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Addressing Students' Difficulties in Electric Circuit Analysis Using the Modified Laboratory Problem-Solving Model

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Abstract
The paper discussed descriptively, the resolution of students' difficulties in electric circuit analyses, identified students' difficulties in electric circuiting such as inability to independently conduct experiment based on direct current circuit analyses, analysis of data and making prediction using derived equation and graph. However, the model resolved these difficulties by improving teacher- student interactivity, use of specify content knowledge, students' engaged activity, skill acquisition and engaged problem solving. Two instruments Electric Circuit Assessment Schedule (ECAS) and Modified Laboratory Problem Solving Model LAPSOM validated by two experts in Physics in the research area. They have reliability coefficients of 0.76 and 0.82 respectively Students improved on their abilities to state purpose of design (20%), experimental procedure (38%) measurement (66%) and Analysis of data (27%). The model has provided the procedural approach of identifying student's problem, recall of procedure, predicting laws and use of mathematical analytical tools, capable of resolving students' deficiencies in electric circuit problem solving. It suggested that modified LAPSOM model be adopted as a laboratory teaching model cum experimentation for practical knowledge in electricity circuit analyses.

Keywords: Laboratory, Electric Circuit, Skills, Model Students' Difficulties

Introduction

Physics curriculum has demand for specific teacher responsibilities in areas of choosing adequate and reliable teaching methods to meet the specific learning objectives provided in the themes and topical issues embedded in the curriculum. Most of the Physics practical are carried out in the laboratory. Laboratory is a place for careful scientific investigation and experimentation. It is an equipped building containing scientific apparatus which the science teachers and students uses in carryout experiment (Nbina, 2011). The nature of Physics makes it \imperative that the use of Model will help in the cause of teaching and learning. Models are miniature representation of something that is complex to give it a simple meaning. It could be iconic, pictorial, verbal or symbolic form (Vikoo, 2014). They undergo three phases which are designing, implementation and evaluation. The teacher responsibilities involve application of different teaching methods in the learning process, evaluating outcome of instruction emphasizing feedback from participating learners and ensuring adequate progress in their productivity. To achieve this the teacher engage his experience, advantaged in a cordial atmosphere of acceptable learner behaviour to participate in the major three categories of learning objectives, such as the cognitive, affective and psychomotor (Olele and Williams, 2015). Apart from ensuring students level of cognition, they apply skills especially the motor skills when dexterity is needed which is so rewarded in the successful tasks of electric circuiting. More as the students are being exposed to the study of electricity at the secondary school level.

Electric current which has to do with the flow of electron (Otuka et al., 2014), most cases during its analyses poses some difficulties to learners. It is therefore necessary the teacher consider how best to handle some difficult concepts in Physics which will benefit the learners (Okey and Avwiri, 2012). The ability to use information, principles, laws and theories to resolve students' difficulties would improve performance on formulation of skills. This means that the learner need to have the ability to recall (knowledge) and apply, interpret information such as symbolic terms for apparatus and equipment, understanding circuit connections, mostly on use of signage and line diagrams, ensuring breakdown of complex knowledge into specific but new patterns (synthesis) to evaluate and break new grounds (discovery learning). The specific content of electricity concepts in secondary school curriculum is that students' show of knowledge is central to entrepreneurship in Physics learning, operations, repairs and maintenance of devices such as radios, televisions, electric motors, computers and high energy accelerators, and a host of electronic devices used in medicine (Serway, 1982). More so, Dike and Avwiri (2015) are of the opinion that students should not only be taught by teachers with the aim of passing external examinations but students should be trained to become self-reliant as they study the sciences, Physics inclusive.

Students would develop interest in entrepreneurship and get actively self-employed after few years of instruction in Physics hence achieving one of the basic goals of science – education. Teachers are adjured to in still inquiry and acquisition of essential skills as a requirement to the application of Physics (Adeyemo 2010). The skills in electricity concepts in the organization of content of the subject matter, through students' requisite activity would motivate students to specifically learn to participate in product design, enumerate facts, principles which relate to the topic of instruction, master the steps involved or necessary procedures and what techniques that would be required in performing the essential tasks.

