EFFECT OF BRAINSTORMING, JUST-IN-TIME AND DEMONSTRATION TEACHING TECHNIQUES ON STUDENTS' LEARNING OUTCOMES IN DIGITAL ELECTRONICS IN COLLEGES OF EDUCATION IN NORTH-WEST, NIGERIA

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF TECHNOLOGY (MTECH) DEGREE IN INDUSTRIAL AND TECHNOLOGY EDUCATION (ELECTRICAL/ELECTRONIC TECHNOLOGY)

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ABSTRACT

The study identified the effects of brainstorming, Just-in-time Teaching (JiTT) and demonstration teaching techniques on students' cognitive achievement, skill achievement, interest and retention of students in colleges of education in North-West Nigeria. Four research questions were raised and answered as well as four hypotheses were formulated and tested at 0.05 level of significance. The study adopted pretest–posttest non-equivalent control group design of quasi-experimental study alongside, 3×3 factorial research design. The study was conducted in North-West, Nigeria. The population of this study comprised of the entire 142 Nigerian Certificate in Education (NCE) III electrical/electronic students in all the Colleges of Education in the study area offering technical education. Due to the manageable size of the population of the study, there was no sampling of subjects. The Colleges of Education in the study area were assigned to control and experimental groups I and II using purposive and simple random sampling techniques. The instruments used for data collection include: Digital Electronics Cognitive Achievement and Retention Tests (DECART), Digital Electronics Skill Achievement Tests (DESAT) and Digital Electronics Interest Inventory (DEII). The instruments were subjected to face and content validation by three experts. The reliability co-efficients of: DECART was determined as 0.78 using Kuder-Richardson 20 (K-R 20), DESAT was determined as 0.81 using Kendall's tau coefficient of concordance and DEII was determined as 0.83 using Cronbach Alpha. The collection of data for the study was achieved through physical administration of the instruments by the lecturers involved in the study. The study employed the use of descriptive statistics using mean and inferential statistics using Analysis of Covariance (ANCOVA) to analyze the data. The study found out that, brainstorming teaching technique had positive effect on the cognitive achievement ($\bar{X}$=79.76) and the retention of students ($\bar{X}$=75.27) in digital electronics, demonstration teaching technique had positive effect on the skill achievement of students ($\bar{X}$=77.95) in digital electronics and JiTT technique had positive effect on the interest of students ($\bar{X}$=84.79) in digital electronics. The study also revealed that, there was significant difference (Sig. 0.00) between the mean cognitive and skill achievement, interest and retention scores of students taught digital electronics using brainstorming, JiTT and demonstration teaching techniques. The study recommended among others that, digital electronics lecturers should adopt the use of: brainstorming teaching technique to enhance students' cognitive achievement and retention, JiTT technique to stimulate students' interest and demonstration teaching technique to enhance students' skill achievement.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Digital electronics is a compulsory two credit unit course with code: TEE 328 offered by final year Electrical Electronic Technical Education (EETE) students in colleges of education (Technical) in Nigeria. The course deals with electronic appliances which function on the principle of logic gate and logic decisions with the use of integrated circuits as their main component. According to Federal Republic of Nigeria (FRN, 2012), the course is aimed at equipping students with the knowledge of basic computer parts, types and other devices, computer hardware configuration and techniques of computer aided designs, number system, logic gates, flip-flop, counters, decoders and

encoders and microprocessors. Halliru and Muhyideen (2018) noted that, the aim of digital electronics is far from being achieved due to the persistently manifested low student's performance. The low performance of students in the course could be influenced by instructional techniques used by lecturers.

Instructional techniques entail the principles and methods used for instruction to be implemented by lecturers to achieve the desired learning by students. These strategies are determined partly based on subject matter to be taught and partly on the nature of the learner. For a particular instructional technique to be appropriate and efficient, it has to be in relation with the characteristic of the learner and the type of learning it is supposed to bring about. However, many teaching methods and approaches have been in use in the teaching of technical courses such as demonstration, lecture and discussion among others (Pilato & Ulrich, 2014). Moreover, these methods do not seem to be yielding the expected results currently. Literatures such as Afolabi and Akinbobola (2019) and Ogwo (2006) shows that, activity stimulating and student-centred instructional techniques could improve students' academic performance in different subjects better than teacher-centred instructional techniques. Umar *et al.* (2015) noted that, the most commonly used instructional technique used by colleges of education lecturers is demonstration methods.

Demonstration method refers to the type of teaching method in which the teacher is the principal actor while the learners watch with the intention to act later. Here the teacher does whatever the learners are expected to do at the end of the lesson by showing them how to do it and explaining the step-by-step process to them (Ameh *et al.*, 2017). Mundi (2016), described demonstration method of teaching as a display or an exhibition usually done by the teacher while the students watch with keen interest. The gains of using demonstration method in teaching lies in the fact that it bridges the gap between

theory and practice, enables learners to become good observers and generate their interest; students see immediate progress as a result of a correct effort and it enables the lecturer to impart manipulative and operational skills. Despite these benefits, Dorgu (2015) advocated that, improving students' performance especially in digital electronics require students' centre instructional techniques such as brainstorming.

Brainstorming is one of the most important teaching technique in provoking creativity and solving problems in the field of education. As the name suggests, brainstorming is meant to stimulate or excite the brain into thinking about issues in a new way. Filgona *et al.* (2016) described brainstorming teaching method as a technique that emphasizes the participation, dialogue and two-way communication between teacher and students. According to Akinboye (2013), brainstorming teaching method involves asking of carefully framed questions aimed at teaching students to find out facts and learn skills for themselves and do critical thinking. It encourages students to arrest conventional, logical thinking and embrace spontaneity, originality, and imagination. Eble (2016) noted that, students performed and retained knowledge better when taught using brainstorming teaching method and other active technique such as Just-in Time Teaching technique.

Just-in-time Teaching (JiTT) technique is problem based and student centred learning approaches that allow students to learn and express their idea about yet to be taught topic. The technique combined the use of out-of-class web-based exercise with active learning pedagogy. According to Simkins and Maier (2016), JiTT technique engage students with reading to answer warm-up questions on new topics outside the class and submit electronically prior to the classroom activity. The teacher review students' response prior to the class and use the responses to organize and modify the upcoming classroom session. Cookman (2010) revealed that, students' responses let the teacher

tailor lectures, demonstrations, discussions or other teaching and learning activities to reinforce the students' understanding and correct their misconceptions. According to Pace and Middendorf (2017), the pre-class experience that students acquired in the course of doing the assignment enhance their learning outcomes. Moreover, the conspicuous similarity among JiTT, brainstorming and demonstration techniques is their ability to enhance students' learning outcomes.

Learning outcomes are assessment standards indicating the expected levels of learning that students should achieve for that class. Idodo and Oladimeji (2018) defined learning outcomes as statements of what a learner is expected to know, understand and/or be able to demonstrate at the end of a period of learning. They are usually defined in terms of a mixture of knowledge, skills, abilities, attitudes and understanding that an individual will attain as a result of his or her successful engagement in a particular set of educational experiences. Carey and Gregory (2013) stated that, the learning outcome of colleges of education is generally low due to the use of students' centred teaching techniques by the lecturers. Assessing students' learning outcome provides teachers with the indicator of students' academic achievement.

Academic achievement connotes the performance of students in school subject as symbolized by a score or mark on achievement test. Kareem (2015) stated that, achievement is the outcome of education which involves the determination of the degree of attainment of the learner in a task, course or programmes to which the learner is sufficiently exposed. Academic achievement in the context of this study could be seen as the degree to which EETE students acquire the contents of digital electronics. Halliru and Muhyideen (2018) revealed that, low academic achievement among EETE students jeopardizes the realization of digital electronics aim. The non-realization of this aim is a serious threat to the goal of producing technicians capable of maintaining digital

electronic devices. Basically, there are two types of achievement in education which include cognitive and skill.

Cognitive achievement refers to students' ability to perform various mental activities most closely associated with learning and problem solving. Olatoye and Aderogba (2011) defined cognitive achievement as a general mental capability involving reasoning, problem solving, abstract thinking complex idea comprehension and learning from experience. The mental ability of EETE student to display high level knowledge after learning digital electronics as a course over the years is generally low. Oyetunde (2010) disclosed that, cognitive achievement of EETE students in digital electronics is declined due to non-utilization of effective teaching techniques among lecturers such as brainstorming, JiTT and demonstration. According to Afolabi and Akinbobola (2019), the low cognitive achievement among students hinders positive development of the overall learning outcomes. This implies that, the low cognitive achievement of students in digital electronics largely affect students' skill performance.

Skill performance refers to the psychomotor ability of students related to set of actions required for the completion of a practical task. According to Eilks (2019) skill performance refers to expertness, practiced ability or proficiency displayed in the performance of a task. It can be broadly seen as the ability of EETE students to carry out practical task in digital electronics with expertise. In order to perform tasks in the repairs of varieties of digital electronics devices, EETE students require high skills achievement in order to carry out the maintenance of digital electronics components. Skill performance primarily deals with physical dexterity that can be acquired through the use of practical oriented teaching techniques such as brainstorming, JiTT and demonstration. James (2015) revealed that, the utilization of these teaching techniques by the lecturers is capable of addressing the low skill peformancein digital electronics

among EETE students that translate into inadequate qualified and competent technicians to repair digital electronic products such as laptop computers, mobile phones and digital camera among others. According to Azih and Nwosu (2018), cognitive and skill performance is dependent upon several factors amongst which is students' interest.

Interest is described as the attraction which forces or compels a learner to respond to a particular stimulus. According to Mondane (2014), interest is a subjective feeling of concentration or curiosity over something. Interest is an important variable in learning because when a student becomes interested in an activity, he/she is likely to be more deeply involved in that activity. Schraw *et al.* (2011) noted that, lack of interest in a subject such as digital electronics could contribute greatly to students' low academic achievement which is largely influenced by teaching methods. This implies that, the low academic achievement recorded in digital electronics among EETE students is caused by low interest. According to Mondane (2014), active teaching techniques such as brainstorming, JiTT and demonstration methods can induce student's interest and as well enhance their performance in a particular subject. Martinez (2012) confirmed that, the use of brainstorming, JiTT and demonstration methods has shown to stimulate attention and arouse student's interest in sciences and humanities. Thus, it might also enhance students' interest in digital electronics and lead to high cognitive and skill performance as well as retention of knowledge.

Retention of knowledge is the ability of an individual to reproduces valuable knowledge after a period of time. According to Adamu (2016), retention of knowledge is the repeat performance by a learner of the behaviour earlier acquired, elicited after an interval of time. Retention in the context of this study refers to the extent to which digital electronics students repeat performance earlier acquired after an interval of time. Green (2017) noted that, retention of knowledge is affected by the learner's memory capacity

and the instructional techniques utilized by lecturers. Akinbobola (2019) further stated that, the low retention of knowledge among students is due to non-utilization of active teaching techniques such as brainstorming, JiTT and demonstration. This implies, these active instructional techniques may have the tendencies of enhancing students' retention of knowledge. Hence, this study sought to investigate the effect of brainstorming, JiTT and demonstration teaching methods on students' learning outcomes in digital electronics in colleges of education in North-West, Nigeria**.**

1.2. Statement of the Research Problem

Digital electronics is aimed at equipping EETE students with the knowledge and skills in the maintenance of digital electronics appliances. To realize this aim, Governments at both State and Federal levels have made provision for several inputs that include, building structures, well designed and developed curriculum as well as teaching staff to ensure effective learning. Unfortunately, despite these efforts by the Governments, it seems as if the aim is defeated as results of the continuous low cognitive and skill performance, and declining interest of students in studying EETE courses such as digital electronics as revealed by Halliru & Muhyideen (2018). The examination records on the performance of student's in digital electronics in North-West, Nigeria from 2015 to 2019 as shown in Appendix A (p91) revealed that, in 2014/2015 academic session, 51.06% failed, 48.09% in 2015/2016 and 50% in 2016/2017, 50.86% in 2017/2018 and 48.52% in 2018/2019. Supporting this claim, Azih and Nwosu (2018) reported that, the achievement of students in digital electronics is generally low in examinations due to use of non-effective methods of teaching such as lecture methods that do not take into account the needs of students, their interests, their tendencies and their desires. Okon (2018) equally noted that, demonstration method of teaching that is mostly used by

colleges of education lecturers is not challenging enough to meet the needs of the EETE students.

The continued use of lecture and demonstration methods in teaching digital electronics to students largely manifests some shortcomings that reflect low academic achievements among students in school subjects such as digital electronics (James, 2015). In a quest to address these shortcomings, there is an urgent need for teaching technique to keep up with the contemporary times in order to improve students' academic achievement, interest and retention in digital electronics. Thus, the study determined the effect of brainstorming, JiTT and demonstration teaching methods on students' learning outcome to ascertain the most suitable teaching methods in order to enhance students' cognitive and skill performances, interest and retention in digital electronics in colleges of education in North-West, Nigeria.

1.3. Aim and Objectives of the Study

The aim of the study was to determine the effect of brainstorming, JiTT and demonstration teaching methods on students' learning outcome in digital electronics in colleges of education in North-West, Nigeria. Specifically, the objectives of the study are to determine the effect of:

1. Brainstorming, JiTT and demonstration teaching methods on students' cognitive achievement in digital electronics
2. Brainstorming, JiTT and demonstration teaching methods on students' skill performance in digital electronics
3. Brainstorming, JiTT and demonstration teaching methods on students' interest in digital electronics
4. Brainstorming, JiTT and demonstration teaching methods on students' retention of learning in digital electronics

1.4. Significance of the Study

The findings of this study will be of benefit to digital electronics lecturers, students, college of education administrators and researchers in technical education.

The findings of this study will be beneficiary to digital electronics lecturers in colleges of education if documented and properly disseminated through seminars and workshops. The findings will serve as a guide by providing lecturers with a novel instructional technique that is students' centred capable of assisting the effective transfer of knowledge to students as well as increase their academic achievement, interest and retention. The findings will also help lecturers to provide a learning environment that promotes active learning, intrinsic motivation, exposure to online learning platforms and cooperation among students.

The findings of this study will be of benefit to digital electronics students as exposure to brainstorming and Just-in-time teaching techniques will equip them with sense of responsibility and control over their own learning. The use of these techniques will make them come to class very prepared and actively involved in the teaching and learning processes. The use of Brainstorming, JiTT and demonstration teaching methods will in no small way help to improve students' thinking abilities, internet abilities, learning and problem solving skills. Consequently, more students might likely pass with good grades and have the aptitude to read digital electronics related courses like computer, electrical and electronic engineering in universities.

The findings of this study will be useful to college of education administrators if made available through workshop, seminar as the information from this study will serve as a guide in focusing the training priorities of digital electronics lecturers on the application of brainstorming and Just-in-time teaching techniques.

The findings of this study will be of benefit to researchers in technical education if documented in the libraries as it will provide empirical information on the effect of brainstorming and Just-in-time teaching techniques on digital electronics students in colleges of education. This study will contribute to literatures on effectiveness of web-based and problem solving teaching techniques useful to researchers in technical education for future researches.

1.5. Scope of the Study

The study will be delimited to the effect of brainstorming, JiTT and demonstration teaching methods on students' learning outcomes in digital electronics in colleges of education in North-West, Nigeria. Specifically, the brainstorming teaching method will be delimited to group brainstorming because of time management; Just-in-time teaching technique will be delimited to the use of warm-up questions because it prepares students to develop understanding of learning contents; demonstration teaching method will be delimited to methods demonstration because it involves showing students every step in carrying out a task. Nevertheless, the study will cover all digital electronics topics of instruction taught in second semester to EETE final year students as contained in the technical education minimum standard. The topics include: basic computer parts, types and other devices; computer hardware configuration and techniques of computer aided designs; number system; logic gates; flip-flop; counters; decoders and encoders; and microprocessors. These topics will be covered in this study because they are contained in the scheme of digital electronics for EETE final year students.

1.6. Research Questions

The following research question were raised and answered:

1. What is the effect of Brainstorming, JiTT and demonstration teaching methods on students' cognitive achievement in digital electronics?

2. What is the effect of Brainstorming, JiTT and demonstration teaching methods on students' skill performance in digital electronics?
3. What is the effect of Brainstorming, JiTT and demonstration teaching methods on students' interest in digital electronics?
4. What is the effect of Brainstorming, JiTT and demonstration teaching methods on students' retention of learning in digital electronics?

1.7. Hypotheses

The following null hypotheses were formulated and tested at .05 level of significance:

1. There is no significant difference among the cognitive achievement scores of students taught digital electronics using Brainstorming, JiTT and demonstration teaching methods
2. There is no significant difference among the skill performance scores of students taught digital electronics using Brainstorming, JiTT and demonstration teaching methods
3. There is no significant difference among the interest scores of students taught digital electronics using Brainstorming, JiTT and demonstration teaching methods
4. There is no significant difference among the retention of learning scores of students taught digital electronics using Brainstorming, JiTT and demonstration teaching methods.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical Frameworks of the Study

2.1.1 Piaget's theory of cognitive development

The theory of cognitive development was propounded by Piaget (1952). The theory lay emphasis on meaning and knowledge contribution. The theory contend that children are active and motivated learners, and that they can create knowledge and meanings from their experiences and ideas, or from the interaction of both. He also theorizes that children inherit two tendencies (organization and adaptation) that are necessary for thinking and learning. They can organize (i.e. arrange, combine, or recombine or rearrange) their thoughts or behaviour into a scheme, and as well, through social

interaction adapt or adjust to the environment. Accordingly, he suggested two basic processes of adaptation- assimilation and accommodation through which knowledge and meanings can be constructed. By assimilation the student relates and integrates the new knowledge, concept or experiences into an existing scheme or framework without altering the scheme, and by accommodation, the child learns new concept by either modifying or reframing an already existing schemes to anchor in the new knowledge or by outright forming a new scheme.

Piaget believed that equilibration (the process of seeking for mental or conceptual balance between new experience and already existing schemes) influenced learning. This occur when the learner is in a state between equilibrium and disequilibrium. In the state of equilibrium, the learner can explain a new experience in relation to already existing schemes, whereas in the state of disequilibrium, the learner finds the new experience conflicting and incompatible with the existing scheme. This process promotes cognitive development and restructuring, development of higher and complex thought as well as learning.

The theory identified prior knowledge and experiences as critical elements in learning and as such form the basis for further knowledge and meaning construction. Furthermore, Piaget included social interactions in the environment as an additional variable for effective learning. Thus, this study assumed that students' pre-existing knowledge about any topic or content to be learned before receiving instructions and participation during instruction play a very significant influence on the learning of the topic during instructions. It is against this view that, the study employed brainstorming as an instructional technique that allow students' participation in the instructional process to determine digital electronics students' academic achievement, interest and retention.

2.1.2 Activity theory of learning

Activity theory of learning was propounded by Vygotsky *et al*. (1970). The theory emphasizes the importance of action on the part of the learner, to support the learning process. Learning is considered an active construction process, inseparable from doing, not a passive reception of knowledge. Activity and conscious learning are dynamically interrelated and cannot be separated. Therefore, it would be important to examine the activity systems (structures of activities in their socio cultural and socio historical) as part of the process of instructional design. Activity theory of learning emphasizes the importance of action on the part of the learner to support the learning process which is related to the principle of Just-in Time Teaching Techniques where learning is considered an active process of knowledge construction through listening, watching, critical examination and social interaction with the pre class web based experience of Just-in Time Teaching. The study considered activity theory as the fundamental ground for this study because it emphasizes on the importance of action on the part of the learner which is an active ingredient of Just-in Time Teaching Techniques.

2.2 Conceptual framework of the study

Figure 2.1 represents the conceptual framework for the effect of brainstorming, JiTT and demonstration teaching methods on students' learning outcome in digital electronics in colleges of education in North-West, Nigeria. The figure comprises of two main segments. The first segment comprises of the independent variables of the study which consists of brainstorming, JiTT and demonstration teaching methods. These are variables to be manipulated by the various lecturers involved in the study in order to obtain the desired learning outcomes. The second segment comprises of the dependent variables of the study which consists of cognitive achievement and retention, skill performance and interest in digital electronics. These are variables measured by the

researcher which were enhanced after the utilization of the independent variables on digital electronics students.

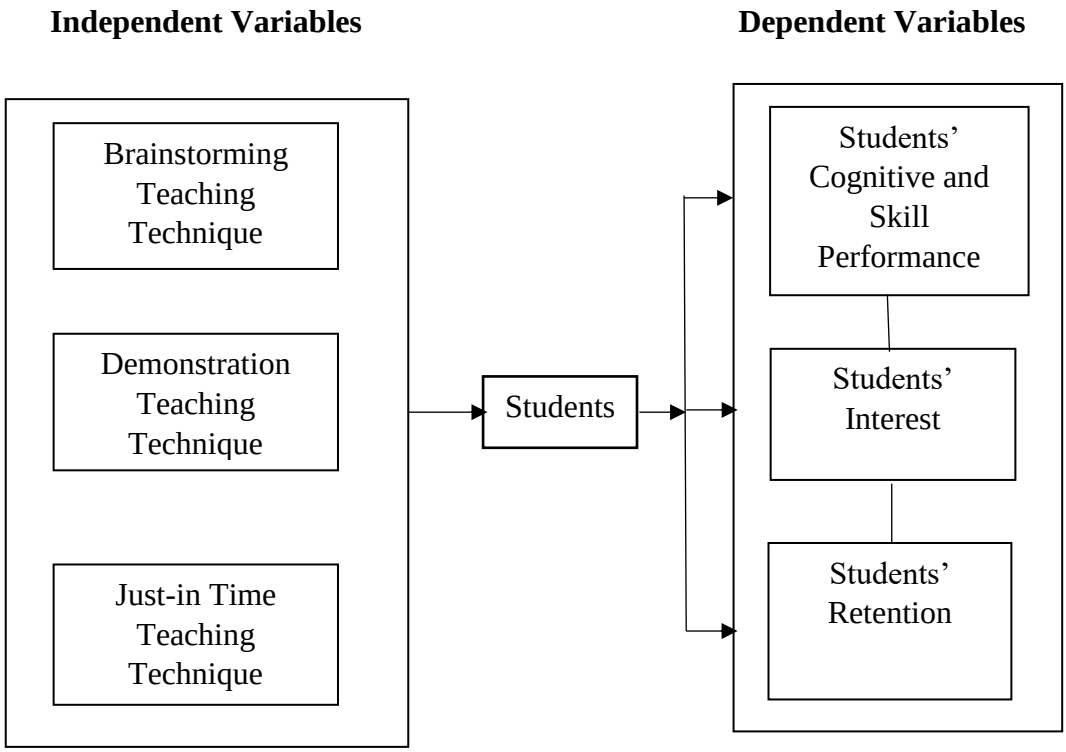

Figure 2.1: The Conceptual Framework for the Effect of Brainstorming, JiTT and demonstration teaching methods on Students' Learning Outcome in Digital Electronics in Colleges of Education in North-West, Nigeria.

Source: Researcher

2.3 Digital Electronics

Electronics generally deals with electrical circuits that involve active electrical components and devices. It equally involves associated passive interconnection technologies. The terms electronic and electronics are not exactly the same. Electronic as a term may be seen as the science of electronics. According to Ogbuanya (2009) electronics is a branch of science which deals with the motion emission and behavior of current as free electronics especially in vacuum, gas or photo tubes and special conductors or semiconductors. Electronics on the hand involves electronic components, devices, systems or equipment, and these devices operate on a relative low voltage (Crecraft & Gergey, 2012). Electronics are devices that operate on low voltage sources, as in electron tubes, transistors, integrated circuits, and printed circuit boards and use electricity as part of its driving force.

2.3.1 Basic building blocks of digital electronic appliances

The operation of digital electronic appliances depends largely on the electronic building blocks, components or devices. The building blocks of digital electronics include the logic gates, adders, flip-flops, counters, registers, multiplexers, Schmitt triggers, encoders and decoders (Singmin, 2011; Theraja & Sedha, 2009). There are other highly integrated devices or building blocks of digital electronics, and these include microprocessors, microcontrollers, memories, Application of Specific Integrated Circuits (ASIC), Digital Signal Processor (DSP) and Field Programmable Gate Array (FPGA) (Tokheim, 2015). In every manufactured electronic appliance, these devices are usually incorporated to perform their unavoidable functions. Some of the building blocks are briefly discussed below:

- **Logic gates**: these are the basic building blocks from which most of the digital systems are built up (Paton, 2018). They are essential electronic circuits which make

logic decisions. The circuit designs of logic gates have one output and one or more inputs. The output signal appears only for certain combinations of input signals. Logic gates implement the hardware logic function based on logical algebra. These gates are available in today in the form of various IC families. The most popular families are the transistor-transistor logic (TTL), emitter-coupled logic (ECL), metaloxide semiconductor (MOS) and complementary metal-oxide-semiconductor (CMOS) (Theraja & Sedha, 2009).

- **Flip-flops**: Flip-flop is the common name given to two-state devices which offer basic memory for sequential logic operations. Flip-flops are heavily used for digital data storage and transfer and are commonly used in banks called "registers" for the storage of binary numerical data. According to Tokheim (2015), there are different types of flip-flops, this include J-K flip-flop, R-S flip-flop, D-type transparent latch, S-R clocked flip-flop, edge triggered D-flip-flop, negative-edged triggered master-slave flip-flop, TTL flip-flop and true single-phase edge-triggered flip-flop.

