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EFFECT OF JIGSAW MODEL ON SENIOR HIGH SCHOOL STUDENTS' CONCEPTUAL UNDERSTANDING IN ELECTRICITY

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DEPARTMENT OF INTEGRATED SCIENCE EDUCATION
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DECLARATION

STUDENT'S DECLARATION

I, **NATHASIA EDEM AHOTO**, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: ……..

Date: …….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

Name of Supervisor: DR. (MRS.) NELLY ADJOA SAKYI-HAGAN

Signature: ……

Date: ……...

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DEDICATION

This work is dedicated to my dear mum Ivy Mawusi Manyo, my siblings Bernard, Courage and Lordina, my dear husband Francis Assumang (ASI) and my lovely son Nkunim Kofi Assumang.

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ABSTRACT

This research was to examine the effect of the Jigsaw learning model on the conceptual understanding, attitude, and retention of Senior High School students in selected concepts of electricity. The study adopted a quasi-experimental design involving 80 Form Two Visual Arts students from Mawuli School in Ho, Ghana. The participants were divided into an experimental group taught using the Jigsaw model and a control group taught through traditional instruction. Student Achievement test 1 and 2(Pre-test and post-test respectively), and retention tests were administered to measure students' conceptual understanding and long-term learning, while a Likert-scale questionnaire assessed their attitudes toward learning the concepts using the jigsaw learning model. Data were analysed using descriptive and inferential statistics. The findings revealed that students who was taught through the Jigsaw learning model demonstrated significantly higher post-test scores (M= 27.08, SD=1.42) with an independent samples t-test revealing statistically significant difference, t (3.91), p=0.001 with alpha level ($p<0.05$).The results further indicated that the Jigsaw strategy promoted cooperative interaction, motivation, and accountability, leading to deeper cognitive processing and long-term learning. The study confirmed that peer teaching and group interdependence inherent in the Jigsaw model enhance meaningful learning and conceptual understanding in science education. It is recommended that science teachers adopt the Jigsaw learning model to improve students' understanding and interest in abstract concepts such as electricity. The study contributes to the growing evidence supporting student-centered, cooperative learning strategies as effective tools for improving conceptual understanding, affective outcomes, and sustained retention in integrated science and other science subjects.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter deals with the background to the study, statement of the problem, purpose of the study, objectives and research questions of the study, significance of the study, delimitation and limitation, and organisation of reports

1.1 Background to the Study

Electricity is one of the most conceptually demanding topics in the senior high school physics and Integrated Science curricula in Ghana. It encompasses fundamental but abstract ideas such as electric current, voltage, resistance, potential difference, and the behavior of series and parallel circuits. These concepts require students to visualize invisible microscopic processes, reason with symbols, and connect theoretical explanations to observable electrical behavior tasks that many learners find difficult. research conducted by (Agyei & Agyei, 2021) which consistently shows that students hold misconceptions about electricity that persist despite instructional efforts. Agyei & Voogt (2020) stated that many students view science as an abstract and conceptually challenging subject, which makes them dislike pursuing it as a course.

However, existing literature also states that many senior high school students, especially those in non-science classes like Visual Arts, often find it challenging to understand and apply scientific concepts due to insufficient student-centred strategies (Boateng & Koomson, 2019).

In Ghanaian senior high schools, difficulties in learning electricity are intensified by the predominance of teacher-centered pedagogies. Many classrooms still rely heavily on expository lesson delivery, chalkboard demonstrations, rote learning, and note-

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copying approaches. These methods focus on information transmission rather than conceptual construction, resulting in limited opportunities for learners to ask questions, collaborate, reason, or engage in hands-on exploration. Musah et al., (2025) highlight that such approaches lead to shallow learning, low conceptual understanding, and minimal development of higher-order thinking skills in physics across Ghanaian schools.

These challenges are repeatedly reflected in national assessment reports (WAEC 2023). WAEC Chief Examiners have consistently drawn attention to widespread misconceptions among students inability to differentiate current from voltage, poor application of Ohm's Law, incorrect interpretation of circuit diagrams, and confusion regarding resistor behavior in series and parallel circuits. These weaknesses point toward a systemic instructional issue that demands innovative, student-centered approaches to support meaningful conceptual change.