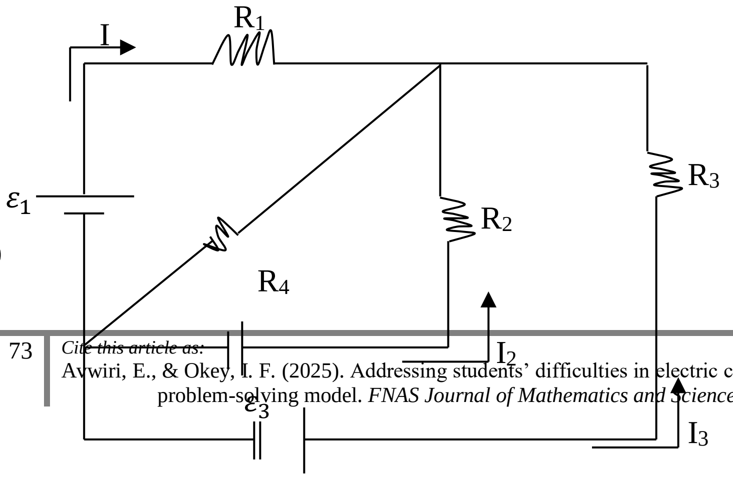
Statement of the Problem

Students' face difficulties in understanding and application of electricity concepts through experiments, based on inadequate knowledge of the symbols and working principles of electrical apparatus and connections met in electric circuits. Teachers rely on the traditional method stating purpose and procedures with minimal information on analyses, identification of physical laws and principles, mathematics, are hidden details hence students lack in depth knowledge and independence in acquisition of practical knowledge in Physics, the use of models, graphic organizers as guided procedures have been effective in guaranteeing students independence in resolving problems in electric circuit analyses.

Most students become uncommitted to acquisition of practical knowledge at the school certificate level. Examiners allow some levels of guide to ease the difficulties in commencing experiments perhaps due to lack of the apparatus, equipment and previous knowledge. Instructors for practical knowledge see students lack of interest, poor mathematics knowledge and improper management of time as indices that have crippled improved performances in Physics. This study therefore examines the educational implications and relevance of the Laboratory Problem- Solving Model (LAPSOM) in identifying and resolving students' difficulties in electric circuit and meaningful practical knowledge in electric circuit analyses.

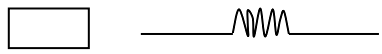
The following difficulties are faced by students during classroom instruction of electricity concepts.

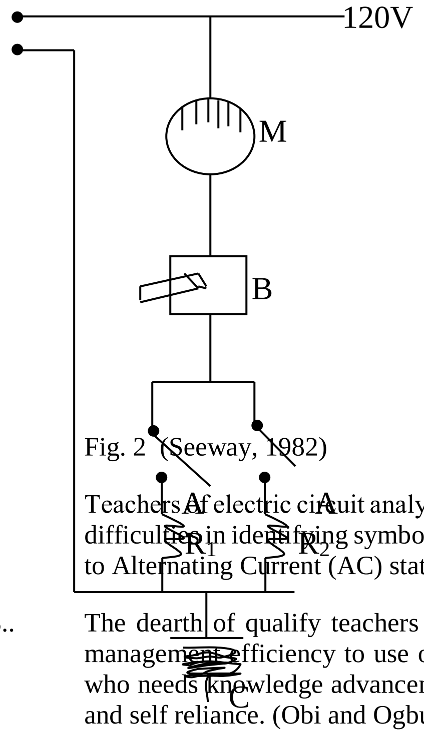
1. Limitation of provision of adequate power laboratory at the secondary school level. The practical nature of Physics and diverse product formulations and involving fabrication of electric devices require a specialized power laboratory rather than the conventional one. However, the provision of conventional laboratory and man power for instruction has remained a far cry in most schools in Rivers State (Avwiri & Okey, 2009). Demonstration of electric field lines produced using small charged conductors, use of the oscilloscope machine; cathode ray tube, trailing of electric field pattern between two parallel plates, capacitors, among others constitute difficulties amongst Physics learners.
2. Students bemoan the abstractness of electricity concepts as a result of insufficient demonstration.
3. The complexity of electric circuit diagrams and its interpretation, become a wonder to many learners. Electric symbols and codes too. How would students differentiate single loop, double loop and electricity flow patterns in these circuits?
4. Laws of electricity and circuits such as kirchoff's single and double loop analysis are strange and difficult due to the involved Mathematics. They are not abreast with when to apply the algebraic sum of current, voltage and ohmic laws.