- **Shift Registers**: The shift register is another type of sequential logic circuit that is used for the storage or transfer of data in the form of binary numbers and then "shifts" the data out once every clock cycle, hence the name "shift register". It basically consists of several single bit "D-Type Data Latches", one for each bit (0 or 1) connected together in a serial or daisy-chain arrangement so that the output from one data latch becomes the input of the next latch and so on (Paton, 2018).

- **Microprocessors**: The microprocessor, also known as the Central Processing Unit (CPU), is the brain of the computer and many household and electronic devices. Multiple microprocessors, working together, are the "hearts" of datacenters, super-computers, communications products, and other digital devices. A microprocessor

incorporates the functions of a computer's central processing unit (CPU) on a single integrated circuit (IC), or at most a few integrated circuits (Paton, 2018). It is a multipurpose, programmable device that accepts digital data as input, processes it according to instructions stored in its memory, and provides results as output. It is an example of sequential digital logic, as it has internal memory. Microprocessors operate on numbers and symbols represented in the binary numeral system.

Digital Electronic Appliances: In the context and scope of this study, the digital electronic appliances put into consideration are mobile phones, laptop computers, home theatre sound system, and LCD television. These appliances are becoming inevitable to the users in Nigeria, especially in our homes, offices and institutions of learning. They are briefly described as follows;

- **Mobile phones**: A cell phone, cellular phone, or mobile phone is a low powered transceiver that provides voice telephone service to mobile users. Cell phones are of three bands, there are single band, dual band and tri-band (Daniel, 2015). Daniel stated that mobile phones used in Nigeria are made of different brands as licensed by Nigerian Communication Commission (NCC). Some of these brands are Nokia, Samsung, Siemens, Sony Ericsson, Motorola, Sagem, Tecno, LG, Ericsson, Sony, Sendo, Alcatel, Bird, Panasonic and Philips. Mobile phones have so many features that gives them the opportunities to be in different modes.
- **Laptop computers**: These are computers that have been designed differently from the desktop computers. They are also electronic transceivers and are made of different brands such as Dell, Mitsubishi, Sony, Philips, Compaq and HP.
- **LCD televisions**: This television has gained recognition in recent over the cathode ray tube television. It is made of compressed and portable circuits that gave it the flat nature.

2.4 Brainstorming teaching method

Brainstorming is one of the most important strategies that facilitates creativity and solving problems in the educational, commercial, industrial and political fields. Brainstorming can be defined as a group or an individual creativity method in which attempts are made to determine a definite conclusion for a particular problem by obtaining information in form of a list of ideas that are spontaneously contributed by the members (Rowan, 2014). Brainstorming strategy was introduced by Alex Osborn, an American advertisement company manager in 1938 as a result of his inconvenience of traditional business meetings. He claims that individuals working alone to come up with ideas are less efficient than when the ideas are generated through brainstorming. Brainstorming means the use of brain to the active problem solving and the brainstorming session aims to develop creative solutions to problems. Al-gorashi (2008) defined it as the multiple thinking that includes the breaking up of old ideas, making new connections, enlarging the limits of knowledge and the onset of wonderful ideas.

Brainstorming can be viewed as a technique in which an individual or a group engages in critical thinking to generate wide-ranging ideas and creative solution toward solving a problem. This strategy is now widely applied in different fields of human endeavor including education (Owo *et al.*, 2016). Brainstorming provides a free and open environment that encourages everyone to participate. Quirky ideas are welcomed and built upon, and all participants are encouraged to contribute fully, helping them develop a rich array of creative solutions. When used during problem solving, brainstorming brings team members' diverse experience into play. It increases the richness of idea explored, which means that you can often find better solutions to the problems that you face. What's more, because brainstorming is fun, it helps team members bond, as they solve problems in a positive, rewarding environment. While brainstorming can be

effective, it's important to approach it with an open mind and a spirit of non-judgment (Al-Mutairi, 2015).

Brainstorming is simple and effective when used as a strategy for teaching electrical/electronic technology education courses especially digital electronics. It is effective because it activates the students' background knowledge and captures their interest (Gupta, 2014). While the students are learning, the lecturer can determine whether they possess enough background knowledge to move ahead with the lesson or not. Brainstorming helps advanced level students to identify and come up with real questions to include in learning projects such as in digital electronics (Al-khatib, 2012). Moreover, the students are autonomous in developing ideas, no matter how obnoxious they may seem; therefore, they feel free. As such, students can increase the opportunity to learn from their mistakes and their peers while still reinforcing basic skills of brainstorming and social studies (Ikwumelu & Oyibe, 2014). Brainstorming incorporates other forms of study such as critical thinking that are necessary for the thought process (Al-khatib, 2012). Critical thinking helps students understand the problem and come up with its most suitable solution.

Moreover, brainstorming helps with team building, as it is appropriately suited for group projects. It is helpful in teaching electrical/electronic technology education courses especially digital electronics. Students are able to come up with ideas regarding how to solve particular problems; and therefore, can come up with questions relating to how the problem comes about and the best way to tackle it (Ikwumelu & Oyibe, 2014). While brainstorming can be effective in teaching electrical/electronic technology education courses, it's important to approach it with an open mind and a spirit of non-judgment. If you don't do this, people "clam up," the number and quality of ideas

plummets, and morale can suffer. Brainstorming can either be carried out individually or in groups.

Individual Brainstorming: Individual brainstorming involves the relationship between individuals' cognitive domain to generate wide-ranging ideas and creative solution toward solving a problem. Individual brainstorming is often more effective at generating ideas than normal group problem solving, several studies have shown that individual brainstorming produces more and often better ideas than group brainstorming. This can occur because groups aren't always strict in following the rules of brainstorming, and bad behaviors creep in (AlMutairi, 2015). Mostly, though, this happens because people pay so much attention to other people that they don't generate ideas of their own or they forget these ideas while they wait for their turn to speak. This is called "blocking."

Group Brainstorming: In group brainstorming, one can take advantage of the full experience and creativity of all team members. When one member gets stuck with an idea, another member's creativity and experience can take the idea to the next stage. You can develop ideas in greater depth with group brainstorming than you can with individual brainstorming. Owo *et al.* (2016) noted that, another advantage of group brainstorming is that it helps everyone feel that they've contributed to the solution, and it reminds people that others have creative ideas to offer. It's also fun, so it can be great for team building. Group brainstorming can be risky for individuals. Unusual suggestions may appear to lack value at first sight this is where you need to chair sessions tightly, so that the group doesn't crush these ideas and stifle creativity (AlMutairi, 2015). Where possible, participants should share similar goal of learning. This cross-section of experience can make the session more creative. However, don't make the group too big: as with other types of teamwork, groups of five to seven people are usually most effective.

Using Brainstorming teaching method

To run a group brainstorming session effectively, Al-Mutairi (2015) suggested the following steps:

Step 1: Prepare the Group

First, set up a comfortable classroom environment for the session. Make sure that the classroom is well-lit and that you have the instructional facilities that are needed for the session. Consideration should be made on the instructional facilities does the session required in order to brainstorm solutions to the learning problem (Al-gorashi, 2008). Remember that preparation is important; as such adequate preparation should be made to enhance the freewheeling nature of a brainstorming session. Consider the nature of students to be assigned in the brainstorming group session. A room full of like-minded people won't generate as many creative ideas as a diverse group, so try to include students with variety of thinking styles.

When everyone is gathered, appoint one person to record the ideas that come from the session. This person shouldn't necessarily be the team manager – it's hard to record and contribute at the same time. Post notes where everyone can see them, such as on flip charts or whiteboards; or use a computer with a data projector. If people aren't used to working together, consider using an appropriate warm-up exercise, or an icebreaker.

Step 2: Present the Problem

Clearly define the problem that you want to solve, and lay out any criteria that you must meet. Make it clear that that the meeting's objective is to generate as many ideas as possible. Give people plenty of quiet time at the start of the session to write down as many of their own ideas as they can (Owo *et al.,* 2016). Then, ask them to share their ideas, while giving everyone a fair opportunity to contribute.

Step 3: Guide the Discussion

Once everyone has shared their ideas, start a group discussion to develop other people's ideas, and use them to create new ideas. Building on others' ideas is one of the most valuable aspects of group brainstorming. Encourage everyone to contribute and to develop ideas, including the quietest people, and discourage anyone from criticizing ideas. Ikwumelu & Oyibe, 2014) noted that, as the group facilitator, one should share ideas if you have them, but spend your time and energy supporting your team and guiding the discussion. Stick to one conversation at a time, and refocus the group if people become sidetracked.

Although you're guiding the discussion, remember to let everyone have fun while brainstorming. Welcome creativity, and encourage your team to come up with as many ideas as possible, regardless of whether they're practical or impractical. Use thought experiments such as Provocation or Random Input to generate some unexpected ideas. Don't follow one train of thought for too long. Make sure that you generate a good number of different ideas, and explore individual ideas in detail. If a team member needs to "tune out" to explore an idea alone, allow them the freedom to do this. Also, if the brainstorming session is lengthy, take plenty of breaks so that people can continue to concentrate.

2.5 Demonstration teaching method

The way to teach an occupational skill in electrical/electronic technology education is to demonstrate it. Demonstration teaching method involves showing by reason or proof, explaining or making clear by use of examples or experiments to ensure effective transfer of knowledge and skills. Demonstration, in a simple term refers to the process of clearly showing by practice (Sola & Oloyede, 2017). In teaching by demonstration, students are set up to potentially conceptualize class material more effectively as shown

in a study which specifically focuses on demonstrations presented by lecturers (Bruce, John, Tara, & Rich, 2009). Demonstration method has been shown to be used with both large and small groups. The greater the degree of participation and sensory involvement by the learner, the more effective learning will be. The lecturers can improve the use of demonstration method in the classroom by allowing students to use several senses which involve seeing, hearing and possibly experiencing.

In practice, in using demonstration teaching method, ideas should be presented to stimulate interest. If these precautionary measures are not taken, demonstration can limit students' participation. According to Achounye (2012), demonstration method is a practical method of teaching. It involves showing, doing and telling something. Therefore, the lecturer needs to display the steps in the process and explain them accurately and clearly, while students are expected to practice by repeating the things the lecturer has done. Demonstration means any planned performance of an occupational skill, scientific principle or experiment. Demonstration method has become an instructional approach that is widely utilized within the engineering education community (Hadim & Esche, 2012). Duch (2012) describes demonstration method as an instructional strategy that challenges students to "learn how to learn" working cooperatively in groups to seek solutions to real world problems. Prpic and Hadgraft (2009) address the key ingredients of demonstration method and postulate that it should not be confused with design projects or case studies where the focus is predominantly on the application of existing knowledge and integration of what is already known.

Demonstration method goes beyond these; students will encounter some concepts for the first time and therefore they need strategies for acquiring this new knowledge (Prpic & Hadgraft, 2009). For instance, Lee (2014) reported that during demonstration,

students were able to identify some difficulties they faced in learning science when they were given problem to solve. Demonstration method is no substitute for laboratory exercise or for learning proper techniques of handling laboratory equipment, but are effective means of supplementing and clarifying the material being taught. Demonstration instructional method is a method of teaching concepts, principles or real things by combining explanation with handling or manipulation of real things, equipment or materials (Edu, Etelbert & Idaka, 2012). Basically, demonstration teaching method is classified into two, which include: method and result demonstration.

Method Demonstration: This involves showing students how to carry out a practice or use a tool/implement. Here, students are taught specific skill, techniques required and procedure involved in accomplishing as task. Olatoye and Adekoya (2011) stated that, the examples of method demonstration describe how to use a hand tools to develop practical projects such as circuit of digital electronics.

Result Demonstration: This involves showing the end process of learning or practice to the learner before he embarks on learning. Mills (2010) refers result demonstration as a very useful method because it explains the reason for undertaking certain task or new practice. This shows the product of a new practice and its feasibility.

Using Demonstration Teaching Method: Before presentation in demonstration teaching method, relevant materials like tools, equipment, visual and teaching aids should be obtained in advance and their useful condition checked during the preparation stage. The lecturer can prepare for demonstration teaching method by rehearsing the presentation before the lesson delivery to find out difficult steps and possible interruptions. Nsa, (2012) stated that, during presentation in demonstration teaching method, the lecturer should make sure that all students can see and hear the lesson, be

enthusiastic, professional, effective but not dramatic, relax; use any mishaps or humour to your advantage, observe all safety rules and procedures, keep eye-contact with the class; ask and encourage class questions, explain why and how: use the techniques of show and tell and use a medial summary to strengthen your explanation. Timing of the demonstration, removal of all extraneous materials, visibility, students grouping should be ascertained before commencement of demonstration (Lambros, 2012).

Adequate preparation and presentation in demonstration approach comes with some challenges. Therefore, Daluba (2013) reports that the lecturer can take precautions by avoiding interruptions to keep demonstration smooth and continuous; not demonstrate on a student's material, working towards one aim and allowing time for possible student participation. In carrying out demonstration, the lecturer should give a good performance bearing in mind that the trainees learn by good example, and also, explain each step or process as they proceed following the lesson plan; make sure the trainees see the demonstration from the angle they will perform it themselves; and be sure everyone can see and hear and maintaining eye contact. Emphasis should be on key points, and if possible, prepare beforehand to ask key questions as you go along and allow trainees to ask questions.

The lecturer has to pay attention to all safety rules, precautions and procedures; and emphasize them to the students. Use proper instructions, aids such as chalkboard, charts, handouts etc. to support the demonstration. Provide for students' participation where possible, during and after demonstration. First impressions are important, therefore, make them correct ones and always summaries the steps and emphasize key points again. Ogologo and Wagbara (2013) noted that, after demonstration, return all items used during demonstration to their storage places, make arrangements to have the trainees practice the skill as soon as possible in a practical class session, observe and

analyses trainee(s) performance and correct mistakes, offer reinforcement where necessary, coach weak or slow trainees, check trainee's completed work for accurate performance and record and allow sufficient time interval before demonstrating another operation.

It is however, important to note that the choice of any form of teaching method should not be arbitrary, but needs to be governed by the subject matter and the instructional objective that the lecturer intends to attain by the end of instruction. At the same time each method is not fool-proof, but has its own advantages and disadvantages (Uhumuavbi & Mamudu, 2009). That is why the use of complementary methods rather than one method is necessary.

2.6 Just-in-time teaching technique

Just-in-Time Teaching (JiTT) technique is a teaching and learning strategy designed to promote the use of class time for more active learning developed by Novak, Patterson, Gavrin and Christian (1999). The goal of JiTT approach is to help the whole spectrum of students to advance in learning through engagement in scholastic activities. JiTT was developed for introductory physics course students to address their needs. Despite the fact that JiTT was developed to address physics students' need, JiTT has been implemented in a wide array of classes, such as psychology, anthropology, education, computer science, accounting, economics, history, and more due to its flexible nature and its design based on seminal theories in educational research (Simkins & Maier, 2016). JiTT is a strategy that utilizes web-based technology to foster active learning. It is a pedagogical strategy that uses feedback between classroom activities and work that students do at home, in preparation for the classroom meeting (Sinkins & Maier, 2016).

The goal of the JiTT assignments is for students to come to class prepared, engaged, and motivated. The students complete these assignments at their own pace and submit them electronically. In turn, the teacher organizes the classroom lessons in response to the student submissions. Students then experience the organized lesson by the teacher as shaped by their own responses (Gavrin, 2010). The pre-class assignments target specific content-related issues such as misconceptions, developing concepts, vocabulary among others. The feedback also provides opportunities to address differences in skills and needs of diverse learners. According to Guertin *et al.* (2017), the pre-class web-based assignments could be configured so responses would open a window on the mental models of students' thinking and understanding. In order words, these assignments often have complex answers and the outside class work of the students serves as preparation for more complete work in class.

The students' answers are delivered to the instructor via web based a few hours before class starts, allowing the instructor to adapt the lesson as needed. The instructor receives students' answers to the JiTT via web based just in time to fine-tune his or her lesson based on this feedback, hence the name of the technique. The instructor can then decide how to use class time in order to best address specific misconceptions, gaps in learning, and students' concerns about content (Camp, Middendorf & Subiño-Sullivan, 2017). Even though JiTT utilizes Web-based technology, Novak (2015) pointed that, the strategy should not be confused with distance learning or computer-aided instruction, since all JiTT instruction occurs in a classroom with human teachers, only that prior to the classroom instruction, students received web based assignment.

The JiTT is a structured teaching and learning strategy that makes use of students' responses to web-based questions covering upcoming course material to; (i) promote time on task; (ii) encourage better preparation for course meeting; (iii) providing prompt

feedback on students conceptual understanding, and (iv) inform "just-in-time" modifications of in-class activities and discussion (Novak & Petterson, 2010). Marrs and Novak (2014) also stated that JiTT allows students to gain control of their own learning process, gain motivation, increase student overcome time constraints and enhance student performance towards problem solving, collaboration and high expectation. Mars further noted that students come to class better prepared for the subject, and instructors come to class better prepared for their students.

The JiTT assignment questions can exist in a variety of forms, depending on the academic discipline and the specific topic of study. Regardless of their form, writing good JiTT questions is one of the most important and challenging aspects of implementing JiTT technique among instructors (Marrs & Novak, 2014). Effective JiTT questions are ones that yield a rich set of students' responses for classroom discussion, encourage students to examine prior knowledge and experience, require an answer that cannot easily be looked up, evoke an emotional response, connect previously learned material and newly acquired information, and require students to use their own words (Novak & Patterson, 2010). Gavrin (2010) recommended that, for the JiTT assignment to be effective, assignment scores should reflect into student's overall grades and teachers should use a variety of scoring rubrics to assess students' performance on JiTT assignment. According to Camp *et al.* (2017), there are several types of JiTT assignment which included the following: Warm Ups, Puzzles and GoodFors.

Warm Ups: Warm Ups are short, web-based assignments designed for students to complete before receiving instruction on a topic. They prompt students to think about the upcoming lesson and to answer a few simple questions before class to prepare them to develop more complex answers in cooperative groups in class. Class time can focus

on the points for which students need more help, and it can be structured around specific student responses, allowing an element of personalization

Puzzles: Puzzles are short, web-based assignments that are designed to help structure a wrap-up session on a topic that has already been covered in a class. They provide closure and often integrate concepts

***GoodFors*:** GoodFors are enrichment essays that help students connect the class to the real world, help keep material fresh, and are starters for classroom discussion.

Elements of JiTT: Marrs and Novak (2014) suggested that, Just-in-Time Teaching technique incorporates three major elements that are important for helping students learn which included the following:

1. **Just-in-Time Teaching Incorporates Active Learning Approaches:** By moving the "content- transfer" element of the course to pre-class preparation and focusing class time on cooperative problem solving, JiTT encourages the active learning approaches that have been found to promote learning (Paulson, 2009).

2. Just-in-Time Teaching Provides Structured Opportunities for Students to Actively Construct New Knowledge from Prior Knowledge: As noted in how people learn, current research on learning indicates that all new learning depends on the learner's prior knowledge and current state of understanding. If students' initial understanding is not engaged, they may fail to grasp the new concepts they are taught or they may revert to their preconceptions outside of the classroom. Effective learning requires that students uncover and address pre-existing knowledge and misconceptions.

3. Just-in-Time Teaching Provides Prompt Feedback: How People Learn notes that the best learning environments are assessment-centered, and emphasizes that formative

assessment is particularly valuable for learners because it provides opportunities for learners to adjust or clarify their thinking prior to a summative assessment (such as a graded exam). This is a key element of JiTT, occurring during essentially every class meeting through instructor responses to the WarmUps that student submit in preparation for the class.

2.7 Students' academic achievement in science and technology education

Achievement in education has attracted a lot of research studies in recent years. Most of the researchers sought to find out the factors that influence it, how it is measured and how it can be enhanced or improved. Achievement is therefore an important educational variable because it is concerned with the terminal behavior of students at the end of a given period of time or even within a given time range (Wushishi & Usman, 2013). Matawal (2013) defined achievement as the competence of students in relation to a domain of knowledge. It then means that a student's achievement in cognitive or psychomotor test is an indication of the competence of that student in relation to that domain. Odetoyinbo (2014) highlighted that, academic achievement is concerned with assessment of terminal or criterion behavior which involves the determination of students' performance with respect to specific standard.

Furthermore, achievement can therefore be inferred as 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 within a given period. Oyetunde (2010) disclosed that, there are two dimensions to academic achievement: good academic achievement that resulted to success and poor academic achievement that resulted to failure. Each of the achievement has been experienced by students in one form or another. The importance of achievement stems out of the fact that it enables teachers to obtain information on the extent to which a student has attained the criterion

performance. This information can be used to determine the relative position or rank of the students with respect to their achievement test.

Achievement test is an instrument administered to an individual as a stimulus to elicit certain desired and expected responses, as demanded in the instrument, performance on which the is assigned a score representing his achievement (Olaitan, Ali, Eyoh & Sowande, 2010). Achievement test could also be seen as the instrument used for obtaining information from students. Wushishi and Usman (2013) reported that, the information obtained from the achievement test makes it possible to compare the capability of one student to the capabilities of other group of students which is very important in education. It is due to its relative importance that students, teachers, parents and even the society are very much concerned with achievement in the educational setting. However, for manipulative type of educational setting like technical education, with particular reference to digital electronics which is the focus of this research, the students' achievement is further pronounced in the areas of skills acquisition and learning domain of cognitive and psychomotor.

2.7.1 Students' cognitive achievement in science and technology education

Cognitive abilities are brain-based skills we need to carry out any task from the simplest to the most complex. Dehn (2018) disclosed that, they have more to do with the mechanisms of how we learn, remember, problem-solve, and pay attention, rather than with any actual knowledge. Cognitive abilities or skills are supported by specific neuronal networks. For instance, memory skills rely mainly on parts of the temporal lobes and parts of the frontal lobes (behind the forehead). Carroll (2013) revealed that, cognitive abilities are aspects of mental functioning, such as memorizing and remembering; inhibiting and focusing attention; speed of information processing; and spatial and causal reasoning. It could be seen as defined as the ability of an individual to

perform the various mental activities most closely associated with learning and problem solving.

According to Koran (2011), cognitive achievement relates to knowledge and the development of mental and intellectual abilities which involves thinking, reasoning and remembering. Abidoye (2010) highlighted some of the cognitive skills in the field of digital electronics to include: ability to understand basic computer parts, types and other devices, computer hardware configuration and techniques of computer aided designs, number system, logic gates, flip-flop, counters, decoders and encoders and microprocessors among others. Cognitive achievement of an individual measured is obtained by collecting scores using tests of mental abilities. Anderson (2010) disclosed that, tests of general intelligence, such as the Wechsler Adult Intelligence Test, are based on a broad sample of these mental ability tests, and measures of aptitudes for learning in specific instructional domains, such as mathematics, or language learning, are based on a narrower sampling of the domain-relevant abilities.

Bloom in 1956 characterized the six cognitive levels in the hierarchy: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. The cognitive achievements at the highest level are synthesis and evaluation, which rely on comprehension, application, and analysis capabilities in the knowledge domain, and are consequently the most difficult and challenging to teach. However, to teach post-secondary school courses such as digital electronics effectively, it is important to ensure an adequate coverage of these higher-level skills, rather than limiting their education to one based on just lower order skills (Krathwohl, 2012). Anderson (2010) noted that, to determine the achievement of the course outcomes in the cognitive domain it is first necessary to analyze the educational objectives and corresponding learning abilities of

the students at different levels of the cognitive domain that include knowledge, comprehension, application, analysis, synthesis and evaluation.

- **Knowledge:** At this level, students are provided with sufficient knowledge so that they can list or state the problems and also exhibit memory of previously learned materials by recalling facts, terms, basic concepts and answers. Knowledge may be of different categories, such as, Knowledge of specifics- terminology, specific facts Knowledge of ways and means of dealing with specifics conventions, trends and sequences, classifications and categories, criteria, methodology Knowledge of the universals and abstractions in a field- principles and generalizations, theories and structures.
- **Comprehension:** At this level, students demonstrate understanding of terms and concepts and State the concept in their own words and also interpret the results. Here, students demonstrate the understanding of the facts and ideas by organizing, comparing, translating, interpreting, giving descriptions and stating main ideas and also by extrapolation.
- **Application**: At this level, students apply the learned information to solve a problem, to calculate or to solve for the required value. The students also solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.
- **Analysis:** At this level, students break things down into their elements, formulate theoretical explanations or mathematical or logical models for observed phenomena, derive or explain something by identifying motives or causes. They make inferences and find evidence to support generalizations. They also do analysis of elements, analysis of relationships or analysis of organizational principles.

- **Synthesis:** At this level, students create something combining elements in novel ways; formulate an alternative to the existing design. They also compile information together in a new pattern to produce a unique communication or to propose a set of operations or to derive a set of abstract relations.
- **Evaluation:** At this level, students make and justify the values obtained by judgment or select an appropriate value among the various alternatives and also determine which one is better and explain its reasoning, analyze the values critically for accuracy and precision. They also opine by making judgments about information, validity of ideas or quality of work based on a set of criteria or evidences.

2.7.2 Students' skill performance in science and technology education

Skills are the psychomotor ability that enables an individual to perform practical tasks. According to Osinem (2018) skill refers to expertness, practiced ability or proficiency displayed in the performance of a task. In order to perform tasks in the repairs of varieties of digital electronics by college of education electronics graduates, it is essential that the skills are learnt in the school workshop. According to Hampton (2012) practical skills means ability to performed by hand or with human intervention using equipment, tools or technology requiring guidance, force or movement (as in welding a joint). Practical skills primarily require physical dexterity, although an understanding of principles, process and sequences is also essential, especially for more complex practical skills.