Antwi et al. (2021) demonstrated that practical, hands-on instructional strategies significantly improve SHS students' achievement and scientific process skills in electricity. Assuah (2024) also found that inquiry-based learning enhanced students' ability to conceptualise electricity and magnetism, while Agyei and Agyei (2021) reported that PhET simulations supported deeper understanding by enabling learners to visualize electrical interactions. These studies collectively point to the need for more interactive, participatory, and learner-centered methods in the teaching of electricity.

Despite these advances, cooperative learning especially structured models like the Jigsaw strategy has received limited attention within Ghanaian science education research. Cooperative learning aligns well with the Ghanaian classroom context, where peer interaction, group work, and communal learning are culturally valued.

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One of the few Ghanaian studies applying Jigsaw in physics is that of Acquah (2025), who reported that students taught electric circuit analysis using the Jigsaw method achieved significantly higher conceptual understanding than those taught using traditional methods. The Ghanaian Senior High School curriculum also continues to emphasize competencies such as collaboration, critical thinking, communication, and problem-solving competencies that cooperative learning naturally promotes. However, many teachers continue to struggle with how to implement such pedagogies in practice.

Although the jigsaw learning model have demonstrated positive outcomes in science education, many studies have examined general academic achievement rather than focusing specifically on conceptual understanding of electricity concepts. Hence this study seeks to use the Jigsaw learning model to improve students' conceptual understanding of electricity concepts.

1.2 Statement of the Problem

Electricity is a core component of the Senior High School Integrated Science curriculum, yet it remains one of the most conceptually challenging topics for students. Empirical research continues to document persistent misconceptions regarding electric current, voltage, resistance, and circuit behaviour among secondary school learners. These misconceptions undermine students' ability to develop coherent conceptual understanding and apply electricity concepts meaningfully.

Within the Ghanaian context, WAEC Chief Examiners' Reports (2023) have consistently highlighted students' weaknesses in solving electricity-related problems, particularly in interpreting circuit diagrams and applying Ohm's Law correctly. Observations and classroom assessments in many Senior High Schools similarly

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indicate that students struggle to explain fundamental electrical concepts beyond procedural calculations.

Although the Jigsaw model have been shown to improve academic achievement in science education, limited empirical evidence exists on their effectiveness in improving conceptual understanding of electricity within Ghanaian Senior High School classrooms. Much of the existing research has focused on general science achievement rather than topic-specific conceptual understanding in electricity.

This gap between persistent conceptual difficulties and limited context-specific intervention research highlights the need for this study. Therefore, this research seeks to examine the effect of the Jigsaw learning model on Senior High School students' conceptual understanding of electricity concepts.

1.3 Objectives of the study

The objectives of the study were to:

1. examine the difference in conceptual understanding between students taught electricity concepts using the jigsaw learning model and those taught using traditional instructional strategies.
2. find out the attitude of students towards learning the concepts of electricity when taught using the jigsaw learning model strategy.
3. assess the effect of the jigsaw learning model strategy on students' retention of the concepts of electricity.

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1.4 Research Questions

1. What is the difference in conceptual understanding between students taught electricity concepts using the jigsaw learning model and those taught using traditional instructional strategies?
2. What is the attitude of students towards learning the concepts of electricity when taught using the jigsaw learning model strategy?
3. What is the effect of the jigsaw learning model strategy on students' retention of the concepts of electricity?

1.5 Research Hypotheses

H_{01}: There is no significant difference in mean conceptual understanding scores between students taught electricity concepts using the Jigsaw model and those taught using traditional instructional strategies.

1.6 Purpose of the Study

The purpose of the study was to determine the effect of the jigsaw model on Senior High School students' conceptual understanding of electricity.

1.7 Significance of the Study

The findings of this study are expected to be beneficial to Mawuli School students in Ho, by enhancing their conceptual understanding of electricity concepts through the use of the Jigsaw learning model. Improved understanding of fundamental electricity principles such as current, voltage, resistance, and circuit behaviour may help reduce persistent misconceptions commonly observed among students.