(Fig. 1)

5. Shortage of textbooks moderating procedures and analyses. A cursory look at modern textbooks in electricity reveal that most authors leave out adequate supply of problems, moderately complex circuits are not accompanied with adequate examples for students homework. For example the application of Kirchoffs' rules on the circuits lead to a set of linear equations in which current in the circuit is unknown. The students find it difficult to solve for n = 2 equations, and are at sea when n = 3.
6. Mathematics knowledge pre-requisite:
   Concepts in Mathematics which are pre-requisite to learning electricity circuit analyses are averse, sum and product rules, transformation of formula, linear equations, that is use of Cramer's rule or matrices resolve linear equations involving 3 unknowns, integration in energy loss in resistors, variation concepts, differentiation, interpretation of slopes, are related to circuit laws, among others.
7. Interpretation of electric symbols and circuit diagrams. Fig. II shows a proposed wiring diagram for a household circuit indicating appliance resistances R_1 and R_2 for an applied voltage. What does M,B,A,C represent and what connection pattern (series/parallel) is used? What is the problem? or as symbols for resistors,





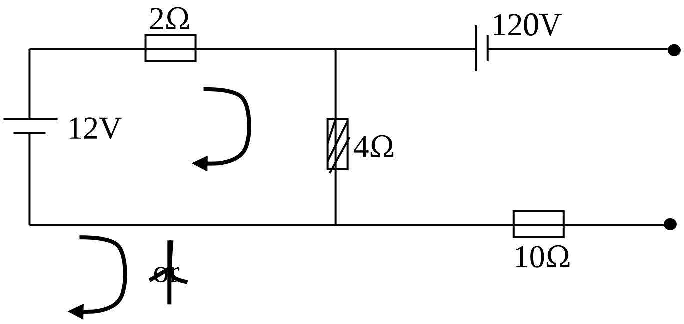


Fig. 2 (Seeway, 1982)

Teachers of electric circuit analyses can differentiate between similarities in circuits and resolve students' difficulties in identifying symbols and their meanings beginning with simple Direct Current (DC) circuits to Alternating Current (AC) stating product elements and uses.

8.. The dearth of qualify teachers in Physics in most schools, dearth of resources and non-existence of management efficiency to use of resources effectively has worsened the plight of the Physics learner who needs knowledge advancement for entrepreneurial, technical and vocational job-specific expertise and self reliance. (Obi and Ogbuagu, 2020; Nwankwo,2014).

9. Students misconceive the use of terms such as electricity, electric current, electric voltage and charge (Cepni & Keles, 2006). These misuses of terms create misconceptions especially between electric current and voltage.

Resolving students' difficulties using LAPSOM modified Laboratory Problem Solving Model (Onwiduokit, 1992).

The need for practical skill acquisition of students during Physics instruction as posited by Onyehalu (1988) will promote learning and transfer of specific learning skill. Teachers should provide learning situations where students' cognitive preferences will be challenged, making them to apply what they have learnt and open their minds for functional use of the knowledge they have acquired.

The modification of LAPSOM (Onwiduokit, 1992) is target to resolving students' difficulties in learning through laboratory practice. Since electric circuiting is practical, LAPSOM provided pedagogy and skills for Physics

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practical learners. Students difficulties in learning science have been the concern of modern research, attracting different pedagogical approaches, differentiated with difficulty of instructional design in order to embrace steps to knowledge acquisition through technology skills. LAPSOM (1992) agree with Kemp (1977) instructional design and problem solving application where technology is applied to instruction, in order to ease learning by use of interactive info graphics in instruction and academic performace. (Elaidi & Cifei, 2021). Laboratory teaching method LAPSOM (2013) is advantaged in exposing students to manipulative, observational and computational skills. It exposes students to laboratory problem solving (LAPSOM), help them acquire the ability to identity, define problems and logically carry out through a sequential procedure an experimental investigation. Models such as the PAM models (Programme of Action and Methods), Mettes, *et al.*, (1980) and the linear Model provide adequate algorithm or methodology, aimed to resolve students' difficulties in learning various concepts in science. The modified LAPSOM model (Onwioduokit, 2013) has been effective as a laboratory-based model or skills to improve students' cognitive skills, manipulative skills, observational skills, and communicative skills (Onwiduokit, 2013). The model allow for effective teacher-student interaction in order to identify, classify and recognize the problem and objective of the study.

Materia and Methods

The research adopted a descriptive research design in which the procedural approach of modified LAPSOM was used as a means of instruction to twenty six senior secondary Physics students from three schools purposively selected in Port Harcourt metropolis. These schools have comparative advantages in terms of presence of a suitably equipped laboratory, qualified teachers and have presented candidates for external examinations in Physics practical .Students entry behaviour and level of practical knowledge in electric circuit were assessed using the self structured Electric Circuit Assessment schedule .A teacher demonstration method based on the modified LAPSOM was adopted by a specialist Physics instructor. Instructions involved use of laboratory skill, ,measurement, data collection, prediction using equations and graphical solution. Students were exposed to experimentation on electric circuit, while their performance were evaluated using the LAPSOM Assessment Schedule in order to remedy and unravelled the difficulties encountered by learners.