These are skills that students learn or are expected to learn in the school workshop in order to carry out experiment, design, construction, production, testing, assembling, disassembling and repairs of relevant material/systems are called practical skills (Ohikhuare, 2009). Osaigbovo (2010) argued that the teaching and learning of practical

skills is different from teaching knowledge or theory and it requires special considerations the author stated that within the educational institutions, the learning of practical is most often associated with laboratory and workshop, specialist materials and equipment, smaller class sizes and, frequently, longer blocks of time for practice or rehearsal.

Practical skills in digital electronics include manipulation of basic computer parts, types and other devices, computer hardware configuration and techniques of computer aided designs, number system, logic gates, flip-flop, counters, decoders and encoders and microprocessors among others (Abidoye, 2010). Practical skills in the context of this study involve skills that students acquire in the laboratory through testing, design, construction and repairs. In the view of the Centre for Inclusive Learning Support (CILS, 2012) having practical skills means being able to use what you have learnt in the classroom in real life situations and in works.

Categories of Practical Skills: Recognizing the importance of practical skills at the post-primary level, the Centre Board of Secondary Education, CBSE, (2008) identified the categories of practical skills in science and technology fields of studies. The categories are as follows:

Procedural and manipulative skills – these include to select appropriate instrument for performing the experiment, know the limitation of the instrument, assemble and adjust apparatus or instrument systematically, handle instruments carefully, perform experiment with reasonable efficiency and accuracy, use appropriate methods and materials, locate and rectify errors, add chemical in appropriate quantity, dismantle experimental set-up and practice precautions in handling instruments and materials.

· **Observational skills** – these involve the learner to find the least count of the instrument, read the instrument correctly, notice colour change, locate the desired parts

in a specimen correctly, take observation carefully and systematically and read graph correctly.

· **Drawing skills** – these include to make proper observation table, draw circuit diagrams, label sketches and draw graph from observed data correctly.

· **Reporting and interpreting skills** – include making proper plan to for recording observations, record the observation, classify and categorize organisms, use proper formula and mode, report results using correct symbols and interpret observation and results correctly.

Following the above identified skills in science under their categories, it would be observed that they are similar to the practical skills in technical education workshops, but the skills in technical education workshops are more detailed with handing of tools and equipment and with less of theory relating to a particular trade. It therefore explains that practical skills in the repairs of digital electronics require students in the college of education to lay more emphasis on rectifying faults in the appliances since the primary goal of the programme is for employment.

Skill performance could be seen as the level of competence attained by a student in a course of study represented by a score or marks obtained in a skill performance test. Skill performance is the degree of skills demonstrated by the students in the completion of a task that lecturers determine the level of competence of the trainee (Wushishi & Usman, 2013). Peyton (2018) advocated that, to determine the achievement of the course outcomes in the practical skill domain, it is first necessary to analyze the educational objectives and corresponding learning abilities of the students at different levels of the skill domain that include perception, set, guided response, mechanism, complex overt response, adaption and origination.

Perception (Level 1): This is characterized by sense organs guide motor activity. Action verb attributed to this level are: choose, describe, detect, differentiate, draw, feel, identify, isolate, relate and select.

Set (Level 2): This is characterized by readiness to take actions. Action verb attributed to this level are: begin, display, explain, move, proceed, react, show, state and volunteer

Guided response (Level 3): This is characterized by institution; trial and error. Action verb attributed to this level are: copy, trace, follow, react, response, respond and watch.

Mechanism (Level 4): This is characterized by do alone in less time without describing the steps; responses become habitual; move with some confidence and proficiency. Action verb attributed to this level are: assemble, calibrate, construct, dismantle, display, fasten, fix, grind, heat, manipulate, measure, mix and sketch.

Complex Overt Response (Level 4): This is characterized by do without error; skillful performance of motor acts that involve complex movement patterns; performing without hesitation; quick; accurate; and highly coordinated performance. Action verb attributed to this level are similar to Mechanism (Level 4).

Adaption (Level 5): This is characterized by do in a different way; skills are well developed and can be modified to fit special requirements. Action verb attributed to this level are: adapt, alter, change, rearrange, reorganize, revise and vary.

Origination (Level 6): This is characterized by do in a new way; create new movement pattern to fit a particular situations or problem; highly developed skills. Action verb attributed to this level are: arrange, build, combine, compose, construct, create, design, initiate, make and organize.

Both cognitive and psychomotor achievements are dependent upon several factors among which the instructional methods, the learning environment are and even the learners (Afuwape, 2013). This assertion is line with the postulation of Atsumbe *et al.*

(2014) that incorporating e-learning multimedia such as Just-in Time Teaching techniques in teaching skills is capable of enhancing students' learning and achievement. Because of the interactive nature of brainstorming, demonstration and JiTT methods, they are capable of providing a platform where students would be stimulated and active to learn as a result of the interaction. Thus, the use of brainstorming, demonstration and JiTT methods for this research is capable of enhancing the achievement and interest of students in digital electronics in colleges of education in Nigeria.

2.8 Students' interest as a factor of achievement

Interest is generally concerned with the state of attention which may be evoked as a result of emotion or passion for something. According to Scholl (2010) the excitement and feeling, whether pleasant or unpleasant is known as interest. In educational setting, interest is concern with the keen desire or curiosity to learn more about a topic or engage more often in any teaching and learning activity. According to Schraw *et al.* (2011), interest is concern with the persistent tendency of students to pay attention to and enjoy some activity or content in the teaching and learning in an academic setting.

In academic settings, researchers have classified interest into two, namely situational and personal interest. According to Adamu (2016) personal interest is the interest which an individual brings into a situation; a student can for instance approach a learning situation with or without interest. Situational interest on the other hand is the interest which the individual acquired through involvement in an activity. Adamu contended that, situational interest is spontaneous, transitory, and environmentally activated while personal interest is on the other hand, less spontaneous of enduring personal value and activated internally. According to Schraw *et al.* (2011), situational interest often proceeds and facilitates the development of personal interest. Situational interest

appears to be especially important in catching students' attention, whereas personal interest may be more important in sustaining it.

Furthermore, recent researchers focused more on situational interest because it is changeable, partially under the control of teachers and supports learning. Chi (2011) revealed that situation interest is changeable and increase students' achievement. According to Schraw *et al.* (2011), situational interest increase learning when a task or to-be-learn task is novel or when task is relevant to learning goal. Learning goals are largely affected by the positive effect of interest. Interest in the classroom, is capable of increasing students' intrinsic motivation and promote learning to a greater height. Downes (2015) noted that students' intrinsic motivation is important in getting the student to resist distractions and to form favorable attitude towards learning and can be also keep the student at work without pressure from the teacher. A student's desire to accomplish educational tasks is directly related to interest possessed for such task. This is supported by several educational researches.

Moreover, among these researches is Ogwo (2006), who suggested multiple ways to promote interest; including changing the environment in which students read and study, for instance, transiting from the conventional teaching in the classroom to the use of Just-in Time Teaching techniques, providing better written texts that students find more interesting and helping students to access relevant background knowledge before regular classes. Downes (2015) noted that, several studies supported three general conclusions:

1. Interest is related positively to attention and learning.
2. Interest varies from person to person, and
3. Interest is elicited by a variety of factors such as prior knowledge, unexpected text content, text structure, and readers' goals.

Furthermore, interest can be increased in number of ways in the classroom, and it is important to do so to increase engagement and learning. It is also very important for teachers to know how information on the students' interest can be obtained and the classes of interest. Nworgu (2012) classified interest into four categories, namely: expressed, manifest, tested and inventoried interest.

Expressed Interest: Expressed interest refers to the verbal declaration of interest in an activity or object. It is where an individual professes whether he likes, dislike or is indifferent to an activity. Downes (2015) described expressed interest as interest in an object, activity, subject of study or occupation as verbally expressed by an individual. In the expressed interest the person expresses his personal likings through such sentences as: 'I love Digital Electronics'. Although, it is the first source of knowing the interest of a person yet much reliance cannot be based on it, as such expressions like permanency and are prone to vary from time to time depending upon the maturity of the person.

Manifest Interest: In manifest interest, a person declares the extent of like for the activity or object and actually shows it by the extent to which he takes part in the activity. For example, a student who shows interest in studying Introduction to Theory of Structures is always seen in the class, always with his textbook or notebook and even seen solving one problem or the other on the subject.

Tested Interest: Tested interest is concerned with objective measurement of interest, this can be done through the use of achievement or performance test. A person who is interested in an activity or in a school subject is expected to perform the activity or interact with it several times to the extent that the action would give accumulated relevant information which can be measured using Introduction to Theory of Structures achievement test with the belief that the student will do well having spent a lot of time

studying the subject. When such achievement or performance test is used in this way, the measured is said to have tested interest.

Inventoried Interest: Inventoried interest gives subjective estimates of an individual's likes and dislikes on a large number of items surrounding activities or objects of concern like occupation or school subject usually listed in an interest inventory. The subject interest inventory is used in assessing student's interest in a learning area and can be described as a person's like, dislike or indifferent responses towards the subject. For instance, in this study, students' interest in studying digital electronics will be measured using interest inventory to determine which among brainstorming, JiTT and demonstration teaching methods is more effective in stimulating students' interest.

Sustaining students' interest is very important since interest was identified as the persisting tendency to pay attention to and enjoy some level of enhanced academic achievement within the teaching and learning process. Hence, students' interest in digital electronics is paramount as it is an essential requirement for effective teaching and learning. Ogwo (2006) reinforced this fact as they stressed that, it is very important for the lecturers to sustain the interest of students in order to ensure consistency and progress throughout the teaching process. lecturer should constantly find ways to stimulate the interest of the students throughout the period of studies. One major ways of doing so, it is for lecturer to introduce innovative teaching methods such as brainstorming, demonstration and JiTT methods to stimulate students' interest. The lecturer is required to relate the subject matter not only to real life situation or to every day experience of the learner to stimulate their interest (Downes, 2015). It can therefore be summed up that, the use of brainstorming, demonstration and JiTT methods to teach students digital electronics stimulate interest of students and also helps in increasing achievement retention.

2.9 Students retention in science and technology education

Retention is viewed as the replicate performance by a learner of the behaviour that an acquired piece of knowledge is always intended to elicit in the learner (without practice) after an interval of time (Momoh-Olle, 2007). Momoh-Olle further explained that, retention simply refers to how much a person remembers after an interval of time without practice and that is the difference between what is initially learnt and what is later forgotten. Retention learning can equally refer to learning which lasts beyond the initial testing and it is assessed with tests administered two or more weeks after the information has been taught and tested (Haynie, 2013). The period between the completion of training and subsequent performance of the trained skill is conventionally referred to as the ‘‘retention interval’’ (Oloyede & Adekunle, 2019).

Nevertheless, Haynie (2013) explained that, retention of learning is measured with two tests: the “initial” pretest and the “delayed” retention test. The initial test is the test employed at the beginning of the instruction while the delayed or retention test is the test administered two or more weeks after the initial testing and instruction to measured retained knowledge. Haynie (2017) emphasized that retention test is important because it determines the information and concepts that the students still know two, three or more weeks after the effects of “cramming” for the test have evaporated. Perhaps, the learning which resulted from the use of active instructional techniques such as brainstorming, demonstration and JiTT methods are more efficient in terms of effective transfer of knowledge as well as the facilitation of recall and the quality of retention (Sims, 2018). Demonstrating a task as contained in brainstorming, demonstration and JiTT methods may be far more effective than trying to describe how to perform it especially when the task involves spatial motor skills and the experience of seeing a task performed or having a pre class experience is likely to lead to better retention.

The use of brainstorming, demonstration and JiTT methods as a medium of instruction in digital electronics can teach physical tasks that students may likely perform by being involved in brainstorming, watching the process in demonstration or having a pre class experience in JiTT technique. More importantly, learning appears to be enhanced mostly when instructions engage the active involvement and participation of students on a well-defined and challenging set of instruction (Okurumeh, 2018). The student's participation or having a pre class experience provide an interactive learning environment which has a direct positive relationship with student's cognitive processes and a tendency to improve students' construction of knowledge and transfer of learning (Chi, 2011). This suggest that, adopting brainstorming, demonstration and JiTT methods can be effective as teaching strategies to enhance student's achievement and retention of knowledge (Simeon, 2018), especially in the field of digital electronics in colleges of education in Nigeria.

The elements of brainstorming, demonstration and JiTT methods are considered as part of the supportive learning environments used to provide students with various forms of real, complex, and contextualized learning experiences. These sets of complex and contextual learning experiences triggers the retention level of the learners. In addition, brainstorming, demonstration and JiTT methods provide rich background knowledge by exposing students to a problem in classroom teaching (Okurumeh, 2018). This exposure features of brainstorming, demonstration and JiTT methods could increase the retention rate of students (Hasselbring & Moore, 2006). However, brainstorming, demonstration and JiTT methods serves as the focal point for initiating active and various interactions in students that promotes their retention ability.

Students in science and technology courses such as digital electronics retained what they have learned for several weeks after instruction, when exposed to active learning

techniques such as brainstorming, demonstration and JiTT methods. Sims (2018) confirmed that active learning techniques such as brainstorming, demonstration and JiTT methods are more memorable than the traditional or conventional teaching methods. Chi (2011) also argued that, information obtained via active learning are more memorable and can help students' retention.

2.10 Review of related empirical studies

Claude *et al.* (2006) studied the effects of the Just in Time Teaching (JiTT) method on the interest and engagement of students in a history of photography course. Three research questions and one hypothesis guided the study. The study was conducted in Indiana University's Bloomington campus, United States of America (USA). The study adopted both quantitative and qualitative research designs. The population for the study consisted of 153 students (70 from journalism and 83 from art history) without sampling. The questionnaire was the instrument used for data collection and the reliability coefficient of the instrument was found to be .86 using Pearson's Product Moment Correlation (PPMC). Data collected were analyzed using Statistical Package for Social Science (SPSS). Finding emerged that JiTT, which requires students to respond to questions via the Web shortly before class, increased students critical thinking (73 percent), helped students better understand course concepts (79 percent) and made students feel responsible for their own success (75 percent); 66.6 percent of the students spent much more or more time than in comparable courses. The study recommended that, teachers in history of photography course should adopt the use of JiTT.

The study reviewed is related to this study because the two studies employed JiTT to determine students' learning outcomes. The studies are also common in terms of sampling technique, methods of analyzing data to answer research questions and test hypotheses. The two studies also differed in research design, geographical location, population, methods of establishing reliability coefficient of the instrument and subject matter. The studies also differ because the study reviewed compared the effect of only JiTT technique on students' interest and engagement of students in a history of photography course while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of JiTT technique on students' motivation and engagement in a history of photography course.

Gavrin (2013) assessed the effects of JiTT on students' retention, interest and cognitive gains in Physics. Multiple research design was used which include surveys, pre-test, post-test quasi experiment, classroom observations and anonymous web-based surveys to measured students' attitudes towards several of the web-based components. The study was conducted at Indiana University Purdue, Indianapolis and the USA Air Force Academy. The population for the study consisted of 88 students in the introductory physics classes taken by engineering majors. Purposive sampling was used. The instrument for data collection was Physics Achievement and Retention Test (PART) and Interest Inventory (II). The reliability coefficient of the instrument used was .79 and .84 using Kuder-Richardson 20 and Cronbach's Alpha statistics. Mean and percentage were used to answered the research questions using excel function of the Microsoft office suite for data analysis. Results from the study indicated that students' cognitive

gains, interest and retention were improved with 40percent. The study recommended the use of JiTT technique in a variety of science and technology classes.

The study reviewed is related to this study because the two studies employed JiTT to determine the achievement and retention of students. The studies are common in terms of sampling technique, methods of establishing reliability coefficient of the instrument and analyzing data to answer research questions and test hypotheses. The two studies also differed in research design, geographical location, population, and subject matter. The studies also differ because the study reviewed compared the effect of only JiTT methods on students' retention, attitudes and cognitive gains in Physics while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of JiTT technique on students' retention, attitudes and cognitive gains in Physics.

Ogologo and Wagbara (2013) ascertained the effect of demonstration strategy on senior secondary school students' psychomotor achievement in separation techniques in Chemistry in Obio/Akpor Local Government Area, Rivers State. Two objectives, two research questions and two hypotheses were raised. The quasi experimental design was adopted for the study. Senior students offering chemistry were used as population for the study and a sample size of 100 Senior Secondary School (SSS) II selected by random sampling technique. Chemistry Achievement Test (CAT) was used to collect data on the students' achievement in chemistry. The data was analyzed using mean and t-test at 0.05 level of significance. Demonstration method of teaching was found to be potent in raising students' achievement and retention in chemistry. The study also found no significant difference between achievement and retention of students taught using demonstration and lecture methods over solving mathematics-related problems in

chemistry. The study recommended the use of demonstration in teaching Chemistry in secondary schools.

The study reviewed is related to this study because the two studies employed demonstration technique to determine the achievement of students. The studies are common in terms of research design, sampling technique, methods of establishing the reliability of the instrument and analyzing data to answer research questions. The two studies also differed in geographical location, sampled population, methods of analyzing data to test hypotheses and subject matter. The studies also differ because the study reviewed compared the effect of demonstration and conventional teaching methods on students' achievement and retention in Chemistry while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of demonstration strategy on senior secondary school students' psychomotor achievement in separation techniques in Chemistry.

Daluba (2013) investigated the effect of demonstration method of teaching on students' achievement in agricultural science in secondary school in Kogi East Education Zone of Kogi State. Two research questions and one hypothesis guided the study. The study employed a quasi-experimental research design. The population for the study was 18225 senior secondary two (SSII) students in 195 secondary schools. Six (6) secondary schools were used for the study using purposive random sampling technique. In each of the school selected, two intact classes of the SSII were used. Four hundred and eighty (480) students in the twelve intact classes constituted the sample for the study. The instrument for data collection was a 30-item 'Agricultural Science Achievement Test' (ASAT). Using Kuder-Richardson 20 (K-R20) formula, a reliability index of 0.78 was

obtained. Research questions 1 and 2 and the only hypothesis were answered using mean, standard deviation and analysis of covariance (ANCOVA) at 0.05 level of significance. The result of study revealed that demonstration method had significant effect on students' achievement than those taught with the conventional lecture method. Useful recommendations such as: efforts should be made by teachers to thoroughly integrating demonstration method in the teaching of agricultural science in secondary schools; efforts should be intensified by teachers to aggressively adopt demonstration method in teaching agricultural science in all classes at the secondary school level were proffered.

The study reviewed is related to this study because the two studies employed demonstration technique to determine the achievement of students. The studies are common in terms of research design, sampling technique and methods of establishing reliability coefficient of the instrument, analyzing data to answer research questions and test hypotheses. The two studies also differed in geographical location, population and subject matter. The studies also differ because the study reviewed compared the effect of only demonstration teaching method on students' achievement in agricultural science while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of demonstration method of teaching on students' achievement in agricultural science in secondary school.

Marrs and Novak (2014) assessed effect of Just-in Time Teaching (JiTT) on students' learning success in biology. The study was conducted at Browns University, USA. Pretest/posttest quasi experimental study and descriptive survey research design were

used for the study. The population for the study consisted of 102 undergraduate biology students without sampling. The instruments for data collection included Biology Achievement Test (BAT) and interest inventory. The reliability coefficient of BAT was found to be 8.7 and .91 for interest inventory using Kuder-Richardson 20 and Cronbach's Alpha statistics. Mean and Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) were used for data analysis. Findings from the study revealed that: JiTT increased classroom interactivity, increased student academic success as measured by course achievement and retention rates, improved student interest. The study recommended among others that teachers, especially those teaching sciences and technology should adopt the use of JiTT technique in teaching as it has proven to be the most appropriate teaching technique in the teaching of biology at undergraduate level.

The study reviewed is related to this study because the two studies employed JiTT to determine the achievement and retention of students. The studies are common in terms of research design, and methods of establishing reliability coefficient of the instrument, analyzing data to answer research questions and test hypotheses. The two studies also differed in geographical location, population, sampling technique and subject matter. The studies also differ as the study reviewed compared the effect of only JiTT methods on students' achievement in biological science while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of JiTT technique on students' learning success and interest in biology.

Kholoud (2016) investigated the effect of brainstorming strategy in Balqa Applied University's students' achievement in the course "E 101" (Physics). The study applied the quasi- experimental approach. The population of this study consists of 1300 male

and female students in the first semester of the academic year 2013-2014. The sample of the study which was chosen randomly, consisted of 68 male and female students and it was divided into two groups; as experimental group (34 studied using brain storming strategy) and the control group that learns traditionally. An achievement exam was used to measure the students' achievement with reliability (0.80) ascertained using Kuder-Richardson 20. The results of the study showed that, there were statistically significant differences between the means of students' achievement in Physics due to the two groups at method of teaching in favor of brainstorming strategy and to the gender in favor of females. The research recommended the use of brainstorming teaching method in schools.

The study reviewed is related to this study because the two studies employed brainstorming teaching method to determine students' academic achievement. The studies are common in terms of research design, sampling technique and methods of establishing reliability coefficient of the instrument. The two studies also differed in geographical location, population and subject matter. The studies also differ as the study reviewed compared the effect of brainstorming and lecture teaching methods on students' achievement in Physics while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of brainstorming teaching method alone on students' achievement in Physics.

Jacob *et al.* (2016) investigated the effect of brainstorming learning strategy on junior secondary school students' academic achievement in social studies in Yola educational zone, Adamawa State, Nigeria. Three null hypotheses were formulated to guide the study. The study adopted a quasi-experimental design. The sample for the study

consisted of 203 Junior Secondary School (JSS) II Social Studies Students. Four intact classes (two each) were randomly selected and assigned to experimental and control groups. The instrument used for data collection was Social Studies Achievement Test (SSAT). The reliability of the instrument was established using Guttmann's Split-Half statistic; which yielded a reliability index of 0.72. Independent samples t-Test and chi-square analysis of data revealed that there was a significant difference in the mean achievement and retention score of students taught social studies using brainstorming learning strategy and lecture method. Based on the findings, it was recommended that social studies teachers should incorporate brainstorming learning strategy with other instructional approaches in lesson delivery in order to improve students' ability in learning and understanding social studies in junior secondary schools.

The study reviewed is related to this study because the two studies employed brainstorming teaching method to determine students' academic achievement. The studies are similar in terms of research design and sampling technique. The two studies also differed in geographical location, population, methods of establishing reliability coefficient of the instrument and subject matter. The studies also differ because the study reviewed compared the effect of brainstorming and lecture teaching methods on students' prior knowledge and academic performance in chemistry while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of brainstorming teaching method on students' achievement in Social Studies.

Wisdom *et al.* (2016) examined the effects of brainstorming strategy on students' prior knowledge and academic performance in chemistry in South-South, Nigeria. Simple random sampling technique was used to select a sample of 148 participants (made up of

71 female and 77 male students) in their intact classes from four selected coeducational secondary schools in two states in South-South, Nigeria. The schools were assigned into two instructional groups- the experimental (brainstorming strategy) group with 73 and control (lecture method) group with 75 students using simple random sampling technique. Chemistry Achievement Test was used as instrument for data collection. The reliability of the instrument was established as .87 using Cronbach's Alpha statistical technique. Data were obtained through the administration of Pretest followed with a seven-week treatment, and then the administration of posttest. Data were analyzed using mean and analysis of covariance (ANCOVA). Results showed statistically significant difference in both mean knowledge and mean academic performance in favour of the brainstorming group. The result further showed no statistically significant difference in the mean academic performance of male and female students in the experimental group. More so, the study revealed no significant interaction effect of instructional strategies and sex on academic performance. The study recommended that, chemistry teachers should employ brainstorming strategy in the teaching of chemistry concepts.

The study reviewed is related to this study because the two studies employed brainstorming teaching method to determine students' prior knowledge and academic performance in chemistry. The studies are common in terms of sampling technique, methods of establishing reliability coefficient of the instrument and analyzing data to answer research questions and test hypotheses. The two studies also differed in research design, geographical location, population and subject matter. The studies also differ because the study reviewed compared the effect of brainstorming and lecture teaching methods on students' prior knowledge and academic performance in chemistry while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention

in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of brainstorming teaching method on students' students' prior knowledge and academic performance in chemistry.

Bako (2017) determined the effects of project and demonstration teaching methods on acquisition of brooding skills in woodwork technology among students in colleges of education in Plateau State, Nigeria. The study had three objectives, three research questions and three null hypotheses which were stated to guide the researcher. The study adopted quasi-experimental, pretest post-test design. The population for the study consist of all the 147 NCE II agricultural education students of the two colleges of education in Plateau State. Purposive sampling was used to select the Federal College of Education Pankshin and 75 NCE II students were selected using simple random sampling technique. A 25-item multiple choice agricultural skill acquisition test was used for data collection. The Data obtained were analyzed using mean, standard deviation and t-test statistics at 0.05 level of significance (P=0.05). The findings revealed that both project and demonstration teaching methods had significant effects on students' acquisition of brooding skills. The result also showed that, project teaching method was more effective in teaching brooding skills than demonstration teaching method. The study recommended among other things that, agricultural education teachers should emphasize the importance of using project and demonstration teaching methods in colleges of education, and adopt these methods for teaching agricultural education skills areas.

