item06	1.90	.304	40
item07	2.95	.504	40
item08	2.05	.221	40
item09	1.30	.791	40
item10	2.20	.758	40
item11	1.10	.441	40
item12	2.10	.441	40
item13	2.20	.758	40
item14	1.20	.687	40
item15	3.10	.955	40
item16	2.15	.362	40
item17	3.05	.932	40
item18	2.15	.483	40
item19	2.95	.221	40
item20	2.20	.758	40
item21	2.20	.758	40
item22	3.05	.221	40
item23	2.05	.221	40
item24	2.95	.221	40
item25	2.05	.221	40
item26	2.95	.221	40
item27	2.10	.441	40
item28	2.10	.441	40
item29	3.15	.975	40
item30	2.15	.483	40
item31	3.10	.304	40
item32	2.20	.758	40
item33	2.10	.304	40
item34	2.20	.758	40
item35	3.00	.320	40

item36	2.30	.723	40
item37	2.15	.483	40
item38	2.20	.758	40
item39	2.05	.221	40
item40	2.85	.483	40
item41	2.20	.758	40
item42	2.00	.320	40
item43	2.20	.758	40
item44	2.90	.545	40
item45	2.20	.758	40
item46	2.05	.221	40
item47	2.80	.608	40
item48	2.00	.320	40
item49	1.80	.405	40
item50	2.20	.758	40

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
114.30	139.087	11.794	50

ANOVA with Cochran's Test

		Sum of Squares	df	Mean Square	Cochran's Q	Sig
Between People		108.488	39	2.782		
Within People	Between Items	509.808	49	10.404	960.866	.000
	Residual	530.112	1911	.277		
	Total	1039.920	1960	.531		
Total		1148.408	1999	.574		

Grand Mean = 2.29

Hotelling's T-Squared Test

Hotelling's T-Squared	F	df1	df2	Sig
.000[a]	.	.	.	.

a. There are not enough cases to compute Hotelling's T-Squared.

APPENDIX P

RESULT OF RELIABILTY OF PSYCHOMOTOR TEST

Correlations

Notes

Output Created		13-APR-2021 03:09:44
Comments		
Input	Data	C:\Users\DELL USER\Documents\SPSS JOBS\nathaniel\PSYCHOMOTOR.sav
	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>

	Split File	<none>
	N of Rows in Working Data File	40
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each pair of variables are based on all the cases with valid data for that pair.
Syntax		CORRELATIONS /VARIABLES=Rater1 Rater2 /PRINT=TWOTAIL NOSIG /STATISTICS DESCRIPTIVES /MISSING=PAIRWISE.
Resources	Processor Time	00:00:00.00
	Elapsed Time	00:00:00.01

Descriptive Statistics

	Mean	Std. Deviation	N
Rater1	21.88	.757	40
Rater2	21.95	.783	40

Correlations

		Rater1	Rater2
Rater1	Pearson Correlation	1	.032
	Sig. (2-tailed)		.843
	N	40	40
Rater2	Pearson Correlation	.032	1
	Sig. (2-tailed)	.843	
	N	40	40

APPENDIX Q

CERTIFIC ATE OF VALIDATION

This is to certify I validated the research instrument of Nathaniel Ndagana Umaru with Reg. No. Phd/SSTE/2018/8611. a Ph.D student of Industrial and Technology Education Department, Federal University of Technology, Minna. Working on research topic titled: The Effects of the Glencoe's Problem-Solving Strategies (GPSS) And Rusbult's Problem-Solving Strategies (RPSS) on Achievement and Interest of EIMW Students in Technical Colleges in North Central Nigeria.

Name of Validate: Dr. Maxwell E. Uduafemhe

Institution/Organisation: National Examinations council

Signature/Date: Uduafemhe 12 04 2021

CERTIFIC ATE OF VALIDATION

This is to certify I validated the research instrument of Nathaniel Ndagana Umaru with Reg. No. Phd/SSTE/2018/8611. a Ph.D student of Industrial and Technology Education Department, Federal University of Technology. Minna. Working on research topic titled: The Effects of the Glencoe's Problem-Solving Strategies (GPSS) And Rusbult's Problem-Solving Strategies (RPSS) on Achievement and Interest of EIMW Students in Technical Colleges in North Central Nigeria.

Name of Validate: Dr. Benjamin S. Bargu

Institution/Organisation: NECO, Abia state office

Signature/Date: [signature] 18/4/2021

CERTIFIC ATE OF VALIDATION

This is to certify I validated the research instrument of Nathaniel Ndagana Umaru with Reg. No. Phd/SSTE/2018/8611. a Ph.D student of Industrial and Technology Education Department, Federal University of Technology. Minna. Working on research topic titled: The Effects of the Glencoe's Problem-Solving Strategies (GPSS) And Rusbult's Problem-Solving Strategies (RPSS) on Achievement and Interest of EIMW Students in Technical Colleges in North Central Nigeria.

Name of Validate Dr. Usman, G. A.

Institution/Organisation FUT Minna

Signature/Date [signature] 25/4/2021