To apply LAPSOM (2013) in learning Electric circuit, the following questions would guide the objectives of the study. What is the objective design of investigation (purpose of experiment).

i) To achieve the purpose of experiment, what are the required apparatus and materials? In electricity, common apparatus include:

a) Use of micrometer screw guage in determination of diameter of the wire, e.g potentiometer wire (constantan) in the construction of Potentiometer, recoiling of metric devices, etc.
b) Use of metre rule in determination of length of wire.
c) Use of screw drivers, glue, metre rule, cellotapes etc.

ii) What are the roles of the learner (experimentation) under the guide of the teacher; How to identify terminals, equipment and circuit elements.

iii) Teacher guide include use of Electric circuit Advance Organizers, directing activity of the students and Evaluation.

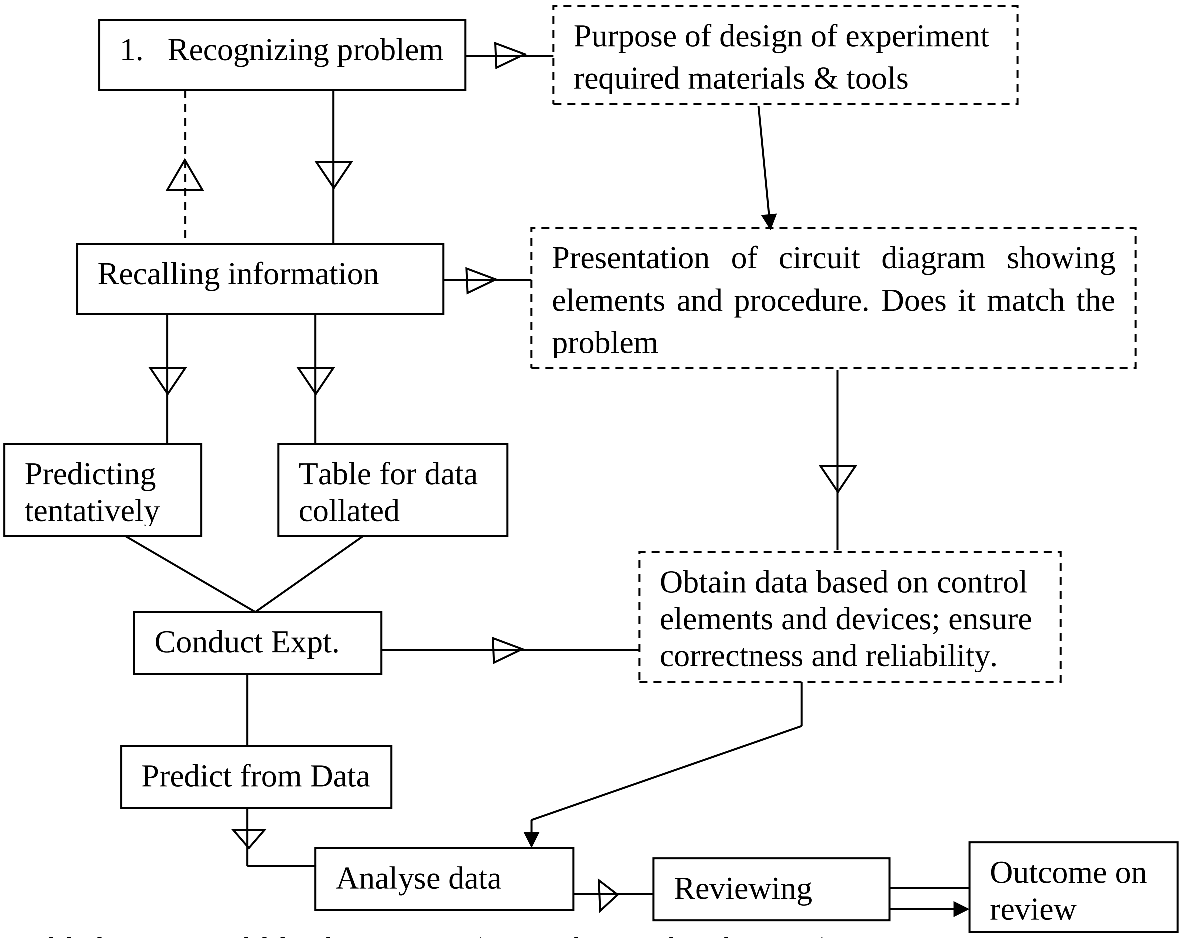
iv) What have we achieved in terms of the product, test of effectiveness; process: Is the current produced measured, what equipment have we used? Learner based Evaluation, can I independently carry out the process?

v) Recall on information based on methodology of the experiment, create template for collection of data and carryout the experiment.