The study reviewed is related to this study because the two studies employed demonstration technique to determine the achievement of students. The studies are common in terms of research design, population, sampling technique and methods of analyzing data to answer research questions. The two studies also differed in

geographical location, methods of analyzing data to test hypotheses and subject matter. The studies also differ because the study reviewed compared the effect of demonstration and project teaching methods on students' achievement in acquisition of brooding skills while this study seek to compare the effect of brainstorming, demonstration and Just-in-time teaching techniques on students' cognitive and skill performance, interest and retention in Digital Electronics. Nevertheless, the study reviewed is limited to identifying the effect of project and demonstration teaching methods on acquisition of brooding skills in woodwork technology.

2.11 Summary of literature review

The literature reviewed revealed that brainstorming, demonstration and Just-in Time Teaching technique are strong teaching techniques used in enhancing students' academic achievement, interest and retention. The conceptual framework of the study shows the relationship between various variables that are related to the study, such as Brainstorming, Demonstration and Just-in Time Teaching technique, students' achievement, interest, and retention. In the theoretical framework of the study, Piaget's theory of cognitive development and activity of learning theory were discussed with regard to their relationship with the present study. Related literatures were also review on concepts associated to this study such as Brainstorming, Demonstration and Just-in Time Teaching technique, students' achievement, interest, and retention. The review of related empirical studies gathered information on studies related to the study. These studies were related to this study as they all dwelled on establishing the effect of brainstorming, JiTT and demonstration teaching methods on achievement, interest or retention of students. Moreover, these studies differed with the present study either in terms of population, geographical and content area/subject matter.

In spite of these studies, the achievement of students in digital electronics in colleges of education in North-West, Nigeria is still generally low in examinations which might be associated to the teaching methods such as lecture method adopted by lecturers that do not take into account the needs of students. Thus, there was need to determine the effective teaching techniques capable of enhancing learning outcomes that include cognitive and skill performance, interest and retention in digital electronics in colleges of education in North-West, Nigeria. Hence, this study identified the effects of brainstorming, JiTT and demonstration teaching methods on four learning outcomes that include cognitive and skill performance, interest and retention in digital electronics in colleges of education in North-West, Nigeria.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Research Design

The study adopted pretest–posttest non-equivalent control group design of quasi-experimental study alongside, 3 × 3 factorial research design. According to Nwachukwu (2011), quasi-experimental study is the type of study where random assignment of subjects is not required. The design is most suitable for the study since pre-selection and randomization of groups is often difficult in a school setting, intact classes was used to avoid disruption of normal classes. The factorial research design is the type that allows for the investigation of main and interaction effects between two or more independent variables and one or more outcome variable(s). According to Niewenhuis (2011), a factorial design is the type of research design involving two or more factors in a single experiment. The design is most suitable for the study since it involves the investigation of the effect of multiple independent variables (Brainstorming, Just-in Time and Demonstration teaching methods) on learning outcomes (achievement, interest and retention). The research design is presented as:

Gc O_1 X_2 O_2 O_3 Demonstration teaching method

Ge I	O_1	X_1	O_2	O_3	Brainstorming teaching method
Ge II	O_1	X_3	O_2	O_3	Just-in-Time teaching method

Where:

O1	=	Pretest for all groups
O2	=	Posttest for all groups
O3	=	Retention test for all groups
X_1	=	Treatment with Brainstorming teaching method
X_2	=	Treatment with Demonstration teaching method
X_3	=	Treatment with Just-in-Time Teaching Technique
Gc	=	The Control Group
Ge I	=	The Experimental Group I
Ge II	=	The Experimental Group II

3.2 Area of the Study

The study was conducted in North-West, Nigeria. The North-West, Nigeria comprises of Kaduna, Kano, Katsina, Sokoto and Zamfara States. The area was chosen for the study due to the low performance of electrical/electronic technology students in digital electronics recorded in semester examination for the period of five years from 2015 to 2019 as shown in Appendix A (p91) as requested (Appendix B, p99).

3.3 Population of the Study

The population of this study comprised of all the 142 Nigerian Certificate in Education (NCE) III electrical/electronic students in all the Colleges of Education offering technical education in the study area during 2019/2020 academic session. These Colleges of Education include: Isah Kaita College of Education, Katsina, Federal College of Education, Bichi, Federal College of Education (Technial), Gusau, Kaduna State College of Education, Gidan Waya and Shehu Shagari College of Education,

Sokoto. NCE III Electrical/electronic class was chosen for the study because, it is the only class level in the colleges of education that digital electronics as a course is offered. The distribution of the population of NCE III Electrical/electronic students is as shown in Appendix C (p100) according to school in the study area.

3.4 Sample and Sampling Technique

The sample size of 142 was the whole population. Due to the manageable size of the population of the study, there was no sampling. However, purposive sampling technique was used to assigned Federal College of Education (Technical), Gusau and Federal College of Education, Bichi to the experimental group II. This is simply because, the two colleges of education possessed the necessary learning facilities that supports the use of JiTT such as E-learning centres with internet connection. Furthermore, Simple Random Sampling Technique was used to assign Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto to control group and Kaduna State College of Education, Gidan Waya to experimental group I. Details of the sample for the study is indicated in Appendix C, p100.

3.5 Instrument for Data Collection

Three instruments were used to collect data for this study. This include: Digital Electronics Cognitive Achievement and Retention Tests (DECART) as shown in Appendix E (p102), Digital Electronics Skill performance Tests (DESAT) as shown in Appendix I (p114) and Digital Electronics Interest Inventory (DEII) as shown in Appendix K (p120). The initial draft of DECART consisted of 60 multiple choice questions prior to item analysis as shown in Appendix V (p198) for measuring cognitive achievement and retention and two skill tasks for measuring skill performance. Both the DECART and DESAT were developed by the researcher with the help of Table of Specification for DECART as shown in Appendix D (p101) and DESAT as shown in

Appendix H (p113). The DEII consists of 30 items with five response options for measuring student's interest in digital electronics. The items were designed based on the five point Likert scale of Strongly Agree = 5; Agree = 4; Undecided = 3; Disagree = 2 and Strongly Disagree = 1 point respectively. The DEII was adopted from Oyenuga (2010) and modified to suit the present study. The instrument was adopted because it was used with no record of limitations.

The researcher also developed a three set of lesson plans. Each set contains eight lesson plans that concurrently lasted for a period of eight weeks for the minimum of two-hour duration. First set of the lesson plan was written based on brainstorming teaching method as shown in Appendix L (p122) and was used by the lecturer for the experimental group I, second set was written based on Just-in-Time Teaching Technique as shown in Appendix M (p141) and was used by the lecturer for the experimental group II while the third set was prepared based on demonstration teaching method as shown in Appendix N (p173) and was used by the lecturer for the control group. The keys to the questions on DECSART as shown in Appendix F (p111), rating scale for DESAT as shown in Appendix J (p115) and student's answer sheet for answering DECSART questions as shown in Appendix G (p112) were also developed by the researcher.

3.6 Validation of the Instruments

Digital Electronics Cognitive Achievement and Retention Tests (DECART), Digital Electronics Skill performance Tests (DESAT) and Digital Electronics Interest Inventory (DEII) were subjected to face and content validation by three experts, one each from Electrical/electronic Education option, Department of Industrial and Technology Education, Federal University of Technology Minna, Department of Science and Technology Education, Bayero University Kano and Research and Development

Division, Psychometric Department, National Examination Council, Minna. The experts were specifically requested as indicated in Appendix O (p189), to ascertain the suitability of the items, their relevance, language clarity, its scope the content area and the instrument appropriateness in measuring what it was intended to for, and sign the validation certificate as shown in Appendix P (p190). The observations made by the experts include development of table of specification for skill performance test, provision of rater's guide in the skill performance test rating scale, generation of more items and emphasis should be on higher cognitive domain in the DECART among others. Their corrections and suggestion were of great assistance in making essential adjustment in the final draft of the instruments.

3.7 Reliability of the Instruments

A trial test of the instruments was conducted using 15 NCE III Electrical/electronic students in Federal College of Education, Gombe State, Nigeria which does not form part of the area of the study. The data for the trial test was collected using split half technique. The reliability co-efficient of DECART was determined as 0.78 using Kuder-Richardson 20 (K-R 20) as shown in Appendix S (p195). The adoption of K-R 20 was because it was considered most suitable on test with dichotomous choices (Easton & McColl, 2017). The reliability coefficient value of DESAT was determined as 0.81 using Kendall's tau coefficient of concordance as shown in Appendix T (p196). Kendall's tau coefficient of concordance was used because it is more suitable for establishing the reliability coefficient of instrument assessed by two raters (Easton & McColl, 2017). Furthermore, the reliability coefficient value of DEII was determined as 0.83 using Cronbach Alpha as shown in Appendix U (p197). Cronbach's Alpha reliability techniques was used because it is most suitable on instrument designed on Likert's scale (Adamu, 2016). Statistical Package for Social Science (SPSS) was used

for all the statistics. The reliability coefficient values of 0.78, 0.81 and 0.83 indicted that, the instruments are consistent and good for use.

Nevertheless, item analysis was carried out on the 60 items developed in the DECART to ensure that, each item in the test is standardized as shown in Appendix V (p198). According to Boopathiraj & Chellamani (2013), item with negative value or less than 0.20 is rejected while items with positive value above 0.20 is withheld. Hence, a total of the 46 items of the DECART had positive corrected total values but 40 items were selected for the study.

3.8 Experimental Procedures

The study was conducted in 11 weeks' period during which, 8 topics in digital electronics were covered. The study involved four stages which include: administration of pre-test, treatment, posttest and retention test. The pre-test was administered to all the students involved in the study in the first week of the research exercise before both groups were subjected to treatment. After the administration of the pre-test, the students in the experimental group I and II were taught using brainstorming and Just-in Time Teaching techniques and the students in the control group were taught using demonstration method. All the groups were taught by their regular digital electronics lecturers. Prior to the treatment, a training session was organized for the participating lecturers in the experimental group I and II.

During the training session, general description and procedures involved in the use of brainstorming teaching method as shown in Appendix Q (p191) and Just-in Time Teaching techniques as shown in Appendix R (p193) was practically revealed. The treatment process lasted for a period of 8 weeks after which the posttest was administered to the students on the 9^{th} week. After the administration of posttest, a

retention test was administered to all the students on the 11th week to determine their mean retention scores in digital electronics. The two weeks is sufficient as retention (delayed) period (Uzoagulu, 2011).

3.9 Control of Extraneous Variables

Extraneous variables such as Hawthorne effect was controlled by the use of regular course lecturers, influence of subject interaction was controlled by the use of intact classes, pre-test and posttest sensitization were controlled by re-arrangement of questions and response options in the DECART after the administration of the pre-test and posttest.

3.10 Method of Data Collection

The collection of data for the study was achieved through physical administration of the DECART, DESAT and DEII to all NCE III digital electronics students by their lecturers to determine their cognitive and skill performances, retention and interest in digital electronics. The administration of the instruments was achieved with the help of five digital electronics lecturers, one each from the colleges of education in the study area.

3.11 Method of Data Analysis

The study employed the use of descriptive and inferential statistics to analyze the data. Descriptive statistics using mean and standard deviation was used to answer all the research questions and inferential statistics using Analysis of Covariance (ANCOVA) to test all the hypotheses at significant level of 0.05. The ANCOVA was considered suitable for this study because effects of secondary variable or covariate (pre-test) are removed or drastically reduced (Uzoagulu, 2011). Group with higher mean value indicates to have performed better in cognitive and skill performances or retention test or showing much interest in digital electronics. Decision regarding the stated null

hypotheses was based on comparing significant of F calculated value and significant level of 0.05. The significant of F calculated value less than 0.05 indicates significant difference between the groups and the null hypotheses were rejected. However, post hoc analysis was carried out to determine the particular group responsible for the significant difference between the groups. All statistical calculations were conducted using Statistical Package for Social Science (SPSS) version 25.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Research Question 1

What is the effect of Brainstorming, Just-in-time and Demonstration teaching methods on students' cognitive achievement in digital electronics? The result showing the effect of Brainstorming, Just-in-time and Demonstration teaching methods on students' cognitive achievement in digital electronics is contained in Table 4.1.

Table 4.1: Mean of Pre-test and Post-test Cognitive Achievement Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

Groups		Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain
Control Group (Demonstration Method)	62	25.14	0.35	67.10	0.30	41.96
Experimental Group I (Brainstorming teaching method)	42	26.10	0.30	79.76	0.43	53.66
Experimental Group II (Just-in-time Technique)	38	26.08	0.49	67.08	0.27	41.00

Table 4.1 shows that, the control group taught with demonstration teaching method had pre-test mean cognitive achievement score of 25.14 with standard deviation of 0.35 and post-test score of 67.10 with standard deviation of 0.30 The mean gained between the

pre-test and post-test of the control group was 41.96. The experimental group I taught with Brainstorming teaching method had pre-test mean cognitive achievement score of 26.10 with standard deviation of 0.30 and post-test score of 79.76 with standard deviation of 0.43. The mean gained between the pre-test and post-test of the experimental group I was 53.66. The experimental group II taught with JiTT method had pre-test mean cognitive achievement score of 26.08 with standard deviation of 0.49 and post-test score of 67.08 with standard deviation of 0.27. The mean gained between the pre-test and post-test of the experimental group II was 41.00. The experimental group I had higher mean gained than experimental group II and control group. This indicated that, students taught digital electronics using brainstorming teaching method had higher mean cognitive achievement scores than students taught using JiTT and demonstration methods.

4.2 Research Question 2

What is the effect of Brainstorming, Just-in-time and Demonstration teaching methods on students' skill performance in digital electronics? The result showing the effect of Brainstorming, Just-in-time and Demonstration teaching methods on students' skill performance in digital electronics is contained in Table 4.2

Table 4.2: Mean of Pre-test and Post-test Skill performance Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

Groups		Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain
Control Group (Demonstration Method)	62	28.19	0.51	77.95	0.22	49.76
Experimental Group I (Brainstorming teaching method)	42	28.26	0.92	59.90	0.53	31.64
Experimental Group II	38	28.11	0.31	60.05	1.11	31.94

(Just-in-time Technique)

Table 4.2 shows that, the control group taught with demonstration teaching method had pre-test mean skill performance score of 28.19 with standard deviation of 0.51 and post-test score of 77.95 with standard deviation of 0.22 The mean gained between the pre-test and post-test of the control group was 49.76. The experimental group I taught with Brainstorming teaching method had pre-test mean skill performance score of 28.26 with standard deviation of 0.92 and post-test score of 59.90 with standard deviation of 0.53. The mean gained between the pre-test and post-test of the experimental group I was 31.64. The experimental group II taught with JiTT method had pre-test mean skill performance score of 28.11 with standard deviation of 0.31 and post-test score of 60.05 with standard deviation of 1.11. The mean gained between the pre-test and post-test of the experimental group II was 31.94. The control group had higher mean gained than experimental group I and II. This indicated that, students taught digital electronics using demonstration teaching method had higher mean skill performance scores than students taught using brainstorming and JiTT methods.

4.3 Research Question 3

What is the effect of Brainstorming, Just-in-time and Demonstration teaching methods on students' interest in digital electronics? The result showing the effect of Brainstorming, Just-in-time and Demonstration teaching methods on students' interest in digital electronics is contained in Table 4.3

Table 4.3: Mean of Pre-test and Post-test Interest Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

Groups		Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain
Control Group	62	34.21	0.95	59.76	0.43	25.55

(Demonstration Method)						
Experimental Group I (Brainstorming teaching method)	42	34.23	1.04	60.42	1.17	26.19
Experimental Group II (Just-in-time Technique)	38	34.61	2.51	84.79	0.41	50.18

Table 4.3 shows that, the control group taught with demonstration teaching method had pre-test mean interest score of 34.21 with standard deviation of 0.95 and post-test score of 59.76 with standard deviation of 0.43 The mean gained between the pre-test and post-test of the control group was 25.55. The experimental group I taught with Brainstorming teaching method had pre-test mean interest score of 34.23 with standard deviation of 1.04 and post-test score of 60.42 with standard deviation of 1.17. The mean gained between the pre-test and post-test of the experimental group I was 26.19. The experimental group II taught with JiTT method had pre-test mean interest score of 34.61 with standard deviation of 2.51 and post-test score of 84.79 with standard deviation of 0.41. The mean gained between the pre-test and post-test of the experimental group II was 50.18. The experimental group II had higher mean gained than experimental group I and control group. This indicated that, students taught digital electronics using JiTT technique had higher mean interest scores than students taught using brainstorming and demonstration techniques.

4.4 Research Question 4

What is the effect of Brainstorming, Just-in-time and Demonstration teaching methods on students' retention of learning in digital electronics? The result showing the effect of Brainstorming, Just-in-time and Demonstration teaching methods on students' retention of learning in digital electronics is contained in Table 4.4

Table 4.4: Mean of Pre-test and Post-test Retention Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

Groups		Pretest		Posttest		
	N	Mean	SD	Mean	SD	Mean Gain
Control Group (Demonstration Method)	62	25.14	0.35	63.14	0.35	38.00
Experimental Group I (Brainstorming teaching method)	42	26.10	0.30	75.27	0.45	49.17
Experimental Group II (Just-in-time Technique)	38	26.08	0.49	63.16	0.37	37.08

Table 4.4 shows that, the control group taught with demonstration teaching method had pre-test mean retention score of 25.14 with standard deviation of 0.35 and post-test score of 63.14 with standard deviation of 0.35 The mean gained between the pre-test and post-test of the control group was 38.00. The experimental group I taught with Brainstorming teaching method had pre-test mean retention score of 26.10 with standard deviation of 0.30 and post-test score of 75.27 with standard deviation of 0.45. The mean gained between the pre-test and post-test of the experimental group I was 49.17. The experimental group II taught with JiTT method had pre-test mean retention score of 26.08 with standard deviation of 0.49 and post-test score of 63.16 with standard deviation of 0.37. The mean gained between the pre-test and post-test of the experimental group II was 37.08. The experimental group I had higher mean gained than experimental group II and control group. This indicated that, students taught digital electronics using brainstorming teaching method had higher mean retention scores than students taught using JiTT and demonstration methods.

4.5 Hypothesis One

There is no significant difference among the cognitive achievement scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.** The data for testing the hypothesis is contained in Table 4.5

Table 4.5: Analysis of Covariance for the test of Significant difference among the Cognitive Achievement Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	560.73[a]	3	1869.244	145.6	.000
Intercept	144.38	1	144.380	112.6	.000
Pretest	.02	1	.021	.167	.684
Group	449.78	2	2248.391	174.4	.000*
Error	17.73	138	.128		
Total	754.00	142			
Corrected Total	562.46	141			

a. R Squared = .997 (Adjusted R Squared = .997)

Table 4.5 shows the F-calculated value for testing the significant difference among the cognitive achievement scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. The F-calculated value of 174.4 was obtained with associated exact probability value of 0.00. Since the associated probability of 0.00 was less than 0.05 set as level of significance, the null hypothesis which stated that there is no significant difference among the cognitive achievement scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods is rejected. Hence, there is significant difference among the cognitive achievement scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.** In order to determine the group responsible for the significance difference, post hoc test was carried out as shown in Table 4.6.

Table 4.6: Post hoc test for the Significant difference among the Cognitive Achievement Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

(I)	(J)	Mean	Std.	Sig.	95% Confidence Interval

GROUP	GROUP	Difference (I-J)	Error		Lower Bound	Upper Bound
CON	EXP I	-12.66*	.071	.000*	-12.83	-12.48
	EXP II	.016	.080	.979	-.18	.21
EXP I	CON	12.66*	.071	.000	12.48	12.83
	EXP II	12.67*	.073	.000	12.49	12.86
EXP II	CON	-.016	.080	.979	-.21	.18
	EXP I	-12.67*	.073	.000*	-12.86	-12.49

Key: CON = Control Group, EXP I = Experimental Group I and EXP II = Experimental Group II

Table 4.6 reveals p = 0.00 for experimental group I when compared with control and experimental group II. This indicated that, experimental group I (students taught digital electronics using brainstorming teaching method) is responsible for the significant difference between the cognitive achievement scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods.

4.6 Hypothesis Two

There is no significant difference among the skill performance scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.** The data for testing the hypothesis is contained in Table 4.7.

Table 4.7: Analysis of Covariance for the test of Significant difference among the Skill performance Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	957.59[a]	3	319.86	676.01	.000
Intercept	371.70	1	37.70	787.46	.000
Pretest	.079	1	.07	.16	.683
Group	957.65	2	478.32	101.03	.000
Error	65.14	138	.47		
Total	614.00	142			
Corrected Total	964.73	141			

a. R Squared = .993 (Adjusted R Squared = .993)

Table 4.7 shows the F-calculated value for testing the significant difference among the skill performance scores of students taught digital electronics using Brainstorming, Just-

in-time and Demonstration teaching methods. The F-calculated value of 101.03 was obtained with associated exact probability value of 0.00. Since the associated probability of 0.00 was less than 0.05 set as level of significance, the null hypothesis which stated that there is no significant difference among the skill performance scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods is rejected. Hence, there is significant difference among the skill performance scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.** In order to determine the group responsible for the significance difference, post hoc test was carried out as shown in Table 4.8.

Table 4.8: Post hoc test for the Significant difference among the Skill performance Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
CON	EI	18.04*	.136	.000	17.71	18.38
	EII	17.89*	.153	.000	17.52	18.27
EI	CON	-18.04*	.136	.000*	-18.38	-17.71
	EII	-.14	.141	.572	-.49	.19
EII	CON	-17.89*	.153	.000*	-18.27	-17.52
	EI	.14	.141	.572	-.19	.49

Table 4.8 reveals p = 0.00 for control group when compared with experimental group I and II. This indicated that, control group (students taught digital electronics using demonstration teaching method) is responsible for the significant difference among the skill performance scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods.

4.7 Hypothesis Three

There is no significant difference among the interest scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. The data for testing the hypothesis is contained in Table 4.9.

Table 4.9: Analysis of Covariance for the test of Significant difference among the Interest Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	169.11[a]	3	563.23	808.53	.000
Intercept	12.74	1	126.47	181.17	.000
Pretest	.869	1	.86	1.24	.266
Group	166.77	2	833.88	119.59	.000*
Error	96.16	138	.69		
Total	6496.00	142			
Corrected Total	169.87	141			

a. R Squared = .994 (Adjusted R Squared = .994)

Table 4.9 shows the F-calculated value for testing the significant difference among the interest scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. The F-calculated value of 119.59 was obtained with associated exact probability value of 0.00. Since the associated probability of 0.00 was less than 0.05 set as level of significance, the null hypothesis which stated that there is no significant difference among the interest scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods is rejected. Hence, there is significant difference among the interest scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.** In order to determine the group responsible for the significance difference, post hoc test was carried out as shown in Table 4.10.

Table 4.10: Post hoc test for the Significant difference among the Interest Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound

CON	EI	-.65*	.166	.001	-1.07	-.24
	EII	-25.02*	.187	.000*	-25.49	-24.56
EI	CON	.65*	.166	.001	.24	1.07
	EII	-24.37*	.172	.000*	-24.79	-23.94
EII	CON	25.02*	.187	.000	24.56	25.49
	EI	24.37*	.172	.000	23.94	24.79

Table 4.10 reveals p = 0.00 for experimental group II when compared with control group and experimental group I. This indicated that, experimental group II (students taught digital electronics using Jut-in-Time Teaching technique) is responsible for the significant difference between the interest scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods.

4.8 Hypothesis Four

There is no significant difference among the retention of learning scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. The data for testing the hypothesis is contained in Table 4.11.

Table 4.11: Analysis of Covariance for the test of Significant difference among the Retention Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	513.98[a]	3	171.66	107.10	.000
Intercept	116.03	1	11.03	72.82	.000
Pretest	.473	1	.473	2.96	.088
Group	408.51	2	204.75	127.74	.000*
Error	22.06	138	.160		
Total	6703.00	142			
Corrected Total	515.04	141			

a. R Squared = .996 (Adjusted R Squared = .996)

Table 4.11 shows the F-calculated value for testing the significant difference among the retention scores of students taught digital electronics using Brainstorming, Just-in-time

and Demonstration teaching methods. The F-calculated value of 127.74 was obtained with associated exact probability value of 0.00. Since the associated probability of 0.00 was less than 0.05 set as level of significance, the null hypothesis which stated that there is no significant difference among the retention scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods is rejected. Hence, there is significant difference among the retention scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. In order to determine the group responsible for the significance difference, post hoc test was carried out as shown in Table 4.12.

Table 4.12: Post hoc test for the Significant difference among the Retention Scores of Students Taught Digital Electronics Using Brainstorming, Just-in-time and Demonstration teaching methods

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
CON	EI	-12.13*	.080	.000*	-12.33	-11.93
	EII	-.00	.090	.986	-.23	.20
EI	CON	12.13*	.080	.000	11.93	12.33
	EII	12.11*	.082	.000	11.91	12.32
EII	CON	.01	.090	.986	-.20	.23
	EI	-12.11*	.082	.000*	-12.32	-11.91

Table 12 reveals p = 0.00 for experimental group I when compared with control and experimental group II. This indicated that, experimental group I (students taught digital electronics using brainstorming teaching method) is responsible for the significant difference between the retention scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods.