Science teachers in Mawuli School, may find the results of this study useful in adopting and implementing cooperative learning strategies to improve student engagement and understanding of abstract science concepts. The study provides practical classroom-

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based evidence on how the Jigsaw learning model can be structured and applied effectively within resource-limited environments.

1.8 Delimitation

Delimitation of a study refers to limits deliberately set out by researchers which determine the boundary of their study and ensuring the possibility of realization of objectives and aims of the study at hand. Delimitation of a study are actually under the control of the researcher. It includes study background, study sample, objectives, study variable aim and sampling strategy (Dimitrios & Antigoni, 2019).

The study was delimited to only the concept of electricity and to only S.H.S 2 students of Ho Mawuli School in the Ho municipality

1.9 Limitation

Limitation of a research refers to weaknesses of the study that are beyond the control of the researcher. They are usually associated with financial constrain, research design, statistical model and other factors. The limitation of a study has the potential of influencing the conclusion, result and study design (Dimitrios & Antigoni, 2019). The researcher encountered the following limitations:

i. Test anxiety on the part of the students could possibly affect their scores
ii. Different learning ability of the students could also affect the findings.

1.10 Organisation of the Study

The study report was divided into five chapters. The first chapter served as the introduction to the study. This chapter provides the essential context for the study, detailing its background, the problem being addressed, the study's purpose, the research questions guiding the study, and the study's significance. Additionally, it discusses the

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limitations and delimitations identified during the research process. Chapter two was devoted to the review of literature related to the study. Chapter three focused on the method used to gather data in the study. Chapter three contains the research approach and research design used in this study. It also discusses the population of the study, the sampling and sampling technique, the research instrument that will be used to collect data for this study, validity and reliability of the research instruments, pre-intervention activities, intervention, post-intervention activities, data analysis procedure and ethical consideration. Chapter Four presented the results and discussing of the findings. Finally, chapter five, which was the final chapter, consist of a summary, conclusions, recommendations, and suggested areas for further study.

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CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter presents a theoretical framework guiding the study, review of relevant literature to the study and also empirical literature was also reviewed in this chapter.

2.1 Theoretical Framework of the Study

The study was guided by social constructivist theory of learning and social interdependence theory.

2.1.1 Social constructivist theory

Vygotsky, (1978) explains that learning is fundamentally a socially mediated process, in which meaning emerges through collaboration, dialogue, and collective cultural tools.

Social Constructivist Theory emphasises the idea that knowledge is not passively acquired but actively constructed by engagement in social interaction and cultural. Unlike cognitive constructivism's focus on the internal life of the individual learner (Piaget's schema), social constructivism places greater emphasis on the role of community, language, and culture in cognition (Palincsar, 1998).

One of the theory's most central concepts is the Zone of Proximal Development (ZPD), or the difference between what a learner can accomplish independently and what he/she can accomplish with the assistance of a more knowledgeable other (Vygotsky, 1978). Lantolf and Thorne (2006) stated that teaching and learning are considered co-constructed processes, with scaffolding supportive interventions provided by instructors, peers, or instructional materials permitting learners to transcend their current capabilities.

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In the case of Vygotsky, language is the most significant cultural tool mediating thought and learning. According to Mercer and Littleton (2007) found that students negotiate meaning and assume jointly shared understandings. Kim, (2001) also stated that in classes, group activity and peer-to-peer working enable students to learn more profoundly by subjecting them to alternative perspectives and enabling them to reconstruct their knowledge.

Social constructivist implications for education are profound. Teachers are being asked to be not just conduits for pre-existing knowledge but facilitators of learning environments where students can acquire knowledge through inquiry, problem-solving, and cooperative learning (Powell & Kalina, 2009). Teaching practices such as collaborative learning, project-based learning, and discussion-based pedagogy are conducive to this because they offer opportunities for co-meaning-making.

However, social constructivism criticism points out challenges in implementation, such as the possibility of unequal contribution to group work, over-reliance on peer knowledge, and the problem of assessing individual understanding in group settings (Kirschner et al., 2006). Despite criticism, the theory still shapes present-day education, particularly in building critical thinking, socialisation, and lifelong learning skills.