Modification of Model (LAPSOM, 2013) on Electric Circuit Experiment.

Result and Discussion

The essence of electric circuit is to produce electric current. The quantity of current in the circuit depends on resistivity of the materials, (e) cross-sectional area of electric wires (A), control and functionality of measuring devices. Accurate reading of the installed devices help in generating data for mathematical analysis and prediction.



Modified Lapsom model for electric circuit (proposed, researcher idea, 2024)

Fig. 3: Shows modification of the LAPSOM Model Onwidiokit (2013)

Result

Comparison of students rating base on the entry behaviour performance on Electric Circuit Assessment Schedule (ECAS) and application of modified LAPSOM Assessment schedule.

S/N	Construct	ECASN= 26 (%)	Modified LAPSOM	Improvement Response (IRR%)	Rating
1.	Ability to state purpose of experiment (aim)	Inadequate (45%)	Adequate (66%)	20%	
2.	Ability to proceed experiment based on the electric circuit diagram presented.	Inadequate (20%)	Adequate (58%)	38%	
3.	Measurement (Manipulative skill and Observational skill index).	Grossly Inadequate (16%)	Adequate (82%)	66%	
4.	Reasoning Ability mathematical ability (Analysis of Data).	Grossly Inadequate (45%)	Adequate (48%)	27%	

TABLE 3 revealed improved rating of students due to adherence to the procedure of the modified LAPSOM model in areas of design purpose of the experiment on electric circuit, 20%, ability to proceed with the experiment

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with minimal guide using the presented electric circuit diagram 38%, adequacy of manipulative ,and observational skills 66%,and Analyses of data 27%. It is advisable that teachers identify the problem of the electric circuit design , state the purpose, materials and tools used. Secondly, the design should involve specific instruction and procedures. Teaching should proffer solution to interactive questions like, Does the control elements show effective readings without need for recalibration? Does the instrumental error affect the process? If the obtained data is reliable then what treatment procedure are we accepting? This review of design process must yield an outcome which qualifies the process and objectives of the experiment. In order to overcome learning difficulties in electric circuit analyses, Elaidi and Cifei, (2021) advised that students should have available information to explain the increasing complexity of the subject matter. The teacher is expected to present circuit designs in a logical, effective and creative mode such as use of (visual design and application of technology (Ru & Ming, 2014).

Furthermore, experts have uncovered students' lack of knowledge in simple mathematical concepts such as resolution of linear systems of equation or complex calculus of integration and differentiation which hinder their focus on the circuit rather than the mathematical formulae, especially in advanced Physics concepts. The limited engagement of students on self-approach to design of simple circuits, non-application of interactive learning techniques (teacher-student) and specificity of circuit to be analysed whether it be on the basic concepts, Kirchhoff's laws or resistive circuit (especially in secondary schools), mesh and nodal analysis, transient analysis or two or three phase circuits. If the math demand is inadequate, data obtained through experiment will not be analysed adequately to predict or conform to existing theories.

Onwiduokit (2013), suggested that LAPSOM would encourage purposeful participation, activity, verification and increase in student-teacher interactivity on practical aspects of science learning especially in Physics. Students taught Physics practical using the algorithm proposed by the model had higher reasoning ability/mathematical ability and improved computational skills. These skills they added are important in the making of the scientist. The model guarantees the advantage of teaching as to develop and improve meaningful learning, capable of increasing students' ability, to explore scientific phenomena and carryout individual investigations (practical knowledge) in science.

Conclusion

Modified Laboratory Problem Solving Model (LAPSOM) as a laboratory instruction model can be used to remedy students' difficulties in electric circuiting and improve their manipulative observational and mathematical ability required for prediction of circuit behaviour in electricity.

Recommendation

Teachers are advised to employ the algorithm of LAPSOM as modified for electric circuiting (fig 1), if students' observational skills, manipulative skills and measurement ability would improve.

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