4.2 Findings of the Study

1. Students taught digital electronics using brainstorming teaching method had higher mean cognitive achievement scores than students taught using JiTT and demonstration methods.
2. Students taught digital electronics using demonstration teaching method had higher mean skill performance scores than students taught using brainstorming and JiTT methods.
3. Students taught digital electronics using JiTT technique had higher mean interest scores than students taught using brainstorming and demonstration techniques.
4. Students taught digital electronics using brainstorming teaching method had higher mean retention scores than students taught using JiTT and demonstration methods.
5. There was significant difference among the cognitive achievement scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.**
6. There was significant difference among the skill performance scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.**
7. There was significant difference among the interest scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.**
8. There was significant difference among the retention scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods**.**

4.3 Discussion of Findings

Findings on the effects of brainstorming, JiTT and demonstration teaching methods on students' cognitive achievement in digital electronics in colleges of education in North-West, Nigeria revealed that, brainstorming teaching method had positive effects than demonstration and JiTT methods. The findings indicated that, brainstorming teaching method enhanced the cognitive achievement of students in digital electronics. The finding is related to the findings of Kholoud (2016) in his study on investigation of the effect of brainstorming strategy in Balqa Applied University's students' achievement in the course "E 101" (Physics) that revealed significant cognitive achievement of students taught Physics using brainstorming strategy. The positive effects of brainstorming teaching methods on students' cognitive achievement in digital electronics could be due to the interactive nature of the technique that allow active participation of students in the learning processes. Claude *et al.* (2006) argued that, active participation in the learning processes enhances students' cognitive achievement. This implied that, teaching technique that allows interaction between students such as brainstorming teaching methods holds the potential of enhancing students' cognitive achievement.

Furthermore, findings on the test for significant difference among the cognitive achievement scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods revealed statistical significant. The statistical significant difference was traced to the group taught digital electronics using brainstorming teaching method. The finding entails that, the group taught using brainstorming teaching method was responsible for significant difference among the cognitive achievement scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. The finding is similar to the finding of Wisdom *et al.* (2016) that revealed statistically significant difference among the mean academic performance of students taught chemistry using brainstorming strategy

and lecture method in South-South, Nigeria. This implied that, the brainstorming teaching method is capable of causing huge difference in the cognitive achievement of students.

Findings on the effects of brainstorming, JiTT and demonstration teaching methods on students' skill performance in digital electronics in colleges of education in North-West, Nigeria revealed that, demonstration teaching method had positive effects than brainstorming and JiTT methods. The findings entails that, demonstration teaching method enhanced the skill performance of students in digital electronics. The finding is related to the findings of Ogologo and Wagbara (2013) on the effect of demonstration strategy on senior secondary school students' psychomotor achievement in separation techniques in Chemistry in Obio/Akpor Local Government Area, Rivers State that revealed demonstration method of teaching was potent in raising students' psychomotor achievement in separation techniques in chemistry. The positive effects of demonstration teaching method on students' skill performance in digital electronics could be due to the feature of the technique that displayed practical application of knowledge. Bako (2017) confirmed that, demonstration teaching methods helps in achieving psychomotor objectives. This implied that, using demonstration teaching method to teach practical oriented courses as digital electronics can enhance students' skill performance.

Furthermore, findings on the test for significant difference among the skill performance scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods revealed statistical significant. The statistical significant difference was traced to the group taught digital electronics using demonstration teaching method. The finding entails that, the group taught using demonstration teaching method was responsible for significance difference among the

skill performance scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. The finding is similar to the finding of Daluba (2013) that revealed statistical significant difference between the mean skill performance scores of students taught agricultural science using conventional demonstration methods in secondary school in Kogi East Education Zone of Kogi State. This implied that, huge difference in the skill performance of students can be achieved using demonstration teaching method.

Findings on the effects of brainstorming, JiTT and demonstration teaching methods on students' interest in digital electronics in colleges of education in North-West, Nigeria revealed that, JiTT technique had positive effects than brainstorming and demonstration techniques. The findings entails that, JiTT technique enhanced the interest of students in digital electronics. The finding is related to the findings of Gavrin (2013) on the effects of JiTT technique on students' cognitive gains, retention, interest in Physics that revealed that, students' interest was improved with 40 percent. The positive effects of JiTT technique on students' interest in digital electronics could be due to the feature of the technique that allows pre-class activities on learning contents to be studied through the use of multimedia. The finding supports the assertion of Marrs and Novak (2014) that revealed JiTT improved student interest, increased classroom interactivity, increased student academic success and retention rates. The implication of this finding is that, using JiTT technique to teach practical oriented courses as digital electronics can enhance students' interest.

Furthermore, findings on the test for significant difference among the interest scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods revealed statistical significant. The statistical significant difference was traced to the group taught digital electronics using JiTT technique. The finding

entails that, the group taught using JiTT technique was responsible for significance difference among the interest scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. The finding is similar to the finding of Claude *et al.* (2006) that revealed significant difference between students taught history of photography course using JiTT technique and lecture method. This implied that, the JiTT technique is capable of causing vast dissimilarity in students' interest.

Findings on the effects of brainstorming, JiTT and demonstration teaching methods on students' retention in digital electronics in colleges of education in North-West, Nigeria revealed that, brainstorming teaching method had positive effects than demonstration and JiTT methods. The findings entails that, brainstorming teaching method enhanced the retention of students in digital electronics. The finding is related to the findings of Jacob *et al.* (2016) that revealed positive effect of brainstorming learning strategy on junior secondary school students' academic achievement and retention in social studies in Yola educational zone, Adamawa State, Nigeria. This could be due to the interactive nature of brainstorming teaching method that allows active participation of students in the learning processes. Claude *et al.* (2006) contended that, students' participation during learning processes improves their level of retention. This connoted that, the teaching technique that allows students' interaction such as brainstorming teaching method is capable of enhancing students' retention.

Furthermore, findings on the test for significant difference among the retention scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods revealed statistical significant. The statistical significant difference was traced to the group taught digital electronics using brainstorming teaching method. The finding is an indication that, the group taught using brainstorming teaching methods

was responsible for significance difference among the retention scores of students taught digital electronics using Brainstorming, Just-in-time and Demonstration teaching methods. The finding is similar to the finding of Jacob *et al.* (2016) that revealed significant difference in the mean achievement and retention score of students taught social studies using brainstorming learning strategy and lecture method. This implied that, the brainstorming teaching method is capable of causing huge difference in students' retention.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the findings of the study, insights on the effects of brainstorming, JiTT and demonstration teaching methods on students' cognitive achievement, skill performance, interest and retention was provided. The study found out that, students taught digital electronics using: brainstorming teaching method had positive effect on the cognitive achievement and retention of students in digital electronics, demonstration teaching method had positive effect on the skill performance of students in digital electronics and JiTT technique had positive effect on the interest of students in digital electronics. The implication of the findings is that, the adoption of brainstorming, JiTT and demonstration teaching methods hold the potential to enhance students' cognitive achievement, skill performance, retention as well as stimulate interest in digital

electronics. Nevertheless, the findings are limited to the contents of digital electronics at college of education level in North-northwest, Nigeria. Therefore, it is concluded that, brainstorming, JiTT and demonstration teaching methods had positive effects on students' cognitive and skill performance, interest and retention in digital electronics.

5.2 Recommendations

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

1. Digital electronics lecturers should adopt the use of: brainstorming teaching method to enhance students' cognitive achievement and retention, JiTT technique to stimulate students' interest and demonstration teaching method to enhance students' skill performance.

2. National Commission for Colleges of Education should sensitize and train digital electronics lecturers on the effective use of brainstorming, JiTT and demonstration teaching methods in order to enhance students' cognitive achievement, skill performance, interest and retention.

3. Administrators of colleges of education should ensure the availability of facilities that supports the teaching of digital electronics using brainstorming, JiTT and demonstration teaching methods in order to enhance students' cognitive achievement, skill performance, interest and retention.

4. Digital electronics students should also embrace learning through the use of brainstorming, JiTT and demonstration teaching methods in order to enhance their cognitive achievement, skill performance, interest and retention.

5.3 Contribution to Knowledge

Findings that emerged from the study contributed immensely to knowledge by providing empirical evidence on the effectiveness of brainstorming teaching method on

the cognitive achievement and retention of students in digital electronics, demonstration teaching method on the skill performance of students in digital electronics and JiTT technique on the interest of students in digital electronics.

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

1. Effects of brainstorming, JiTT and demonstration teaching methods on students' motivation in digital electronics in colleges of education in North-West, Nigeria.

2. Perception of lecturers on the adoption of brainstorming and JiTT methods in teaching digital electronics in colleges of education in North-West, Nigeria.
3. Strategies for the utilization of brainstorming, JiTT and demonstration teaching methods among lecturers in teaching digital electronics in colleges of education in North-West, Nigeria**.**

4. Development of a framework for training lecturers the use of brainstorming, JiTT and demonstration teaching methods in colleges of education in North-West, Nigeria**.**

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APPENDIX A

STUDENTS' ACADEMIC ACHIEVEMENT IN DIGITAL ELETRONICS IN COLLEGES OF EDUCATION IN NORTH-WEST, NIGERIA FOR 2015-2019 ACADEMIC SESSIONS

2014/2015 ACADEMIC SESSION

		Number of Students and Corresponding Grades					
S/N	**Schools**	**A**	**B**	**C**	**D**	**F**	**Total**
1	Federal College of Education, Bichi	0	1	3	5	10	19
2	Federal College of Education (Technical) Gusau	0	1	4	2	8	15
3	Shehu Shagaria College of Education, Sokoto	1	2	4	2	9	18
4	Isah Kaita College of Education, Katsina	0	0	4	2	8	14
5	Kaduna State College of Education, Gidan Waya	1	3	6	5	13	28
	Total	**2**	**7**	**21**	**16**	**48**	**94**
	Total (%)	2.13%	7.45%	22.34%	17.02%	51.06%	**100%**
	Percentage Passed						**48.94%**
	Percentage Failed						**51.06%**

2015/2016 ACADEMIC SESSION

		Number of Students and Corresponding Grades					
S/N	**Schools**	**A**	**B**	**C**	**D**	**F**	**Total**
1	Federal College of Education, Bichi	1	2	5	2	10	20
2	Federal College of Education (Technical) Gusau	1	1	2	2	10	16

3	Shehu Shagaria College of Education, Sokoto	1	2	4	3	8	18
4	Isah Kaita College of Education, Katsina	0	1	5	2	9	17
5	Kaduna State College of Education, Gidan Waya	0	1	10	7	15	33
	Total	**3**	**9**	**26**	**16**	**52**	**104**
	Total (%)	2.88%	8.65%	25.00%	15.38%	50.00%	**100%**
	Percentage Passed						**51.91%**
	Percentage Failed						**48.09%**

2016/2017 ACADEMIC SESSION

		Number of Students and Corresponding Grades					
S/N	**Schools**	**A**	**B**	**C**	**D**	**F**	**Total**
1	Federal College of Education, Bichi	1	3	5	2	8	19
2	Federal College of Education (Technical) Gusau	1	2	3	3	8	17
3	Shehu Shagaria College of Education, Sokoto	1	2	7	1	11	22
4	Isah Kaita College of Education, Katsina	0	1	2	4	8	15
5	Kaduna State College of Education, Gidan Waya	2	4	6	3	18	33
	Total	**5**	**12**	**23**	**13**	**53**	**106**
	Total (%)	4.72%	11.32%	21.70%	12.26%	50%	**100**%
	Percentage Passed						**50**%
	Percentage Failed						**50%**

2017/2018 ACADEMIC SESSION

		Number of Students and Corresponding Grades					
S/N	**Schools**	**A**	**B**	**C**	**D**	**F**	**Total**
1	Federal College of Education, Bichi	0	3	5	3	10	21
2	Federal College of Education (Technical) Gusau	0	1	4	3	8	16
3	Shehu Shagaria College of Education, Sokoto	1	3	6	2	13	25
4	Isah Kaita College of Education, Katsina	2	1	4	4	14	25

5	Kaduna State College of Education, Gidan Waya	1	2	8	4	14	29
	Total	**4**	**10**	**27**	**16**	**59**	**116**
	Total (%)	3.45%	8.62%	23.28%	13.79%	50.86%	**100**%
	Percentage Passed						**49.14%**
	Percentage Failed						**50.86%**

2018/2019 ACADEMIC SESSION

		Number of Students and Corresponding Grades					
S/N	**Schools**	**A**	**B**	**C**	**D**	**F**	**Total**
1	Federal College of Education, Bichi	0	2	4	6	10	22
2	Federal College of Education (Technical) Gusau	0	1	3	2	6	12
3	Shehu Shagaria College of Education, Sokoto	0	1	4	5	9	19
4	Isah Kaita College of Education, Katsina	0	0	5	3	8	16
5	Kaduna State College of Education, Gidan Waya	1	2	7	6	16	32
	Total	**1**	**6**	**23**	**22**	**49**	**101**
	Total (%)	.99%	5.94%	22.77%	21.78%	48.51%	**100%**
	Percentage Passed						**51.48%**
	Percentage Failed						**48.52x%**

Sources: Examination and Records Office of Electrical Electronics Technology Education Department in Federal College of Education, Bichi**,** Federal College of Education (Technical) Gusau and Shehu Shagaria College of Education, Sokoto

LETTER OF REQUEST FOR STUDENTS' RECORD OF PERFORMANCE IN DIGITAL ELECTRONICS

FO
Please process for the record has requested with emphasis on strict use for the research. 2/11/2020

Department of Industrial and Technology Education,
Federal university of technology, Minna.
P.M.B. 65 Minna.
10th September, 2020.

Dear Examination Officer,

REQUEST FOR STUDENTS' RECORD OF PERFORMANCE IN DIGITAL ELECTRONICS

I am a postgraduate student of the above mentioned department and institution currently conducting research on the "**Effect of Brainstorming, Just-In-Time and Demonstration Teaching Techniques on Students' Learning Outcome in Digital Electronics in Colleges of Education in North-West, Nigeria**". You are kindly requested to provide in the table below the record of students' performance in digital electronics to serve as a basis for carrying out this research.

You are also expected to authenticate the information given by signing and stamping on the filled table. The information provided will only be used for this research purpose.

Thank you.

Yours faithfully,

SAIDU, Hadiza Arah.
MTECH/SSTE/2018/8745

		Please Insert Number of Students on the Corresponding Grades					
S/N	**Academic Session**	**A**	**B**	**C**	**D**	**F**	**Total**
1	2014/2015	0	1	4	2	8	15
2	2015/2016	1	1	2	2	10	16
3	2016/2017	1	2	3	3	8	17
4	2017/2018	0	1	4	3	8	16
5	2018/2019	0	1	3	2	6	12

A
Dean SoTE;
This is for your consideration and pls. further necessary action
23rd/09/2020

DEAN
SCHOOL OF SEC. EDU. (TECH)
FCE (T) BUSAU
SIGN DATE 2nd/11/2020

LETTER OF REQUEST FOR STUDENTS' RECORD OF PERFORMANCE IN DIGITAL ELECTRONICS

Department of Industrial and
Technology Education,
Federal university of technology,
Minna.
P.M.B. 65 Minna.
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1	2014/2015	1	2	4	2	9	18
2	2015/2016	1	2	4	3	8	18
3	2016/2017	1	2	7	1	11	22
4	2017/2018	1	3	6	2	13	25
5	2018/2019	0	1	4	5	9	19

EXAMINATION OFFICE
SCHOOL OF TECHNICAL EDUCATION
SSCOE, SOKOTO
SIGN & DATE 16/10/2021

LETTER OF REQUEST FOR STUDENTS' RECORD OF PERFORMANCE IN DIGITAL ELECTRONICS

Department of Industrial and
Technology Education,
Federal university of technology,
Minna.
P.M.B. 65 Minna:
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1	2014/2015	0	1	3	5	10	19
2	2015/2016	1	2	5	2	10	20
3	2016/2017	1	3	5	2	8	19
4	2017/2018	0	3	5	3	10	21
5	2018/2019	0	2	4	6	10	22

FEDERAL COLLEGE OF EDUCATION (TECHNICAL) BIC
DEAN
TECHNICAL EDUCATION
Date

LETTER OF REQUEST FOR STUDENTS' RECORD OF PERFORMANCE IN DIGITAL ELECTRONICS

Department of Industrial and
Technology Education,
Federal university of technology,
Minna.
P.M.B. 65 Minna.
10th September, 2020.

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S/N	**Academic Session**	**A**	**B**	**C**	**D**	**F**	**Total**
1	2014/2015	0	0	4	2	8	14
2	2015/2016	0	1	5	2	9	17
3	2016/2017	0	1	2	4	8	15
4	2017/2018	2	1	4	4	14	25
5	2018/2019	0	0	5	3	8	16

ISA KAITA COLLEGE OF EDUCATION
H.O.D. 4/11/2020
TECH. EDUCATION
Date.....
Kaisina, Katsina

LETTER OF REQUEST FOR STUDENTS' RECORD OF PERFORMANCE IN DIGITAL ELECTRONICS

Department of Industrial and
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Minna.
P.M.B. 65 Minna.
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2	2015/2016	0	1	10	7	15	33
3	2016/2017	2	4	6	3	18	33
4	2017/2018	1	2	8	4	14	29
5	2018/2019	1	2	8	6	16	32

EXAMINATION OFFICE
SCH. OF TECH. EDUCATION
KADUNA POLYTECHNIC
EDUCATION GIDAN WAYA
SIGN DATE 14/09/20

APPENDIX B

LETTER OF REQUEST FOR STUDENTS' RECORD OF PERFORMANCE IN DIGITAL ELECTRONICS

Department of Industrial and
Technology Education,
Federal university of technology,
Minna.
P.M.B. 65 Minna.
10th September, 2020.

Dear Examination Officer,

REQUEST FOR STUDENTS' RECORD OF PERFORMANCE IN DIGITAL ELECTRONICS

I am a postgraduate student of the above mentioned department and institution currently conducting research on the "**Effect of Brainstorming, JiTT and demonstration teaching methods on Students' Learning Outcome in Digital Electronics in Colleges of Education in North-West, Nigeria"**. You are kindly requested to provide in the table below the record of students' performance in digital electronics to be used for this research purpose only.

You are also expected to authenticate the information given by signing and stamping on the filled table. The information provided will only be used for this research purpose.

Thank you.

Yours faithfully,

,

SAIDU, Hadiza Arah.

MTECH/SSTE/2018/8745

		Please Insert Number of Students on the Corresponding Grades					
S/N	**Academic Session**	**A**	**B**	**C**	**D**	**F**	**Total**
1	2014/2015						
2	2015/2016						
3	2016/2017						
4	2017/2018						
5	2018/2019						

APPENDIX C

THE DISTRIBUTION OF 2019/2020 ACADEMIC SESSION OF NIGERIAN CERTIFICATE IN EDUCATION (NCE III) DIGITAL ELECTRONICS STUDENTS POPULATION IN NORTH WEST, NIGERIA.

S/NO	Name of Schools	State	Number of Students	Group
1	Federal College of Education, Bichi	Kano State	22	Experimental II
2	Federal College of Education (Technical) Gusau	Zamfara State	16	Experimental II
3	Shehu Shagaria College of Education, Sokoto	Sokoto State	34	Control
4	Isah Kaita College of Education, Katsina	Katsina State	28	Control
5	Kaduna State College of Education, Gidan Waya	Kaduna State	42	Experimental I
	TOTAL		**142**	

Sources: Examination and Records Office of Electrical Electronics Technology Education Department in Federal College of Education, Bichi**,** Federal College of Education (Technical) Gusau, Shehu Shagaria College of Education, Sokoto, Isah Kaita College of Education, Katsina and Kaduna State College of Education, Gidan Waya, Kafancha.

APPENDIX D

A 60 ITEMS TABLE OF SPECIFICATION FOR DIGITAL ELECTRONIC COGNITIVE ACHIEVEMENT AND RETENTION TEST

Cognitive Levels									
S/N	Topics	Percentage (%)	Knowledge (0%)	Comprehension (0%)	Application (0%)	Analysis (28.3%)	Synthesis (28.3%)	Evaluation (43.4%)	Total questions.
1	Computer parts, types and devices	13.3	2	2	4				8
2	Computer aided design	13.3	2	2	4				8
3	Number system	15	3	3	3				9
4	Logic gate	13.3	2	2	4				8
5	Flip flops	11.7	2	2	3				7
6	Counters	10	2	2	2				6
7	Decoder and Encoder	11.7	2	2	3				7
8	Microprocessor	11.7	2	2	3				7
	TOTAL	**100%**	**17**	**17**	**26**				**60**

APPENDIX E

DIGITAL ELECTRONICS COGNITIVE ACHIEVEMENT AND RETENTION TEST

Instructions: Answer all questions **Time Allow**: 1 Hour 30 Minutes

1. …….is the computer unit that converts data into information

   a. Arithmetic and logic unit

   b. central processing unit

   c. input unit

   d. output unit

2. ……. is known as the brain of the computer

   a. Arithmetic and logic unit

   b. Central processing unit

   c. Key board

   d. Monitor

3. …… contains devices through which data is entered into the computer

   a. Arithmetic and logic unit
   b. central processing unit
   c. input unit
   d. output unit

4. ……is an interface between the computer and the user

   a. Arithmetic and logic unit
   b. central processing unit
   c. input unit
   d. output unit

5. Computer output device consists of…….

   a. Charger
   b. Central processing unit
   c. Key board
   d. Monitor

6. ……design appears to have length and breadth but no depth

   a. Four dimension
   b. One dimension
   c. Three dimension
   d. Two-dimension

7. ……design appears to have length, breadth and depth

   a. Four dimension

b. One dimension

c. Three dimension

d. Two-dimension

8. The uses of CAD in digital electronic include the following except…….

a. Analysis of a design

b. Creation of a design

c. Modification of a design

d. Molding of a design

9. …… uses two digits (i.e 0 and 1)

a. Binary number system

b. Digital number system

c. Hexa decimal number system

d. Octal number system

10. …… represents a 0 power of the base 8

a. Binary number system

b. Digital number system

c. Hexa decimal number system

d. Octal number system

11. ……. uses 10 digits and 6 letters

a. Binary number system

b. Digital number system

c. Hexa decimal number system

d. Octal number system

12. A binary counter with four output bits counts…… in its sequence

a. 24 or 16

b. 24 or 18

c. 24 or 20

d. 24 or 22

13. The applications of digital counters include…….

a. Digital clocks
b. Multiplexing
c. Timer
d. Video player

14. Example of digital signal from an encoder include…….

a. ABC code

b. BCD code

c. MNO code

d. XYZ coder

15. …….. allows single input line and produces multiple output lines

a. Counter

b. Decoder

c. Encoder

d. None of the above

16. The applications of decoder and encoder include the following except……

a. Accumulator

b. Automatic wireless health monitoring system

c. Home automation system

d. Robotic vehicle

17. ……. performs arithmetical and logical operations on the data received from the memory or an input device

a. Arithmetic Logical Unit
b. Communicating unit
c. Control unit
d. Register array

18. …… consists of registers identified by letters like B, C, D, E, H, L and accumulator

a. Arithmetic Logical Unit
b. Communicating unit
c. Control unit
d. Register array

19. …….. controls the flow of data and instructions within the computer

a. Arithmetic Logical Unit
b. Communicating unit
c. Control unit
d. Register array

20. The following are names of logic gate except…….

a. AB gate
b. AND gate
c. NOT gate

d. OR gate

21……. have only one input and the output is the inverse of the input

a. AB gate

b. AND gate

c. NOT gate

d. OR gate

22. The following are applications of flip flops circuit except…….

a. Bounce elimination switch
b. Counters
c. Frequency multiplication
d. Registers

23. …….is the use of CAD in the design of electronic system

a. Computer electronic design

b. Electronic aided design

c. Electronic design automation

d. All of the above

24. ……..enables the design of an engineering project within an integrated graphical interface (GUI)

a. CAD hardware

b. CAD software

c. CAD system

d. All of the above

25. The most widely use alphanumeric code is……

a. American Standard Code for Information Interchange

b. Australian Standard Code for Information Interchange

c. British Standard Code for Information Interchange

d. German Standard Code for Information Interchange

26. …….is a 7-bit code

a. American Standard Code for Information Interchange

b. Australian Standard Code for Information Interchange

c. British Standard Code for Information Interchange

d. German Standard Code for Information Interchange

27. The ……..gate gives a high output only if all its inputs are high

a. AND

b. NAND

c. NOT

d. OR

28. The ……..gate gives a high output only if one or more of its inputs are high

a. AND

b. NAND

c. NOT

d. OR

29. The ……..gate produces an inverted version of the input at its output

a. AND

b. NAND

c. NOT

d. OR

30. The ……..gate gives a high output only if any its inputs are low

a. AND

b. NAND

c. NOT

d. OR

31. The output of …….is insensitive to the change in the input

a. D flip-flop

b. JK flip-flop

c. SR flip-flop

d. T flip-flop

32. …… can be used for functions such as hold, rest and set

a. D flip-flop

b. JK flip-flop

c. SR flip-flop

d. T flip-flop

33. JK flip-flop is the modification of ……..

a. D flip-flop

b. JK flip-flop

c. SR flip-flop

d. None of the above

34. ……. is a simple version of JK flip-flop

a. D flip-flop

b. SR flip-flop

c. T flip-flop

d. None of the above

35. The following are types of modulus except…….

a. 1–bit up or down

b. 2–bit up or down

c. 3–bit up or down

d. 4–bit up or down

36. The 2-bit ripple counter is called…….

a. MOD-4

b. MOD-6

c. MOD-8

d. MOD-12

37. The two popular encoder IC are…….

a. A12E and AC148

b. H12E and HC148

c. K12E and KC148

d. Z12E and ZC148

38. The following are types of decoder IC except……

a. H12D

b. HT9170B DTMF

c. MT8870C-1 DTMF

d. Z16 DTMF

39. Based on word length, microprocessor can be classified as the following except……

a. 1-bit

b. 8-bit

c. 16-bit

d. 32-bit

40. The following are terms associated with microprocessor except……

a. Bandwidth

b. Clock speed

c. Instruction set

d. Word frequency

APPENDIX F

KEYS TO DIGITAL ELECTRONICS COGNITIVE ACHIEVEMENT AND RETENTION TEST

Questions	Answers	Questions	Answers

1.	**B**	**2.**	**B**
3.	**C**	**4.**	**D**
5.	**D**	**6.**	**D**
7.	**C**	**8.**	**D**
9.	**A**	**10.**	**D**
11.	**C**	**12.**	**A**
13.	**D**	**14.**	**B**
15.	**B**	**16.**	**A**
17.	**A**	**18.**	**D**
19.	**C**	**20.**	**A**
21.	**C**	**22.**	**C**
23.	**C**	**24.**	**B**
25.	**D**	**26.**	**A**
27.	**A**	**28.**	**D**
29.	**C**	**30.**	**B**
31.	**A**	**32.**	**C**
33.	**C**	**34.**	**C**
35.	**A**	**36.**	**A**
37.	**B**	**38.**	**D**
39.	**A**	**40.**	**D**

APPENDIX G

DIGITAL ELECTRONICS STUDENT'S ANSWER SHEET FOR ANSWERING DECART QUESTIONS

Name of College: ……

Registration Number: ……

INTRUCTIONS:

1. Shade ■ against the letter (A-D) that corresponds with the number that you choose on the question booklet.
2. Erase or cancel an earlier choice, if you have changed your mind.
3. Use HB pencil only.