In essence, Social Constructivist Theory focuses on the social aspect of learning, viewing knowledge as dynamic, contextual, and co-constructed in communication with others. The theory still impacts teaching practices in various subject matters, with collaboration, dialogue, and culturally responsive teaching being argued as essential to effective learning.

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2.1.2 Social interdependence theory

Social Interdependence Theory explains how the interdependence of the goals of individuals affects the outcomes of their interactions, particularly in learning and group settings. The theory started in the early 20th century with the works of Koffka (1922) and Lewin (1935).

At its core, Social Interdependence Theory contends that the way goals are structured within a group will determine how people interact and thus how well they do at getting things done (Johnson & Johnson, 2009). There are three types of goal interdependence: positive interdependence, negative interdependence, and no interdependence. Positive interdependence is achieved when individuals perceive that they will be able to achieve their goals if and only if other members in the group achieve theirs, leading to cooperation and support for each other. Negative interdependence is where there is competition such that success for one implies failure for another. No interdependence is observed when individuals' goals are not linked and outcomes are separate (Deutsch, 2012).

Johnson et al. (2013) explained that positive interdependence, in particular, has been shown to promote enhanced achievement, motivation, and positive relationships among students. In schools, cooperative learning structures such as group problem-solving tasks or peer-assisted learning are grounded in this principle, fostering such skills as communication, responsibility, and conflict resolution. Research indicates that students who work in collaboration not only achieve better learning outcomes but also possess better social relationships and good learning attitudes (Slavin, 2014; Gillies, 2016).

The social interdependence processes include both personal accountability and promotive interaction. Promotive interaction involves group members assisting and

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encouraging other group members' efforts, whereas accountability ensures that every member of the group contributes positively to the achievement of the group (Johnson & Johnson, 2005). This balance prevents social loafing and ensures that cooperation yields positive results.

However, implementing cooperative approaches based on Social Interdependence Theory is not devoid of challenges of its own. Teachers may find it difficult to design appropriate group activities, manage unequal contributions, or assess individual work (Gillies & Boyle, 2010). Despite these limitations, the theory remains one of the strongest theories to describe how group processes affect learning and relationships between individuals.

Generally speaking, Social Interdependence Theory highlights the importance of creating learning environments where the goals of students are interdependent in such a way as to foster cooperation. Through this process, teachers can encourage not only improved academic performance but also important life skills such as teamwork, empathy, and shared accountability.

2.1.3 Alignment of jigsaw learning model with theoretical frameworks

Aronson developed the Jigsaw Learning Model in the 1970s, an interdependent strategy for learning where students learn collaboratively as groups and each student becomes an "expert" on a portion of the material and then teaches it to the rest of the group. It is based on both the Social Constructivist Theory and Social Interdependence Theory, which provide the theoretical underpinning for its effectiveness in classrooms.

According to the Social Constructivist Theory viewpoint, learning is active and social where knowledge is constructed through engagement with the world and human beings

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(Vygotsky, 1978). Jigsaw Model illustrates this viewpoint through offering scope for explanation, discussion, and peer instruction, all converging at increased understanding. By teaching others about a concept, students engage in higher-order cognitive processes such as elaboration and synthesis that extend conceptual understanding (Palincsar, 1998). The collaborative nature of the Jigsaw also aligns with Vygotsky's construct of the zone of proximal development (ZPD), where students accomplish more through instructed collaboration with other students than they could accomplish unaided (Powell & Kalina, 2009). By doing this, the model encourages scaffolding through peer-to-peer interaction to the advantage of both comprehension and retention of knowledge.

Social Interdependence Theory is also backed by elaborating on the impact of goal structure on interaction and learning processes (Deutsch, 1949; Johnson & Johnson, 2009). Positive interdependence in the Jigsaw Model is structured in a way that each student's success depends upon others since the complete picture of the lesson cannot be achieved without contributions from everyone. This dependence on a common purpose creates a sense of responsibility, accountability, and motivation in all members of the group to work cooperatively (Johnson et al., 2013).

Moreover, promotive interaction cooperation and assistance in each other's learning inescapably follows from the Jigsaw plan as peers will have to assist one another in order to survive (Slavin, 2014).