1	[A]	[B]	[C]	[D]	21	[A]	[B]	[C]	[D]
2	[A]	[B]	[C]	[D]	22	[A]	[B]	[C]	[D]
3	[A]	[B]	[C]	[D]	23	[A]	[B]	[C]	[D]
4	[A]	[B]	[C]	[D]	24	[A]	[B]	[C]	[D]
5	[A]	[B]	[C]	[D]	25	[A]	[B]	[C]	[D]
6	[A]	[B]	[C]	[D]	26	[A]	[B]	[C]	[D]
7	[A]	[B]	[C]	[D]	27	[A]	[B]	[C]	[D]
8	[A]	[B]	[C]	[D]	28	[A]	[B]	[C]	[D]
9	[A]	[B]	[C]	[D]	29	[A]	[B]	[C]	[D]
10	[A]	[B]	[C]	[D]	30	[A]	[B]	[C]	[D]
11	[A]	[B]	[C]	[D]	31	[A]	[B]	[C]	[D]
12	[A]	[B]	[C]	[D]	32	[A]	[B]	[C]	[D]
13	[A]	[B]	[C]	[D]	33	[A]	[B]	[C]	[D]
14	[A]	[B]	[C]	[D]	34	[A]	[B]	[C]	[D]
15	[A]	[B]	[C]	[D]	35	[A]	[B]	[C]	[D]
16	[A]	[B]	[C]	[D]	36	[A]	[B]	[C]	[D]
17	[A]	[B]	[C]	[D]	37	[A]	[B]	[C]	[D]
18	[A]	[B]	[C]	[D]	38	[A]	[B]	[C]	[D]
19	[A]	[B]	[C]	[D]	39	[A]	[B]	[C]	[D]
20	[A]	[B]	[C]	[D]	40	[A]	[B]	[C]	[D]

APPENDIX H

TABLE OF SPECIFICATION FOR DIGITAL ELECTRONIC SKILL PERFORMANCE TEST

	Psychomotor Levels									
S/N	Topics	Percentage (%)	Perception (0%)	Set (0%)	Guided Response (0%)	Mechanism (28.3%)	Complex Overt (28.3%)	Adaptation (43.4%)	Origination (0%)	Total questions.
4	Logic gate	50	-	-	-	-	1	-	-	1
5	Flip flops	50	-	-	-	-	1	-	-	1
	TOTAL	**100%**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**2**

APPENDIX I

DIGITAL ELECTRONICS SKILL PERFORMANCE TEST

Instruction: You are expected to attempt the two questions. You should note that marks will be awarded based on step by step execution of the tasks.

Time allow: Two Hours

Requirements:

The followings should be made available for the conduct of the examination:

1. Logic trainer kit
2. logic gates / ICs,
3. Digital Trainer Circuit
4. Wire probes
5. IC-7400
6. bread-board
7. on/off LED
8. AC power supply

Questions

1. Verify and interpret the truth tables for AND, OR, NOT, and NAND Gates.
2. Investigate the operation of JK flip-flop.

APPENDIX J

DIGITAL ELECTRONICS SKILL PERFORMANCE TEST RATING SCALE

Question 1

S/N	Performance Tasks in Digital Electronics	Excellent	Very Good	Good	Poor	Very Poor
		5	4	3	2	1
1	Observation of precautions	Score the student 5 marks for observing all of the following precautions; checking the gates before use, cleaning the circuit, tightening the connections, making sure pin-7 is grounded and avoiding short circuit	Score the student 4 marks for observing 4 of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, making sure pin-7 is grounded and avoiding short circuit	Score the student 3 marks for observing 3 of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, making sure pin-7 is grounded and avoiding short circuit	Score the student 2 marks for observing 2 of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, making sure pin-7 is grounded and avoiding short circuit	Score the student 1 marks for observing 1 of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, making sure pin-7 is grounded and avoiding short circuit

2	Ability to connect the trainer kit to AC power supply	Score the student 5 marks for doing all of the following; collecting all the trainer kit, cutting wires, prepare the wires, connecting the trainer kit to AC power supply	Score the student 4 marks for doing 3 of the following; collecting all the trainer kit, cutting wires, prepare the wires, connecting the trainer kit to AC power supply	Score the student 3 marks for doing 2 of the following; collecting trainer kit, cutting wires, prepare the wires, connecting the trainer kit to AC power supply	Score the student 2 marks for doing 1 of the following; collecting all the trainer kit, cutting wires, prepare the wires, connecting the trainer kit to AC power supply	Score the student 1 marks for not doing any of the following; collecting trainer kit, cutting wires, prepare the wires, connecting the trainer kit to AC power supply
3	Ability to connect the inputs of any one logic gate to the logic sources and its output to the logic indicator	Score the student 5 marks for connecting the inputs of any one logic gate to the logic sources and its output to the logic indicator for all of the following AND, OR, NOT, and NAND Gates	Score the student 4 marks for connecting the inputs of any one logic gate to the logic sources and its output to the logic indicator for 3 of the following AND, OR, NOT, and NAND Gates	Score the student 3 marks for connecting the inputs of any one logic gate to the logic sources and its output to the logic indicator for 2 of the following AND, OR, NOT, and NAND Gates	Score the student 2 marks for connecting the inputs of any one logic gate to the logic sources and its output to the logic indicator for 1 of the following AND, OR, NOT, and NAND Gates	Score the student 1 marks for not connecting the inputs of any one logic gate to the logic sources and its output to the logic indicator for any of the following AND, OR, NOT, and NAND Gates
4	Competence in applying various input combinations	Score the student 5 marks for	Score the student 4 marks for	Score the student 3 marks for	Score the student 2 marks for	Score the student 1 marks for

	and observe output for each gate	applying various input combinations and observe output for all of the following AND, OR, NOT, and NAND Gates	applying various input combinations and observe output for 3 of the following AND, OR, NOT, and NAND Gates	applying various input combinations and observe output for 2 of the following AND, OR, NOT, and NAND Gates	applying various input combinations and observe output for 1 of the following AND, OR, NOT, and NAND Gates	not applying various input combinations and observe output for any of the following AND, OR, NOT, and NAND Gates
5	Ability to verify the truth table for each input/ output combination	Score the student 5 marks for verifying the truth table for all of the following AND, OR, NOT, and NAND Gates	Score the student 4 marks for verifying the truth table for 3 of the following AND, OR, NOT, and NAND Gates	Score the student 3 marks for verifying the truth table for 2 of the following AND, OR, NOT, and NAND Gates	Score the student 2 marks for verifying the truth table for 1 of the following AND, OR, NOT, and NAND Gates	Score the student 1 marks for not verifying the truth table for any of the following AND, OR, NOT, and NAND Gates
6	Switching off the ac power supply	Score the student 5 marks for switching off the ac power supply to all of the following AND, OR, NOT, and NAND Gates	Score the student 4 marks for switching off the ac power supply to 3 of the following AND, OR, NOT, and NAND Gates	Score the student 3 marks for switching off the ac power supply to 2 of the following AND, OR, NOT, and NAND Gates	Score the student 2 marks for switching off the ac power supply to 1 of the following AND, OR, NOT, and NAND Gates	Score the student 1 marks for not switching off the ac power supply to any of the following AND, OR, NOT, and NAND Gates
	Scores: = $\frac{\text{Obtained Score}}{\text{x } 100}$					

	30 1					

Question 2

S/N	Performance Tasks in Digital Electronics	Excellent	Very Good	Good	Poor	Very Poor
		5	4	3	2	1
1	Observation of precautions	Score the student 5 marks for observing all of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, observing output carefully and avoiding short circuit	Score the student 4 marks for observing 4 of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, observing output carefully and avoiding short circuit	Score the student 3 marks for observing 3 of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, observing output carefully and avoiding short circuit	Score the student 2 marks for observing 2 of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, observing output carefully and avoiding short circuit	Score the student 1 marks for observing 1 of the following precautions; checking the IC before use, cleaning the circuit, tightening the connections, observing output carefully and avoiding short circuit
3	Ability to connect the digital	Score the student 5 marks for	Score the student 4 marks for	Score the student 3 marks for	Score the student 2 marks for	Score the student 1 marks for

	trainer kit to main power supply	doing all of the following; collecting all the required material, cutting wires, prepare the wires, connecting the digital trainer kit to main power supply	doing 3 of the following; collecting all the required material, cutting wires, prepare the wires, connecting the digital trainer kit to main power supply	doing 2 of the following; collecting all the required material, cutting wires, prepare the wires, connecting the digital trainer kit to main power supply	doing 1 of the following; collecting all the required material, cutting wires, prepare the wires, connecting the digital trainer kit to main power supply	not doing any of the following; collecting all the required material, cutting wires, prepare the wires, connecting the digital trainer kit to main power supply
4	Ability to check the operations of IC-7400	Score the student 5 marks for doing all of the following; making a clean and tidy circuit on the bread-board, providing inputs, vary the inputs, observing the behavior (ON/OFF) LED provided and recording the values in the truth table	Score the student 4 marks for doing 4 of the following; making a clean and tidy circuit on the bread-board, providing inputs, vary the inputs, observing the behavior (ON/OFF) LED provided and recording the values in the truth table	Score the student 3 marks for doing 3 of the following; making a clean and tidy circuit on the bread-board, providing inputs, vary the inputs, observing the behavior (ON/OFF) LED provided and recording the values in the truth table	Score the student 2 marks for doing 2 of the following; making a clean and tidy circuit on the bread-board, providing inputs, vary the inputs, observing the behavior (ON/OFF) LED provided and recording the values in the truth table	Score the student 1 marks for doing 1 of the following; making a clean and tidy circuit on the bread-board, providing inputs, vary the inputs, observing the behavior (ON/OFF) LED provided and recording the values in the truth table
	Scores: = Obtained					

	Score x 100 20 1					

APPENDIX K

DIGITAL ELECTRONICS INTEREST INVENTORY

Instruction: please tick (√) to indicate the degree to which you agree or disagree to the statement below.

SA = Strongly Agree

A = Agree

U = Undecided

D = Disagree

SD = Strongly Disagree

S/N	ITEMS	SA	A	UD	D	SD
1.	The course Digital electronics is easy to understand.					
2.	Digital electronics classes are very interesting.					
3.	Digital electronics classes are always boring to me.					
4.	I attended digital electronics classes regularly.					
5.	I enjoy participating in digital electronics lectures.					
6.	It is better to use digital electronics periods for other course.					

7.	Digital electronics periods should be extended beyond two hours.					
8.	I pay more attention in the digital electronics classes.					
9.	When I am alone, I reflect on digital electronics notes.					
10.	Digital electronics component diagrams are not easy to draw.					
11.	I don't ask questions during digital electronics classes.					
12.	I don't like discussing about digital electronics course.					
13.	I don't like doing assignment on digital electronics course.					
14.	I always feel sleepy during digital electronics lessons.					
15.	I pay much interest in digital electronics lectures more than in any other course.					
16.	I usually like to take permission to absent myself from digital electronics classes.					
17.	If digital electronics lecturer fails to come to the classes on time, I can go to the their office to call any of them whose period is on.					
18.	If digital electronics lecturer misses his class, I always feel happy.					
19.	I like digital electronics course than any other course.					
20.	Digital electronics classes increases my interest in the course.					
21.	I prefer digital electronics course outline that does not require much drawings.					
22.	I take interest in studying digital electronics.					
23.	I always wish that lectures on digital electronics should be continued even after time for the course is over.					
24.	I don't take interest in anything involving digital electronics.					
25.	I encourage my friends to develop interest in digital electronics.					
26.	I don't enjoy reading books on digital electronics.					
27.	The strategies adopted in teaching digital electronics subject by the lecturers negatively affect my interest in the subject.					
28.	Digital electronics lectures are usually noisy and uncomfortable to me.					
29.	I engage myself stylishly with other assignments					

	during digital electronics lectures.					
30.	I don't do any extra studies on digital electronics apart from the normal lectures.					

APPENDIX L

BRAINSTORMING TEACHING METHOD LESSON PLANS

LESSON PLAN ONE

Name of Institutions: Kaduna State College of Education, Gidan Waya

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Basic computer parts, types and other devices

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the function of a computer
2. Mention the three basic units of computer

3. State the function of computer input unit
4. State the function of Central Processing Unit (CPU)
5. State the function of computer output unit

Previous knowledge: The students are familiar with digital electronic devices such as a computer.

Instructional Technique: Brainstorming teaching method

Instructional Requirements: A pen or pencil and sheet of paper to jot down note on Basic computer parts, types and other devices.

Steps	Content	Teachers Activities	Learners Activities
1	Preparation	• The lecturer divides the students into two groups • Assigns group leaders to each group • States the rules guiding brainstorming teaching method such as no judgement, think freely, record each idea, and stay focus on the topic	Students move to the groups they are assigned to and jot down rules they are expected to follow
2	Introduction	The lecturer introduces the lesson by telling the students that they'll be brainstorming about computer	Students prepare for brainstorming about computer
3	State the function of a computer	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the function of a computer such as: computer is an electronic data processing device, which requires input raw data for processing and generates the output in desired form.	The students engage in brainstorming by exploring the function of a computer
4	Mention the three basic units of computer	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the three basic units of computer such as: input, central processing and output units.	The students engage in brainstorming by exploring the three basic units of computer
5	State the function of computer input unit	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the function of computer input unit such as: input unit contains devices with the help	The students engage in brainstorming by exploring the computer input unit

		of which the data is entered into the computer.	
6	State the function of Central Processing Unit (CPU)	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the function of Central Processing Unit (CPU) such as: performs all types of data processing operations.	The students engage in brainstorming by exploring the function of Central Processing Unit (CPU)
7	State the function of computer output unit	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the function of computer output unit such as: notify the information displayed into a form which is understandable by the computer user.	The students engage in brainstorming by exploring the function of computer output unit
8	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: computer is an electronic device that processes raw data	Students listen attentively, ask questions and take down notes
9	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the function of a computer 2. Mention the three basic units of computer 3. State the function of computer input unit 4. State the function of Central Processing Unit (CPU) 5. State the function of computer output unit	Students responds to the lecturers questions
10	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN TWO

Name of Institutions: Kaduna State College of Education, Gidan Waya

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Computer Aided Design

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term Computer Aided Design (CAD)
2. State the types of dimensional diagrams produced by CAD
3. Mention the uses of CAD
4. Mention the application of CAD

Previous knowledge: The students were exposed to the Basic computer parts, types and other devices

Instructional Technique: Brainstorming teaching method

Instructional Requirements: A pen or pencil and sheet of paper to jot down note on Computer Aided Design

Steps	Content	Teachers Activities	Learners Activities
1	Preparation	• The lecturer divides the students into two groups • Assigns group leaders to each group • States the rules guiding brainstorming teaching method such as no judgement, think freely, record each idea, and stay focus on the topic	Students move to the groups they are assigned to and jot down rules they are expected to follow
2	Introduction	The lecturer introduces the lesson by telling the students that they'll be brainstorming about Computer Aided Design (CAD)	Students prepare for brainstorming about Computer Aided Design (CAD)
3	State the term Computer Aided Design (CAD)	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the definition of the term Computer Aided Design (CAD) such as: CAD is the use of computers (or workstations) to aid in the creation, modification and analysis of a design	The students engage in brainstorming by exploring the definition of the term CAD
4	State the types of dimensional diagrams produced by CAD	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the types of dimensional diagrams produced by CAD such as: two and three dimensions.	The students engage in brainstorming by exploring the types of dimensional diagrams produced by CAD
5	Mention the uses of CAD	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the uses of CAD such as: creation, modification and analysis of a design.	The students engage in brainstorming by exploring the uses of CAD
6	Mention the application of CAD	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the application of CAD such as: architectural drawing, interior design and graphs.	The students engage in brainstorming by exploring the application of CAD

7	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Computer Aided Design is the use of computer to aid in the creation of a design.	Students listen attentively, ask questions and take down notes
8	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the term Computer Aided Design (CAD) 2. State the types of dimensional diagrams produced by CAD 3. Mention the uses of CAD 4. Mention the application of CAD	Students responds to the lecturers questions
9	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN THREE

Name of Institutions: Kaduna State College of Education, Gidan Waya

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Number System

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Explain computer number system

2. Mention the three types of number system
3. State the characteristics of binary number system
4. State the characteristics of octal number system
5. State the characteristics of hexadecimal number system

Previous knowledge: The students have been exposed to Computer Aided Design.

Instructional Technique: Brainstorming teaching method

Instructional Requirements: A pen or pencil and sheet of paper to jot down note on number system

Steps	Content	Teachers Activities	Learners Activities
1	Preparation	• The lecturer divides the students into two groups • Assigns group leaders to each group • States the rules guiding brainstorming teaching method such as no judgement, think freely, record each idea, and stay focus on the topic	Students move to the groups they are assigned to and jot down rules they are expected to follow
2	Introduction	The lecturer introduces the lesson by telling the students that they'll be brainstorming about number system	Students prepare for brainstorming about number system
3	State the computer number system	The lecturer gives the students 10 minutes to brainstorm on what computer number system does such as: computer number system translates letters or words into numbers as computers can understand only numbers.	The students engage in brainstorming on computer number system
4	Mention the three types of number system	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the three types of number system such as: binary, octane and hexa decimal number systems.	The students engage in brainstorming by exploring the three types of number system
5	State the characteristics of binary number system	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the characteristics of binary number system such as: uses two digits, 0 and 1, also called as base 2 number system and each position in a binary number represents a 0 power of the base (2).	The students engage in brainstorming by exploring the characteristics of binary number system

6	State the characteristics of octal number system	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the characteristics of octal number system such as: uses eight digits, 0,1,2,3,4,5,6,7, also called as base 8 number system and each position in an octal number represents a 0 power of the base (8).	The students engage in brainstorming by exploring the characteristics of octal number system
7	State the characteristics of hexadecimal number system	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the characteristics of hexadecimal number system such as: uses 10 digits and 6 letters, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F, also called as base 16 number system and each position in a hexadecimal number represents a 0 power of the base (16).	The students engage in brainstorming by exploring the characteristics of hexadecimal number system
8	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: computer number system translates letters or words into numbers	Students listen attentively, ask questions and take down notes
9	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. Explain computer number system 2. Mention the three types of number system 3. State the characteristics of binary number system 4. State the characteristics of octal number system 5. State the characteristics of hexadecimal number system	Students responds to the lecturers questions
10	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN FOUR

Name of Institutions: Kaduna State College of Education, Gidan Waya

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Logic Gates

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term logic gate
2. State the term truth table
3. Mention the type of gates

Previous knowledge: The students were taught number system

Instructional Technique: Brainstorming teaching method

Instructional Requirements: A pen or pencil and sheet of paper to jot down note on logic gate

Steps	Content	Teachers Activities	Learners Activities
1	Preparation	• The lecturer divides the students into two groups • Assigns group leaders to each group • States the rules guiding brainstorming teaching method such as no judgement, think freely, record each idea, and stay focus on the topic	Students move to the groups they are assigned to and jot down rules they are expected to follow
2	Introduction	The lecturer introduces the lesson by telling the students that they'll be brainstorming about the term logic gate	Students prepare for brainstorming about the term logic gate
3	State the term logic gate	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the term logic gate such as: it is an electronic circuit having one or more input but only one output.	The students engage in brainstorming by exploring the term logic gate
4	State the term truth table	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the term truth table such as: it shows each possible input combination to the circuit with the resultant output depending upon the combination of these input(s).	The students engage in brainstorming by exploring the term truth table
5	Mention the type of gates	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the type of	The students engage in brainstorming by exploring the type of

		gates such as: AND, OR, NOT, NAND, NOR etc	gates
6	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Logic gate is an electronic circuit with one or more input and only one output	Students listen attentively, ask questions and take down notes
7	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the term logic gate 2. State the term truth table 3. Mention the type of gates 4. Describe the type of gates	Students responds to the lecturers questions
8	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN FIVE

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Flip flops

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term flip flops
2. Mention the types of flip flops
3. Describe the types of flip flops
4. Mention the applications of flip-flops

Previous knowledge: The students were taught logic gate.

Instructional Technique: Brainstorming teaching method

Instructional Requirements: A pen or pencil and sheet of paper to jot down note on flip flops.

Steps	Content	Teachers Activities	Learners Activities
1	Preparation	• The lecturer divides the students into two groups • Assigns group leaders to each group • States the rules guiding brainstorming teaching method such as no judgement, think freely, record each idea, and stay focus on the topic	Students move to the groups they are assigned to and jot down rules they are expected to follow
2	Introduction	The lecturer introduces the lesson by telling the students that they'll be brainstorming about flip flops	Students prepare for brainstorming about flip flops
3	State the term flip flops	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the term flip flops such as: is an electronic circuit with two stable states that can be used to store binary data.	The students engage in brainstorming by exploring the term flip flops
4	Mention the types of flip	The lecturer gives the students 10 minutes to brainstorm and guide their activities by	The students engage in brainstorming by

	flops	giving them clue to understand the types of flip flops such as: SR, D, JK, and T flip flopss	exploring the types of flip flops
5	Describe the types of flip flops	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the types of flip flops such as: SR flip flops has two inputs, lebeled SET and RESET D flip flops has just one input in addition to the CLOCK input JK flip flops has two inputs lebeled J and K. T flip flops is similar to JK flip flops whose output alternates between HIGH and LOW with each clock pulse.	The students engage in brainstorming by exploring the types of flip flops
6	Mention the applications of flip-flops	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the applications of flip-flops such as: bounce elimination switch, data storage, data transfer, latch registers, counters, memory etc.	The students engage in brainstorming by exploring the applications of flip-flops
7	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Flip flops is a device that stores a single bit (binary digit) of data	Students listen attentively, ask questions and take down notes
8	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the term flip flops 2. Mention the types of flip flops 3. Describe the types of flip flops 4. Mention the applications of flip-flops	Students responds to the lecturers questions
9	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN SIX

Name of Institutions: Kaduna State College of Education, Gidan Waya

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Digital Counters

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Function of a digital counter
2. Mention the two common types of counter
3. Describe the types of counter
4. Mention the applications of digital counters

Previous knowledge: The students were taught flip flops

Instructional Technique: Brainstorming teaching method

Instructional Requirements: A pen or pencil and sheet of paper to jot down note on digital counters

Steps	Content	Teachers Activities	Learners Activities
1	Preparation	• The lecturer divides the students into two groups • Assigns group leaders to each group • States the rules guiding brainstorming teaching method such as no judgement, think freely, record each idea, and stay focus on the topic	Students move to the groups they are assigned to and jot down rules they are expected to follow
2	Introduction	The lecturer introduces the lesson by telling the students that they'll be brainstorming about digital counters.	Students prepare for brainstorming about digital counters
3	Function of a digital counter	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the function of a digital counter such as: digital counter is a device that generates binary numbers in	The students engage in brainstorming by exploring the function of a digital counter

		a specified count sequence.	
4	Mention the two common types of counter	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the two common types of counter that includes: decade and binary counters	The students engage in brainstorming by exploring the two common types of counter
5	Describe the types of counter	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the two common types of counter description such as: A decade counter counts a sequence of ten numbers, ranging from 0 to 9 and binary counter counts a sequence of binary numbers.	The students engage in brainstorming by exploring the two common types of counter description
6	Mention the applications of digital counters	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the applications of digital counters such as: digital clocks and in multiplexing	The students engage in brainstorming by exploring the applications of digital counters
7	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: digital counter generates binary numbers in a specified count sequence	Students listen attentively, ask questions and take down notes
8	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. Function of a digital counter 2. Mention the two common types of counter 3. Describe the types of counter 4. Mention the classification of digital counter based on operational characteristics 5. Mention the applications of digital counters	Students responds to the lecturers questions
9	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN SEVEN

Name of Institutions: Kaduna State College of Education, Gidan Waya

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Encoders and Decoders

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Mention the essential role of encoders and decoders in digital electronics
2. State the function of encoder
3. State the function of decoder
4. Mention the applications of decoder and encoder

Previous knowledge: The students were taught digital counters

Instructional Technique: Brainstorming teaching method

Instructional Requirements: A pen or pencil and sheet of paper to jot down note on encoders and decoders.

Steps	Content	Teachers Activities	Learners Activities
1	Preparation	• The lecturer divides the students into two groups • Assigns group leaders to each group • States the rules guiding brainstorming teaching method such as no judgement, think freely, record each idea, and stay focus on the topic	Students move to the groups they are assigned to and jot down rules they are expected to follow
2	Introduction	The lecturer introduces the lesson by telling the students that they'll be brainstorming about encoders and decoders	Students prepare for brainstorming about encoders and decoders
3	Mention the essential role of	The lecturer gives the students 10 minutes to brainstorm and guide their	The students engage in brainstorming by

	encoders and decoders in digital electronics	activities by giving them clue to understand the essential role of encoders and decoders in digital electronics such as: used to convert data from one form to another.	exploring the essential role of encoders and decoders in digital electronics
4	State the function of encoder	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the function of encoder such as: used to convert an analogue signal to a digital signal.	The students engage in brainstorming by exploring the function of encoder
5	State the function of decoder	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the function of decoder such as: used to convert digital signal to an analogue signal.	The students engage in brainstorming by exploring the function of decoder
6	Mention the applications of decoder and encoder	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the applications of decoder and encoder such as: i. Speed synchronization of multiple motors ii. War-field -flying robort iii. Robotic vehicle iv. Home automation system v. Automatic wireless health monitoring system vi. Secret code enabled secure communication	The students engage in brainstorming by exploring the applications of decoder and encoder
7	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Encoder is an electronic device used to convert analogue signal to digital signal.	Students listen attentively, ask questions and take down notes
8	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as:	Students responds to the lecturers questions

		1. Mention the essential role of encoders and decoders in digital electronics 2. State the function of encoder 3. State the function of decoder 4. Mention the applications of decoder and encoder	
9	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN EIGHT

Name of Institutions: Kaduna State College of Education, Gidan Waya

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Microprocessor

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the function of a microprocessor
2. Mention the three parts of a microprocessor
3. State the functions of the three parts of a microprocessor
4. Mention the features of a microprocessor

Previous knowledge: The students were taught encoders and decoders

Instructional Technique: Brainstorming teaching method

Instructional Requirements: A pen or pencil and sheet of paper to jot down note on microprocessor

Steps	Content	Teachers Activities	Learners Activities
1	Preparation	• The lecturer divides the students into two groups • Assigns group leaders to each group • States the rules guiding brainstorming teaching method such as no judgement, think freely, record each idea, and stay	Students move to the groups they are assigned to and jot down rules they are expected to follow

		focus on the topic	
4	Introduction	The lecturer introduces the lesson by telling the students that they'll be brainstorming about microprocessor	Students prepare for brainstorming about microprocessor
5	State the function of a microprocessor	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the function of a microprocessor such as: controlling unit of a micro-computer, fabricated on a small chip capable of performing ALU (Arithmetic Logical Unit) operations and communicating with the other devices connected to it.	The students engage in brainstorming by exploring the function of a microprocessor
6	Mention the three parts of a microprocessor	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the three parts of a microprocessor such as: i. Arithmetic Logical Unit ii. Register array and iii. Control unit.	The students engage in brainstorming by exploring the three parts of a microprocessor
7	State the functions of the three parts of a microprocessor	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the functions of the three parts of a microprocessor such as: i. ALU performs arithmetical and logical operations on the data received from the memory or an input device. i. Register array consists of registers identified by letters like B, C, D, E, H, L and accumulator. i. The control unit controls the flow of data and instructions within the computer.	The students engage in brainstorming by exploring the functions of the three parts of a microprocessor

8	Mention the features of a microprocessor	The lecturer gives the students 10 minutes to brainstorm and guide their activities by giving them clue to understand the features of a microprocessor such as: cost, size, power consumption, versatility and reliability.	The students engage in brainstorming by exploring the features of a microprocessor
9	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Microprocessor is a controlling unit of a micro-computer capable of performing ALU (Arithmetic Logical Unit) operations	Students listen attentively, ask questions and take down notes
10	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the function of a microprocessor 2. Mention the three parts of a microprocessor 3. State the functions of the three parts of a microprocessor 4. Mention the features of a microprocessor	Students responds to the lecturers questions
11	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

APPENDIX M

JUST-IN-TIME TEACHING TECHNIQUE LESSON PLANS

LESSON PLAN ONE

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Basic computer parts, types and other devices

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the function of a computer
2. Mention the three basic units of computer
3. State the function of computer input unit
4. State the function of Central Processing Unit (CPU)

5. State the function of computer output unit

Previous knowledge: The students are familiar with digital electronic devices such as a computer.

Instructional Technique: Just in Time Teaching Technique

Instructional Requirements: A laptop, internet connection and soft copy of note on Basic computer parts, types and other devices.

Steps	Content	Time	Teachers Activities	Learners Activities	Strategy
1	Warm up assignment	Pre class	The lecturer develops warmup exercises (pre class assignment) based on the objectives of the lesson		
		Pre class	The lecturer uploads the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram channel	The students receives warmup exercises (pre class assignment) from the lecturer, engage in reading or preparatory work and complete the warmup exercises (pre class assignment)	Opportunity to construct knowledge
		Pre class	The lecturer receives students' responses on the warmup assignment, review the pre class assignment and selects important points from students' responses on the pre class assignment	The students sends solutions of the warmup exercises (pre class assignment) online before 24hours from the time received	Feedback
2	Introduction	In class	The lecturer introduces the lesson by asking the students what they know about computer	Students responds to the lecturer's question on what they know	

				about computer	
3	State the function of a computer	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the function of a computer such as: computer is an electronic data processing device, which requires input raw data for processing and generates the output in desired form.	The students engage in the classroom interactive session with the lecturer on the function of a computer	Active learning
4	Mention the three basic units of computer	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the three basic units of computer such as: input, central processing and output units.	The students engage in the classroom interactive session with the lecturer on the three basic units of computer a section	Active learning
5	State the function of computer input unit	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the computer input unit such as: input unit contains devices with the help of which the data is entered into the computer.	The students engage in the classroom interactive session with the lecturer on the computer input unit	Active learning
6	State the function of Central Processing Unit (CPU)	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen	The students engage in the classroom interactive session with the	Active learning

			their understanding and clear their misunderstanding on the function of Central Processing Unit (CPU) such as: performs all types of data processing operations.	lecturer on the function of Central Processing Unit (CPU)	
7	State the function of computer output unit	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the function of computer output unit such as: notify the information displayed into a form which is understandable by the computer user.	The students engage in the classroom interactive session with the lecturer on the function of computer output unit	Active learning
8	Summary	In class	The lecturer summarizes the lesson by explaining the key points of the topic to the students such as: computer is an electronic device that processes raw data	Students listen attentively, ask questions and take down notes	
9	Evaluation	In class	The lecturer evaluates the lesson by asking the students questions such as: 1. State the function of a computer 2. Mention the three basic units of computer 3. State the function of computer input unit 4. State the function of Central Processing Unit (CPU) 5. State the function of computer output	Students responds to the lecturers questions	

			unit		
10	Conclusion	In class	The lecturer concludes the lesson by asking the students to access the next warmup exercises online 24 hours prior to the next class	Students listen attentively to the lecturer	

LESSON PLAN TWO

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Computer Aided Design

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term Computer Aided Design (CAD)
2. State the types of dimensional diagrams produced by CAD
3. Mention the uses of CAD
4. Mention the application of CAD

Previous knowledge: The students were exposed to the Basic computer parts, types and other devices

Instructional Technique: Just in Time Teaching Technique

Instructional Requirements: A laptop, internet connection and soft copy of note on Computer Aided Design

Steps	Content	Time	Teachers Activities	Learners Activities	Strategy
1	Warm up assignment	Pre class	The lecturer develops warmup exercises (pre class assignment) based on the objectives of the lesson		
		Pre class	The lecturer uploads the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram channel	The students receives warmup exercises (pre class assignment) from the lecturer, engage in reading or preparatory work and complete the warmup exercises (pre class assignment)	Opportunity to construct knowledge
		Pre class	The lecturer receives students' responses on the warmup assignment, review the pre class assignment and selects important points from students' responses on the pre class assignment	The students sends solutions of the warmup exercises (pre class assignment) online before 24hours from the time received	Feedback
2	Introduction	In	The lecturer introduces the	Students	

		class	lesson by asking the students what they know about Computer Aided Design (CAD)	responds to the lecturer's question on what they know about Computer Aided Design (CAD)	
3	State the term Computer Aided Design (CAD)	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the definition of the term Computer Aided Design (CAD) such as: CAD is the use of computers (or workstations) to aid in the creation, modification and analysis of a design.	The students engage in the classroom interactive session with the lecturer on the definition of the term Computer Aided Design (CAD)	Active learning
4	State the types of dimensional diagrams produced by CAD	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the types of dimensional diagrams produced by CAD such as: two and three dimensions.	The students engage in the classroom interactive session with the lecturer on the types of dimensional diagrams produced by CAD	Active learning
5	Mention the uses of CAD	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the uses of CAD such as: creation, modification and analysis of a design.	The students engage in the classroom interactive session with the lecturer on the uses of CAD	Active learning
6	Mention the application of CAD	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time	The students engage in the classroom interactive	Active learning

			response to strengthen their understanding and clear their misunderstanding on the application of CAD such as: architectural drawing, interior design and graphs.	session with the lecturer on the application of CAD	
7	Summary	In class	The lecturer summarizes the lesson by explaining the key points of the topic to the students such as: Computer Aided Design is the use of computer to aid in the creation of a design.	Students listen attentively, ask questions and take down notes	
8	Evaluation	In class	The lecturer evaluates the lesson by asking the students questions such as: 1. State the term Computer Aided Design (CAD) 2. State the types of dimensional diagrams produced by CAD 3. Mention the uses of CAD 4. Mention the application of CAD	Students responds to the lecturers questions	
9	Conclusion	In class	The lecturer concludes the lesson by asking the students to access the next warmup exercises online 24 hours prior to the next class	Students listen attentively to the lecturer	

LESSON PLAN THREE

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Number System

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Explain computer number system
2. Mention the three types of number system
3. State the characteristics of binary number system
4. State the characteristics of octal number system
5. State the characteristics of hexadecimal number system

Previous knowledge: The students have been exposed to Computer Aided Design.

Instructional Technique: Just in Time Teaching Technique

Instructional Requirements: A laptop, internet connection and soft copy of note on number system

Steps	**Content**	**Time**	**Teachers Activities**	**Learners Activities**	**Strategy**
1	Warm up assignment	Pre class	The lecturer develops warmup exercises (pre class assignment) based on the objectives of the lesson		
		Pre class	The lecturer uploads the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram channel	The students receives warmup exercises (pre class assignment) from the lecturer, engage in reading or preparatory work and complete the warmup exercises (pre class assignment)	Opportunity to construct knowledge
		Pre class	The lecturer receives students' responses on the warmup assignment, review the pre class assignment and selects important points from students' responses on the pre class assignment	The students sends solutions of the warmup exercises (pre class assignment) online before 24hours from	Feedback

				the time received	
2	Introduction	In class	The lecturer introduces the lesson by asking the students what they know about number system	Students responds to the lecturer's question on what they know about number system	
3	Explain computer number system	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on computer number system such as: computer number system translates letters or words into numbers as computers can understand only numbers	The students engage in the classroom interactive session with the lecturer on computer number system	Active learning
4	Mention the three types of number system	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the three types of number system such as: binary, octane and hexa decimal number systems.	The students engage in the classroom interactive session with the lecturer on the three types of number system	Active learning
5	State the characteristics of binary number system	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the characteristics of binary number system uses two	The students engage in the classroom interactive session with the lecturer on the characteristics of binary number	Active learning

			digits, 0 and 1, also called as base 2 number system and each position in a binary number represents a 0 power of the base (2).	system	
6	State the characteristics of octal number system	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the characteristics of octal number system uses eight digits, 0,1,2,3,4,5,6,7, also called as base 8 number system and each position in an octal number represents a 0 power of the base (8).	The students engage in the classroom interactive session with the lecturer on the characteristics of octal number system	Active learning
7	State the characteristics of hexadecimal number system	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the characteristics of hexadecimal number system uses 10 digits and 6 letters, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F, also called as base 16 number system and each position in a hexadecimal number represents a 0 power of the base (16).	The students engage in the classroom interactive session with the lecturer on the characteristics of hexadecimal number system	Active learning
8	Summary	In class	The lecturer summarizes the lesson by explaining the key points of the topic to the students such as: Computer number system translates letters or words into numbers	Students listen attentively, ask questions and take down notes	

9	Evaluation	In class	The lecturer evaluates the lesson by asking the students questions such as: 1. Explain computer number system 2. Mention the three types of number system 3. State the characteristics of binary number system 4. State the characteristics of octal number system 5. State the characteristics of hexadecimal number system	Students responds to the lecturers questions	
10	Conclusion	In class	The lecturer concludes the lesson by asking the students to access the next warmup exercises online 24 hours prior to the next class	Students listen attentively to the lecturer	

LESSON PLAN FOUR

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Logic Gates

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term logic gate
2. State the term truth table
3. Mention the type of gates

Previous knowledge: The students were taught number system

Instructional Technique: Just in Time Teaching Technique

Instructional Requirements: A laptop, internet connection and soft copy of note on logic gate

Steps	Content	Time	Teachers Activities	Learners Activities	Strategy
1	Warm up assignment	Pre class	The lecturer develops warmup exercises (pre class assignment) based on the objectives of the lesson		
		Pre class	The lecturer uploads the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram channel	The students receives warmup exercises (pre class assignment) from the lecturer, engage in reading or preparatory work and complete the warmup exercises (pre class assignment)	Opportunity to construct knowledge
		Pre class	The lecturer receives students' responses on the warmup assignment, review the pre class assignment and selects important points from	The students sends solutions of the warmup exercises (pre class assignment)	Feedback

			students' responses on the pre class assignment	online before 24hours from the time received	
2	Introduction	In class	The lecturer introduces the lesson by asking the students what they know about the term logic gate	Students responds to the lecturer's question on what they know about the term logic gate	Active learning
3	State the term logic gate	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the term logic gate it is an electronic circuit having one or more input but only one output.	The students engage in the classroom interactive session with the lecturer on the term logic gate	Active learning
4	State the term truth table	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the term truth table it shows each possible input combination to the circuit with the resultant output depending upon the combination of these input(s).	The students engage in the classroom interactive session with the lecturer on the term truth table	Active learning
5	Mention the type of gates	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their	The students engage in the classroom interactive session with the lecturer on the type of gates	Active learning

			misunderstanding on the type of gates such as: AND, OR, NOT, NAND, NOR		
6	Summary	In class	The lecturer summarizes the lesson by explaining the key points of the topic to the students such as: Logic gate is an electronic circuit with one or more input and only one output	Students listen attentively, ask questions and take down notes	
7	Evaluation	In class	The lecturer evaluates the lesson by asking the students questions such as: 1. State the term logic gate 2. State the term truth table 3. Mention the type of gates 4. Describe the type of gates	Students responds to the lecturers questions	
8	Conclusion	In class	The lecturer concludes the lesson by asking the students to access the next warmup exercises online 24 hours prior to the next class	Students listen attentively to the lecturer	

LESSON PLAN FIVE

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Flip flops

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term flip flops
2. Mention the types of flip flops
3. Describe the types of flip flops
4. Mention the applications of flip-flops

Previous knowledge: The students were taught logic gate.

Instructional Technique: Just in Time Teaching Technique

Instructional Requirements: A laptop, internet connection and soft copy of note on flip flops

Steps	Content	Time	Teachers Activities	Learners Activities	Strategy
1	Warm up assignment	Pre class	The lecturer develops warmup exercises (pre class assignment) based on the objectives of the lesson		
		Pre class	The lecturer uploads the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram channel	The students receives warmup exercises (pre class assignment) from the lecturer, engage in reading or preparatory work and complete the warmup exercises (pre class assignment)	Opportunity to construct knowledge

		Pre class	The lecturer receives students' responses on the warmup assignment, review the pre class assignment and selects important points from students' responses on the pre class assignment	The students sends solutions of the warmup exercises (pre class assignment) online before 24hours from the time received	Feedback
2	Introduction	In class	The lecturer introduces the lesson by asking the students what they know about flip flops	Students responds to the lecturer's question on what they know about flip flops	
3	State the term flip flops	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the term flip flops is an electronic circuit with two stable states that can be used to store binary data.	The students engage in the classroom interactive session with the lecturer on the term flip flops	Active learning
4	Mention the types of flip flops	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the types of flip flops such as: SR, D, JK, and T flip flopss.	The students engage in the classroom interactive session with the lecturer on the types of flip flops	Active learning
5	Describe the types of flip flops	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and	The students engage in the classroom interactive session with the lecturer on the	Active learning

			clear their misunderstanding on the types of flip flops such as: SR flip flops has two inputs, lebeled SET and RESET D flip flops has just one input in addition to the CLOCK input JK flip flops has two inputs lebeled J and K. T flip flops is similar to JK flip flops whose output alternates between HIGH and LOW with each clock pulse	types of flip flops	
6	Mention the applications of flip-flops	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the applications of flip-flops such as: bounce elimination switch, data storage, data transfer, latch registers, counters, memory etc.	The students engage in the classroom interactive session with the lecturer on the applications of flip-flops	Active learning
7	Summary	In class	The lecturer summarizes the lesson by explaining the key points of the topic to the students such as: Flip flops is a device that stores a single bit (binary digit) of data	Students listen attentively, ask questions and take down notes	
8	Evaluation	In class	The lecturer evaluates the lesson by asking the students questions such as:	Students responds to the lecturers questions	

			1. State the term flip flops 2. Mention the types of flip flops 3. Describe the types of flip flops 4. Mention the applications of flip-flops		
9	Conclusion	In class	The lecturer concludes the lesson by asking the students to access the next warmup exercises online 24 hours prior to the next class	Students listen attentively to the lecturer	

LESSON PLAN SIX

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Digital Counters

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Function of a digital counter
2. Mention the two common types of counter
3. Describe the types of counter
4. Mention the applications of digital counters

Previous knowledge: The students were taught flip flops

Instructional Technique: Just in Time Teaching Technique

Instructional Requirements: A laptop, internet connection and soft copy of note on digital counters

Steps	Content	Time	Teachers Activities	Learners Activities	Strategy
1	Warm up assignment	Pre class	The lecturer develops warmup exercises (pre class assignment) based on the objectives of the lesson		
		Pre class	The lecturer uploads the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram	The students receives warmup exercises (pre class assignment)	Opportunity to construct knowledge

			channel	from the lecturer, engage in reading or preparatory work and complete the warmup exercises (pre class assignment)	
		Pre class	The lecturer receives students' responses on the warmup assignment, review the pre class assignment and selects important points from students' responses on the pre class assignment	The students sends solutions of the warmup exercises (pre class assignment) online before 24hours from the time received	Feedback
2	Introduction	In class	The lecturer introduces the lesson by asking the students what they know about digital counters	Students responds to the lecturer's question on what they know about digital counters	
3	Function of a digital counter	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the function of a digital counter such as: digital counter is a device that generates binary numbers in a specified count sequence.	The students engage in the classroom interactive session with the lecturer on the function of a digital counter	Active learning
4	Mention the two common types of counter	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and	The students engage in the classroom interactive session with the lecturer on the	Active learning

			clear their misunderstanding on the two common types of counter that includes: decade and binary counters	two common types of counter	
5	Describe the types of counter	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the two common types of counter description such as: A decade counter counts a sequence of ten numbers, ranging from 0 to 9 and binary counter counts a sequence of binary numbers.	The students engage in the classroom interactive session with the lecturer on the two common types of counter description	Active learning
6	Mention the applications of digital counters	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the applications of digital counters such as: digital clocks and in multiplexing	The students engage in the classroom interactive session with the lecturer on the applications of digital counters	Active learning
7	Summary	In class	The lecturer summarizes the lesson by explaining the key points of the topic to the students such as: Digital counter generates binary numbers in a specified count sequence	Students listen attentively, ask questions and take down notes	
8	Evaluation	In class	The lecturer evaluates the lesson by asking the students questions such as: 1. Function of a digital counter 2. Mention the two	Students responds to the lecturers questions	

			common types of counter 3. Describe the types of counter 4. Mention the classification of digital counter based on operational characteristics 5. Mention the applications of digital counters		
9	Conclusion	In class	The lecturer concludes the lesson by asking the students to access the next warmup exercises online 24 hours prior to the next class	Students listen attentively to the lecturer	

LESSON PLAN SEVEN

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Encoders and Decoders

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Mention the essential role of encoders and decoders in digital electronics
2. State the function of encoder
3. State the function of decoder
4. Mention the applications of decoder and encoder

Previous knowledge: The students were taught digital counters

Instructional Technique: Just in Time Teaching Technique

Instructional Requirements: A laptop, internet connection and soft copy of note on encoders and decoders.

Steps	Content	Time	Teachers Activities	Learners Activities	Strategy
1	Warm up	Pre	The lecturer develops		

	assignment	class	warmup exercises (pre class assignment) based on the objectives of the lesson		
		Pre class	The lecturer uploads the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram channel	The students receives warmup exercises (pre class assignment) from the lecturer, engage in reading or preparatory work and complete the warmup exercises (pre class assignment)	Opportunity to construct knowledge
		Pre class	The lecturer receives students' responses on the warmup assignment, review the pre class assignment and selects important points from students' responses on the pre class assignment	The students sends solutions of the warmup exercises (pre class assignment) online before 24hours from the time received	Feedback
2	Introduction	In class	The lecturer introduces the lesson by asking the students what they know about encoders and decoders	Students responds to the lecturer's question on what they know about encoders and decoders	
3	Mention the essential role of encoders and decoders in digital electronics	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the essential role of encoders and decoders in digital electronics such as: used	The students engage in the classroom interactive session with the lecturer on the essential role of encoders and decoders in digital electronics	Active learning

			to convert data from one form to another.		
4	State the function of encoder	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the function of encoder such as: used to convert an analogue signal to a digital signal.	The students engage in the classroom interactive session with the lecturer on the function of encoder	Active learning
5	State the function of decoder	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the function of decoder such as: used to convert digital signal to an analogue signal.	The students engage in the classroom interactive session with the lecturer on the function of decoder	Active learning
6	Mention the applications of decoder and encoder	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the applications of decoder and encoder such as: 1. Speed synchronization of multiple motors 2. War-field -flying robort 3. Robotic vehicle 4. Home automation	The students engage in the classroom interactive session with the lecturer on the applications of decoder and encoder	Active learning

			system 5. Automatic wireless health monitoring system 6. Secret code enabled secure communication		
7	Summary	In class	The lecturer summarizes the lesson by explaining the key points of the topic to the students such as: Encoder is an electronic device used to convert analogue signal to digital signal	Students listen attentively, ask questions and take down notes	
8	Evaluation	In class	The lecturer evaluates the lesson by asking the students questions such as: 1. Mention the essential role of encoders and decoders in digital electronics 2. State the function of encoder 3. State the function of decoder 4. Mention the applications of decoder and encoder	Students responds to the lecturers questions	
9	Conclusion	In class	The lecturer concludes the lesson by asking the students to access the next warmup exercises online 24 hours prior to the next class	Students listen attentively to the lecturer	

LESSON PLAN EIGHT

Name of Institutions: Federal College of Education, Bichi and Federal College of Education (Technical), Gusau

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Microprocessor

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the function of a microprocessor
2. Mention the three parts of a microprocessor
3. State the functions of the three parts of a microprocessor
4. Mention the features of a microprocessor

Previous knowledge: The students were taught encoders and decoders

Instructional Technique: Just in Time Teaching Technique

Instructional Requirements: A laptop, internet connection and soft copy of note on microprocessor

Steps	Content	Time	Teachers Activities	Learners Activities	Strategy
1	Warm up assignment	Pre class	The lecturer develops warmup exercises (pre class assignment) based on the objectives of the lesson		
2		Pre class	The lecturer uploads the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram channel	The students receives warmup exercises (pre class assignment) from the lecturer, engage in reading or preparatory work and complete the warmup exercises (pre class assignment)	Opportunity to construct knowledge
3		Pre class	The lecturer receives students' responses on the warmup assignment, review the pre class assignment and selects important points from students' responses on the pre class assignment	The students sends solutions of the warmup exercises (pre class assignment) online before 24hours from the time received	Feedback
4	Introduction	In class	The lecturer introduces the lesson by asking the students what they know about microprocessor	Students responds to the lecturer's question on what they know about microprocessor	
5	State the function of a microprocessor	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on	The students engage in the classroom interactive session with the lecturer on the function of a microprocessor	Active learning

			the function of a microprocessor such as: controlling unit of a micro-computer, fabricated on a small chip capable of performing ALU (Arithmetic Logical Unit) operations and communicating with the other devices connected to it.		
6	Mention the three parts of a microprocessor	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the three parts of a microprocessor such as: 1. Arithmetic 2. Logical Unit 3. Register array and 4. Control unit.	The students engage in the classroom interactive session with the lecturer on the three parts of a microprocessor	Active learning
7	State the functions of the three parts of a microprocessor	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the functions of the three parts of a microprocessor such as: ALU performs arithmetical and logical operations on	The students engage in the classroom interactive session with the lecturer on the functions of the three parts of a microprocessor	Active learning

			the data received from the memory or an input device. Register array consists of registers identified by letters like B, C, D, E, H, L and accumulator. The control unit controls the flow of data and instructions within the computer.		
8	Mention the features of a microprocessor	In class	The lecturer initiates a classroom interactive session by giving the students just-in-time response to strengthen their understanding and clear their misunderstanding on the features of a microprocessor such as: cost, size, power consumption, versatility and reliability.	The students engage in the classroom interactive session with the lecturer on the features of a microprocessor	Active learning
9	Summary	In class	The lecturer summarizes the lesson by explaining the key points of the topic to the students such as: Microprocessor is a controlling unit of a micro-computer capable of performing ALU (Arithmetic Logical Unit) operations	Students listen attentively, ask questions and take down notes	

10	Evaluation	In class	The lecturer evaluates the lesson by asking the students questions such as: 1. State the function of a microprocessor 2. Mention the three parts of a microprocessor 3. State the functions of the three parts of a microprocessor 4. Mention the features of a microprocessor	Students responds to the lecturers questions	
11	Conclusion	In class	The lecturer concludes the lesson by asking the students to access the next warmup exercises online 24 hours prior to the next class	Students listen attentively to the lecturer	

APPENDIX N

DEMONSTRATION TEACHING METHOD LESSON PLANS

LESSON PLAN ONE

Name of Institutions: Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Basic computer parts, types and other devices

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the function of a computer

2. Mention the three basic units of computer
3. State the function of computer input unit
4. State the function of Central Processing Unit (CPU)
5. State the function of computer output unit

Previous knowledge: The students are familiar with digital electronic device.