The blending of these two theories into the application of the Jigsaw learning Model is evident. Social Constructivism points out the cognitive and developmental process of knowledge building through social interaction, whereas Social Interdependence Theory highlights cooperation's relational and motivational processes. Both theories

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demonstrated the Jigsaw learning Model is effective involving students not only cognitively, as it requires them to build and define knowledge, but also socially and motivationally by making their success integral to the group's achievement.Empirical findings support this congruence, with students learning through Jigsaw demonstrating higher conceptual understanding, retention, and favourable dispositions toward subject matter and peers (García-Herrera & Fisher, 2020; Tran & Lewis, 2012). Jigsaw Model is hence an effortless application of Social Constructivist and Social Interdependence theories and a powerful pedagogical tool for joint and meaningful learning.

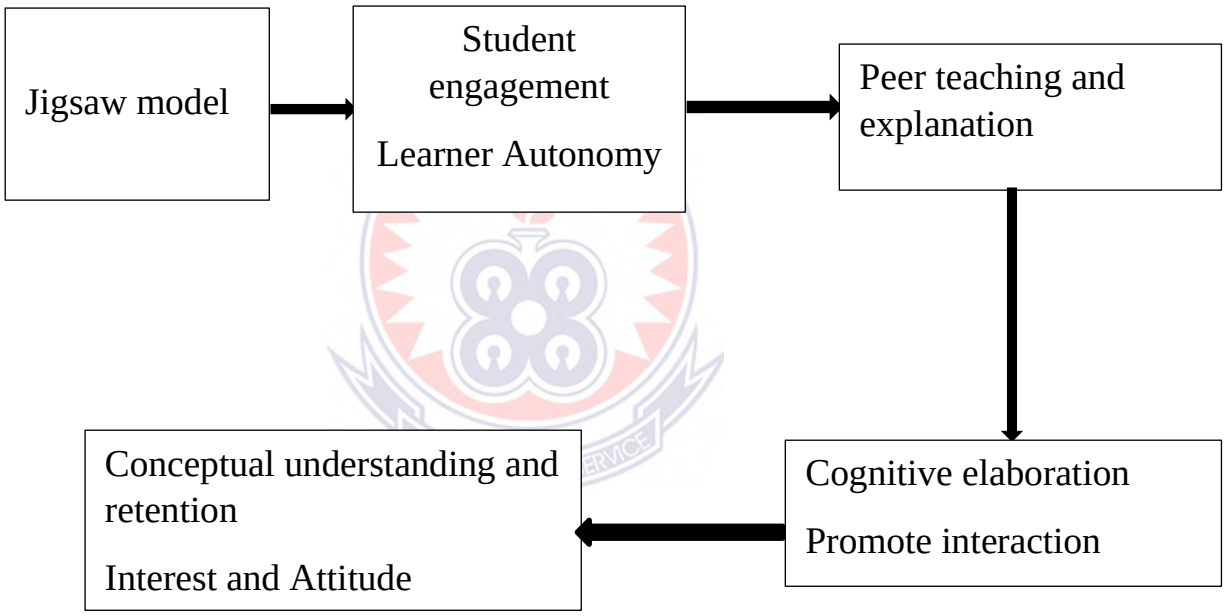

Figure 1:
Conceptual Framework

2.2 Conceptual Understanding in Science Education

Conceptual understanding has been described differently depending on the discipline context. In general, it is the ability to understand facts, procedures, and concepts by putting them in a meaningful mental structure (Bransford et al., 2000).

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Conceptual understanding is the rich comprehension of ideas, principles, and relationships that enables learners to connect knowledge, extend it to new situations, and articulate it in a meaningful way. In contrast to rote memorisation or surface learning, conceptual understanding underpins higher-order thinking and knowledge transfer (Chi & Wylie, 2019). Conceptual understanding is necessary in domains ranging from math and science through social studies, language learning, and professional education. Increasing numbers of scholars and educators appreciate that the establishment of conceptual understanding is central to developing adaptive, competent, and lifelong learners (NRC, 2020; Biggs & Tang, 2022).