Instructional Technique: Demonstration teaching method

Instructional Requirements: A hard copy note and cardboard paper showing diagrams on Basic computer parts, types and other devices.

Steps	Content	Teachers Activities	Learners Activities
1	Introduction	The lecturer introduces the lesson by asking the students what they know about computer	The students respond to the lecturer on what they know about computer
2	State the function of a computer	The lecturer demonstrate to the students the function of a computer	The students listens and watches the lecturer, and also jot down note on the function of a computer
3	Mention the three basic units of computer	The lecturer demonstrate to the students the three basic units of computer	The students listen and watch the lecturer, and also jot down note on the three basic units of computer
4	State the function of computer input unit	The lecturer demonstrate to the students the computer input unit	The students listen and watch the lecturer, and also jot down note on the computer input unit
5	State the function of Central Processing Unit (CPU)	The lecturer demonstrate to the students the function of Central Processing Unit (CPU)	The students listen and watch the lecturer, and also jot down note on the function of Central Processing Unit (CPU)
6	State the function of computer output	The lecturer demonstrate to the students the function of computer output unit	The students listen and watch the lecturer, and also jot down note on the function of

	unit		computer output unit
7	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: computer is an electronic device that processes raw data	Students listen attentively, ask questions and take down notes
8	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the function of a computer 2. Mention the three basic units of computer 3. State the function of computer input unit 4. State the function of Central Processing Unit (CPU) 5. State the function of computer output unit	Students responds to the lecturers questions
9	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN TWO

Name of Institutions: Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Computer Aided Design

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term Computer Aided Design (CAD)
2. State the types of dimensional diagrams produced by CAD
3. Mention the uses of CAD
4. Mention the application of CAD

Previous knowledge: The students were exposed to the Basic computer parts, types and other devices

Instructional Technique: Demonstration teaching method

Instructional Requirements: A hard copy note and cardboard paper showing diagrams on Computer Aided Design

Steps	Content	Teachers Activities	Learners Activities
1	Introduction	The lecturer introduces the lesson by asking the students what they know about Computer Aided Design (CAD)	The students respond to the lecturer on what they know about Computer Aided Design (CAD)
2	State the term Computer Aided Design (CAD)	The lecturer demonstrate to the students the definition of the term Computer Aided Design (CAD)	The students listen and watch the lecturer, and also jot down note on the definition of the term Computer Aided Design (CAD)
3	State the types of dimensional diagrams produced by CAD	The lecturer demonstrate to the students the types of dimensional diagrams produced by CAD	The students listen and watch the lecturer, and also jot down note on the types of dimensional diagrams produced by CAD
4	Mention the uses of CAD	The lecturer demonstrate to the students the uses of CAD	The students listen and watch the lecturer, and also jot down note on the uses of CAD
5	Mention the application of CAD	The lecturer demonstrate to the students the application of CAD	The students listen and watch the lecturer, and also jot down note on the application of CAD
6	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board	Students listen attentively, ask questions and take down notes

		such as: Computer Aided Design is the use of computer to aid in the creation of a design.	
7	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the term Computer Aided Design (CAD) 2. State the types of dimensional diagrams produced by CAD 3. Mention the uses of CAD 4. Mention the application of CAD	Students responds to the lecturers questions
8	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN THREE

Name of Institutions: Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Number System

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Explain computer number system
2. Mention the three types of number system
3. State the characteristics of binary number system
4. State the characteristics of octal number system
5. State the characteristics of hexadecimal number system

Previous knowledge: The students have been exposed to Computer Aided Design.

Instructional Technique: Demonstration teaching method

Instructional Requirements: A hard copy note and cardboard paper showing diagrams on number system

Steps	Content	Teachers Activities	Learners Activities
1	Introduction	The lecturer introduces the lesson by asking the students what they know about number system	The students respond to the lecturer on what they know about number system
2	Explain computer number system	The lecturer gives the students 15 minutes to brainstorm on computer number system	The students engages in brainstorming on computer number system
3	Mention the three types of number system	The lecturer demonstrate to the students the three types of number system	The students listen and watch the lecturer, and also jot down note on the three types of number system
4	State the characteristics of binary number system	The lecturer demonstrate to the students the characteristics of binary number system	The students listen and watch the lecturer, and also jot down note on the characteristics of binary number system
5	State the characteristics of octal number system	The lecturer demonstrate to the students the characteristics of octal number system	The students listen and watch the lecturer, and also jot down note on the characteristics of octal number system
6	State the	The lecturer demonstrate to	The students listen and

	characteristics of hexadecimal number system	the students the characteristics of hexadecimal number system	watch the lecturer, and also jot down note on the characteristics of hexadecimal number system
7	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Computer number system translates letters or words into numbers	Students listen attentively, ask questions and take down notes
8	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. Explain computer number system 2. Mention the three types of number system 3. State the characteristics of binary number system 4. State the characteristics of octal number system 5. State the characteristics of hexadecimal number system	Students responds to the lecturers questions
9	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN FOUR

Name of Institutions: Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Logic Gates

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term logic gate
2. State the term truth table
3. Mention the type of gates

Previous knowledge: The students were taught number system

Instructional Technique: Demonstration teaching method

Instructional Requirements: A hard copy note and cardboard paper showing diagrams on logic gate

Steps	Content	Teachers Activities	Learners Activities
1	Introduction	The lecturer introduces the lesson by asking the students what they know about the term logic gate	The students respond to the lecturer on what they know about the term logic gate
2	State the term logic gate	The lecturer demonstrates to the students the term logic gate	The students listen and watch the lecturer, and also jot down note on the term logic gate
3	State the term truth table	The lecturer demonstrates to the students the term truth table	The students listen and watch the lecturer, and also jot down note on the term truth table
4	Mention the type of gates	The lecturer demonstrate to the students the type of gates	The students listen and watch the lecturer, and also jot down note on the type of gates
5	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Logic gate is an electronic circuit with one or more input and only one output	Students listen attentively, ask questions and take down notes

6	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the term logic gate 2. State the term truth table 3. Mention the type of gates 4. Describe the type of gates	Students responds to the lecturers questions
7	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN FIVE

Name of Institutions: Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Flip flops

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the term flip flops
2. Mention the types of flip flops
3. Describe the types of flip flops
4. Mention the applications of flip-flops

Previous knowledge: The students were taught logic gate.

Instructional Technique: Demonstration teaching method

Instructional Requirements: A hard copy note and cardboard paper showing diagrams on flip flops.

Steps	Content	Teachers Activities	Learners Activities
1	Introduction	The lecturer introduces the lesson by asking the students what they know about flip flops	The students respond to the lecturer on what they know about flip flops
2	State the term flip flops	The lecturer demonstrates to the students the term flip flops	The students listen and watch the lecturer, and also jot down note on the term flip flops
3	Mention the types of flip flops	The lecturer demonstrates to the students the types of flip flops	The students listen and watch the lecturer, and also jot down note on the types of flip flops

4	Describe the types of flip flops	The lecturer demonstrate to the students the types of flip flops	The students listen and watch the lecturer, and also jot down note on the types of flip flops
5	Mention the applications of flip-flops	The lecturer demonstrate to the students the applications of flip-flops	The students listen and watch the lecturer, and also jot down note on the applications of flip-flops
6	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Flip flops is a device that stores a single bit (binary digit) of data	Students listen attentively, ask questions and take down notes
7	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the term flip flops 2. Mention the types of flip flops 3. Describe the types of flip flops 4. Mention the applications of flip-flops	Students responds to the lecturers questions
8	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN SIX

Name of Institutions: Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Digital Counters

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Function of a digital counter
2. Mention the two common types of counter
3. Describe the types of counter
4. Mention the applications of digital counters

Previous knowledge: The students were taught flip flops

Instructional Technique: Demonstration teaching method

Instructional Requirements: A hard copy note and cardboard paper showing diagrams on digital counters

Steps	Content	Teachers Activities	Learners Activities	Strategy
1	Introduction	The lecturer introduces the lesson by asking the students what they know about digital counters	The students respond to the lecturer on what they know about digital counters	
2	Function of a digital counter	The lecturer demonstrate to the students the function of a digital counter	The students listen and watch the lecturer, and also jot down note on the function of a digital counter	Active learning

3	Mention the two common types of counter	The lecturer demonstrate to the students the two common types of counter	The students listen and watch the lecturer, and also jot down note on the two common types of counter	Active learning
4	Describe the types of counter	The lecturer demonstrates to the students the two common types of counter description	The students listen and watch the lecturer, and also jot down note on the two common types of counter description	Active learning
5	Mention the applications of digital counters	The lecturer demonstrates to the students the applications of digital counters	The students listen and watch the lecturer, and also jot down note on the applications of digital counters	Active learning
6	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Digital counter generates binary numbers in a specified count sequence	Students listen attentively, ask questions and take down notes	
7	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. Function of a digital counter 2. Mention the two common types of counter 3. Describe the types of counter 4. Mention the classification of digital counter based on operational characteristics 5. Mention the applications of digital counters	Students responds to the lecturers questions	
8	Conclusion	The lecturer concludes the lesson by asking the students to copy note on	Students copy note on the white board	

		the white board		

LESSON PLAN SEVEN

Name of Institutions: Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Encoders and Decoders

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. Mention the essential role of encoders and decoders in digital electronics
2. State the function of encoder
3. State the function of decoder
4. Mention the applications of decoder and encoder

Previous knowledge: The students were taught digital counters

Instructional Technique: Demonstration teaching method

Instructional Requirements: A hard copy note and cardboard paper showing diagrams on encoders and decoders.

Steps	Content	Teachers Activities	Learners Activities
1	Introduction	The lecturer introduces the lesson by asking the students what they know about encoders and decoders	The students respond to the lecturer on what they know about encoders and decoders
2	Mention the essential role of encoders and	The lecturer demonstrates to the students the essential role of encoders and decoders in	The students listen and watch the lecturer, and also jot down note on the

	decoders in digital electronics	digital electronics	essential role of encoders and decoders in digital electronics
3	State the function of encoder	The lecturer demonstrate to the students the function of encoder	The students listen and watch the lecturer, and also jot down note on the function of encoder
4	State the function of decoder	The lecturer demonstrates to the students the function of decoder	The students listen and watch the lecturer, and also jot down note on the function of decoder
5	Mention the applications of decoder and encoder	The lecturer demonstrate to the students the applications of decoder and encoder	The students listen and watch the lecturer, and also jot down note on the applications of decoder and encoder
6	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Encoder is an electronic device used to convert analogue signal to digital signal.	Students listen attentively, ask questions and take down notes
7	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. Mention the essential role of encoders and decoders in digital electronics 2. State the function of encoder 3. State the function of decoder 4. Mention the applications of decoder and encoder	Students responds to the lecturers questions
8	Conclusion	The lecturer concludes the lesson by asking the students to copy note on the white board	Students copy note on the white board

LESSON PLAN EIGHT

Name of Institutions: Isah Kaita College of Education, Katsina and Shehu Shagari College of Education, Sokoto

Course Title: Digital Electronic

Credit Unit: 2

Level: NCE III

Topic: Microprocessor

Duration: 120 Minutes

Learning objectives: By the end of the lesson, the students should be able to:

1. State the function of a microprocessor
2. Mention the three parts of a microprocessor
3. State the functions of the three parts of a microprocessor
4. Mention the features of a microprocessor

Previous knowledge: The students were taught encoders and decoders

Instructional Technique: Demonstration teaching method

Instructional Requirements: A hard copy note and cardboard paper showing diagrams on microprocessor

Steps	Content	Teachers Activities	Learners Activities
1	Introduction	The lecturer introduces the lesson by asking the students	The students respond to the lecturer on what they know

		what they know about microprocessor	about microprocessor
2	State the function of a microprocessor	The lecturer demonstrate to the students the function of a microprocessor	The students listen and watch the lecturer, and also jot down note on the function of a microprocessor
3	Mention the three parts of a microprocessor	The lecturer demonstrate to the students the three parts of a microprocessor	The students listen and watch the lecturer, and also jot down note on the three parts of a microprocessor
4	State the functions of the three parts of a microprocessor	The lecturer demonstrate to the students the functions of the three parts of a microprocessor	The students listen and watch the lecturer, and also jot down note on the functions of the three parts of a microprocessor
5	Mention the features of a microprocessor	The lecturer demonstrate to the students the features of a microprocessor	The students listen and watch the lecturer, and also jot down note on the features of a microprocessor
6	Summary	The lecturer summarizes the lesson by choosing and writing students' best ideas on the board such as: Microprocessor is a controlling unit of a micro-computer capable of performing ALU (Arithmetic Logical Unit) operations	Students listen attentively, ask questions and take down notes
7	Evaluation	The lecturer evaluates the lesson by asking the students questions and getting feedback such as: 1. State the function of a microprocessor 2. Mention the three parts of a microprocessor 3. State the functions of the three parts of a microprocessor 4. Mention the features of a microprocessor	Students responds to the lecturers questions
8	Conclusion	The lecturer concludes the lesson by asking the students to	Students copy note on the white board

		copy note on the white board	

APPENDIX O

LETTER OF REQUEST FOR EXPERT VALIDATION OF RESEARCH INSTRUMENT

Department of Industrial and
Technology Education,
Federal university of technology,
Minna.
P.M.B. 65 Minna.
10th September, 2020.

Dear Sir,

REQUEST FOR VALIDATION OF INSTRUMENT

I am postgraduate student of the above mentioned department and institution. I am carrying out research on "**Effect of Brainstorming, JiTT and demonstration teaching methods on Students' Learning Outcome in Digital Electronics in Colleges of Education in North-West, Nigeria"**. You are kindly requested to ascertain the suitability of the questions, their appropriateness, the scope, the content area, the language clarity and it relevance for the target population. You are also requested to examine the lesson plans to ensure that the instrument measures the stated objectives in the teaching plan. Your criticism, suggestion and correction would highly be appreciated towards the success of this research.

Thank you.

Yours faithfully,

,

SAIDU, Hadiza Arah.

MTECH/SSTE/2018/8745

APPENDIX P

VALIDATION CERTIFICATE

This is to certify that, the research instruments titled: Digital Electronic Cognitive Achievement and Retention Test, Keys to Digital Electronic Cognitive Achievement and Retention Test, Rating Scale for Digital Electronic Skill performance Test, Digital Electronic Interest Inventory and two sets of lesson plans were validated by:

Name: Dr Ousdum A Samuel

Institution: FUT Minna

Department: ITE

Signature & Date: 5/12/2021

Name: Maxwell E. Nduafemhe, PhD

Institution: National Examinations Council (NECO)

Department: Research and Evaluation Division, Psychometrics Department

Signature & Date: 08022021

Name: Dr. Hassan Yunusa Jamilu

Institution: Bayero University Kano

Department: Science Ed Technology Education

Signature & Date:

APPENDIX Q

BRIEFING TEMPLATE FOR THE USE OF BRAINSTORMING TEACHING METHOD

Introduction

Brainstorming is a tool that uses a relaxed, informal atmosphere combined with lateral thinking to solve problems. This activity will teach students to brainstorm effectively. It can be carried out in a one-period session. No materials are required apart from a pen or pencil and sheets of paper.

Guidelines for Successful Brainstorming teaching method

- All ideas are accepted and written down.
- Unusual, even seemingly irrelevant ideas are welcome
- You may use other students' idea and expand on it
- Criticism is banned at this stage

Roles of the Lecturer in Brainstorming teaching method

- Elicit different ways from students to generate new ideas
- Tell the students that they are going to try an activity called brainstorming to generate ideas.
- divide the class into two groups
- Assign one student in each group to be a leader. Give the group leaders the following tips:
- Give students ten minutes to do the brainstorming activity
- Get feedback from students about the brainstorming.
- Ask which group produced more ideas and which group enjoyed the activity more
- Write these rules of successful brainstorming on the board
- When they finish, groups choose their three best ideas and write them up on the board.

Roles of the Students in Brainstorming teaching method

- Students brainstorm other topics
- Students guess which group was brainstorming the right way
- Generate as many ideas as possible

Group leaders:

- Read out their slips of paper

- Encourage other students to contribute ideas
- If a student states an idea which seems useless, tell the student “That’s no good” or “Bad idea”, then move on to another student
- Ask one student in the group to write down all ideas
- Praise students’ contributions and don’t criticize any of the ideas
- Make sure all ideas are accepted and written down

APPENDIX R

BRIEFING TEMPLATE FOR THE USE OF JUST-IN TIME TEACHING TECHNIQUE

Introduction

Just-in-Time Teaching (JiTT) is a teaching and learning strategy designed to promote the use of class time for more active learning. The goal of JITT approach is to help the whole spectrum of students to advance in learning through engagement in scholastic activities. Students prepare for class by reading from the textbook or using other resources posted to

the web and by completing assignments (called WarmUps and Puzzles) online. These assignments often have complex answers; students' work outside class serves as preparation for more complete work in class. The students' answers are delivered to the instructor a few hours before class starts, allowing the instructor to adapt the lesson as needed. Importantly, JiTT allows the instructor to create an interactive classroom environment that emphasizes active learning and cooperative problem solving.

Guidelines for Using Just-in Time Teaching Technique

- Instruction should be based on website techniques
- Pre class assignment should be sent to the students prio to classroom discussion and received within 24 hours
- Content of pre class assignment must be in line with the topic to be discuss in the classroom
- Both lecturer and students should be engaged in classroom discussion
- Classroom discussion must be based on the questions contained in the pre class assignment

Roles of the Lecturer in Just-in Time Teaching Technique

- Develop warmup exercises (pre class assignment)
- Upload the warmup exercises (pre class assignment) online to students' e-mail, WhatsApp or Telegram channel
- Receive students' responses on the warmup assignment
- Review the pre class assignment
- Select important points from students' responses on the pre class assignment

- Use the important points from students' responses on the pre class assignment to lead class discussion
- Evaluate students' responses made during classroom discussion
- Adjust next warmup exercises (pre class assignment) to best meet students' needs in light of the progress made during class

Roles of the Learners in Just-in Time Teaching Technique

- Receive warmup exercises (pre class assignment) from the lecturer
- Engage in reading or preparatory work
- Complete the warmup exercises (pre class assignment)
- Send solutions to the warmup exercises (pre class assignment) online through o students' e-mail, WhatsApp or Telegram channel before 24hours from the time received
- Engage in discussion on the material with the lecturer and with other students

APPENDIX S

KUDER-RICHASON 20 TEST RESULT FOR DIGITAL ELECTRONIC COGNITIVE ACHIEVEMENT AND RETENTION TEST

Case Processing Summary

		N	%
Cases	Valid	15	100.0
	Excluded[a]	0	.0
	Total	15	100.0

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

Reliability Statistics

Kuder-Richardson 20	N of Items
.783	60

APPENDIX T

KENDALL'S COEFFICIENT OF CONCORDANCE TEST RESULT FOR DIGITAL ELECTRONIC SKILL PERFORMANCE TEST

Correlations

	Assessor 1	Assessor 2

Kendall's tau_b	Assessor 1	Correlation Coefficient	1.000	.810**
		Sig. (2-tailed)	.	.006
		N	15	15
	Assessor 2	Correlation Coefficient	.810**	1.000
		Sig. (2-tailed)	.006	.
		N	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX U

CRONBACH'S ALPHA CORRELATION TEST RESULT FOR DIGITAL ELECTRONICS INTEREST INVENTORY

Case Processing Summary

		N	%
Cases	Valid	15	100.0
	Excluded[a]	0	.0
	Total	15	100.0

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

Reliability Statistics

Cronbach's Alpha	N of Items
.831	30

APPENDIX V

ITEM ANALYSIS RESULT FOR DIGITAL ELECTRONICS COGNITIVE ACHIEVEMENT AND RETENTION TEST

Item No.	No. Students who Answered Correctly	*Item Difficulty Index	Upper Group that Passed the Item U_p	Lower Group that Passed the Item L_p	$U_p - L_p$	Discrimination Index	Remark
1.	10	0.67	7	3	4	0.57	Item is good
2.	12	0.80	8	4	4	0.57	Item is good
3.	11	0.73	7	4	3	0.43	Item is good
4.	9	0.60	6	3	3	0.43	Item is good
5.	10	0.67	6	4	2	0.29	Item is good
6.	9	0.45	7	2	5	0.71	Item is good
7.	2	0.13	0	2	-2	-0.29	Rejected
8.	8	0.53	8	5	3	0.43	Item is good
9.	2	0.13	0	2	-2	-0.29	Rejected
10.	8	0.53	6	2	4	0.57	Item is good
11.	8	0.53	5	3	2	0.29	Item is good
12.	11	0.73	7	4	3	0.43	Item is good
13.	10	0.67	7	3	4	0.57	Item is good
14.	9	0.60	6	3	3	0.43	Item is good
15.	2	0.13	0	2	-2	-0.29	Rejected
16.	2	0.13	0	2	-2	-0.29	Rejected
17.	10	0.67	6	4	2	0.29	Item is good
18.	7	0.47	5	2	3	0.43	Item is good
19.	7	0.47	5	3	2	0.29	Item is good
20.	9	0.60	6	3	3	0.43	Item is good
21.	10	0.67	7	3	4	0.57	Item is good
32.	12	0.80	8	4	4	0.57	Item is good
23.	11	0.73	7	4	3	0.43	Item is good
24.	9	0.60	6	3	3	0.43	Item is good
25.	10	0.67	6	4	2	0.29	Item is good
26.	9	0.45	7	2	5	0.71	Item is good
27.	2	0.13	0	2	-2	-0.29	Rejected
28.	8	0.53	8	5	3	0.43	Item is good
29.	11	0.73	4	7	-4	-0.57	Rejected
30.	8	0.53	6	2	4	0.57	Item is good
31.	8	0.53	5	3	2	0.29	Item is good
32.	11	0.73	7	4	3	0.43	Item is good
33.	10	0.67	5	5	0	0.00	Rejected
34.	9	0.60	6	3	3	0.43	Item is good
35.	2	0.13	0	2	-2	-0.29	Rejected
36.	2	0.13	0	2	-2	-0.29	Rejected
37.	10	0.67	6	4	2	0.29	Item is good
38.	7	0.47	5	2	3	0.43	Item is good
39.	7	0.47	5	3	2	0.29	Item is good
40.	9	0.60	6	3	3	0.43	Item is good
41.	10	0.67	7	3	4	0.57	Item is good
42.	12	0.80	8	4	4	0.57	Item is good
43.	11	0.73	7	4	3	0.43	Item is good
44.	9	0.60	6	3	3	0.43	Item is good
45.	10	0.67	6	4	2	0.29	Item is good
46.	9	0.45	7	2	5	0.71	Item is good
47.	2	0.13	0	2	-2	-0.20	Rejected
48.	8	0.53	8	5	3	0.43	Item is good
49.	11	0.73	3	7	-4	-0.57	Rejected
50.	8	0.53	6	2	4	0.57	Item is good
51.	8	0.53	3	5	-2	-0.29	Rejected
52.	11	0.73	7	4	3	0.43	Item is good
53.	10	0.67	7	3	4	0.40	Item is good

54.	9	0.60	6	3	3	0.30	Item is good
55.	2	0.13	0	2	-2	-0.29	Rejected
56.	2	0.13	0	2	-2	-0.40	Rejected
57.	10	0.67	6	4	2	0.29	Item is good
58.	7	0.47	5	2	3	0.43	Item is good
59.	7	0.47	5	3	2	0.29	Item is good
60	9	0.60	6	3	3	0.43	Item is good

$$\textbf{Difficulty Index} = \frac{\text{Number of Students who Answered Correctly}}{\text{Number of Students that took the test}}$$

Rule for accepting item

Accept if item difficulty is above 0.20

Reject if it falls below 0.19

$$\textbf{Discrimination Index} = \frac{U_p - L_p}{*U}$$

*U = number of upper/lower class test takers.

U_p = Upper group that passed the Item

L_p = Lower group that passed the Item

24, 25, 25, 25, 26, 26, 27, **27**, 28, 28, 28, 29, 29, 31, 31

Median = 27

Scores above 27 are regarded as upper group and scores below 27 are regarded as lower group.

Rule for accepting item

Items having negative discrimination were rejected and items having discrimination index above 0.20 were regarded satisfactory for use.