Rittle-Johnson and Schneider (2021) reported that conceptual understanding involves being aware of "why" a concept functions, not "how." For instance, in math, understanding why the distributive property holds is a sign of conceptual understanding, whereas the mere mechanical application of it is procedural knowledge.

Cognitive psychology conceptualises understanding as an integrated network of meaningful knowledge that allows learners to interpret information, make inferences, and solve problems (Anderson, 2020). It is a foundation of science education that supports critical thinking, problem-solving, and the application of knowledge in new situations (Kang et al., 2019). As the demands of modern science education evolve to cater to the needs of 21st-century learners, conceptual understanding receives greater attention in curriculum and assessment in much of the world. Conceptual understanding of science education is distinguished from recalling facts and procedural knowledge. Conceptual understanding is regarded as essential for the student to apply scientific problem-solving, explanation, and reasoning (Treagust & Duit, 2020). Similarly, conceptual knowledge in language acquisition implies understanding of underlying

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semantic or linguistic patterns rather than word-for-word memorisation of words or grammatical rules (Nation & Webb, 2019).

Conceptual understanding in science learning refers to a rich, coherent conceptualisation of scientific ideas, theories, and allied concepts. Conceptual understanding enables learners to explain phenomena, make predictions, solve problems, and apply what they know to new contexts, unlike rote memorisation of isolated facts (Chi & Wylie, 2019). Conceptual understanding is at the centre of scientific literacy, inquiry, and lifelong learning. With science education moving away from memorisation towards greater learning, emphasis on developing students' conceptual understanding has gained prominence in policy, curriculum, and research (National Academies of Sciences, Engineering, and Medicine [NASEM], 2020).

Across STEM disciplines, research indicates that many learners develop procedural skills without underlying conceptual grasp. In chemistry, Taber (2019) emphasizes that misconceptions about atomic structure and bonding remain even after instruction, reflecting shallow understanding. Similarly, Nehm and Schonfeld (2010) document persistent misconceptions about evolution and inheritance in biology.Heller and Hollabaugh (1992) demonstrated that cooperative problem-solving in groups led to significantly improved performance on physics conceptual assessments. Chi et al. (2018) emphasise that deep conceptual understanding requires active knowledge construction rather than passive reception; this supports the use of collaborative structures that compel learners to explain and reorganise their ideas during electricity learning.

Duit and Treagust (2018) argue that conceptual change is triggered when learners encounter cognitive conflict and are offered intelligible, plausible, and fruitful

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alternatives conditions that cooperative tasks can create effectively in physics. Chiu and Chung (2018) report that students learning electric circuits collaboratively show fewer systematic errors and stronger problem-solving performance than peers taught individually.

Meta-analyses highlight that teaching approaches focused on conceptual understanding such as inquiry-based learning, cooperative methods, and problem-based learning yield stronger long-term outcomes. Freeman et al. (2014) stated that reviewing 225 studies, concluded that active engagement reduces failure rates and strengthens conceptual gains. Lazonder and Harmsen (2016) recently confirmed that guided inquiry improves deep understanding more effectively than unstructured discovery.

2.2.1 Significance of conceptual understanding in mitigating electricity misconceptions

Electricity is perhaps the most basic scientific idea and is a key element in understanding the material world. From lighting a house to energising an appliance, the students could face challenges in having a deep conceptual understanding of electricity. Conceptual understanding of electricity involves the ability to describe, explain, and predict electric phenomena in terms of the interconnection among basic concepts like voltage, current, resistance, circuits, and energy transfer (McDermott & Redish, 2019). Conceptual understanding is a definition of knowledge that is deeply organised, coherent, and generalizable across contexts (Chi & Wylie, 2019). Numerous studies have come out to show that the students would predominantly acquire procedural or remembered information rather than the substance behind it (Kesonen et al., 2021; Fredriksson & Peltonen, 2023).

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The significance of conceptual knowledge of electricity extends beyond the classroom. It enables scientific literacy, fosters problem-solving skill development, and is instrumental to the progression of study and career in STEM areas. As science education worldwide continues to emphasise inquiry and conceptual knowledge, enhancing students' conceptual knowledge of electricity is of high priority (National Research Council, 2020; NASEM, 2023).

For electricity, this means the ability to be able to distinguish among voltage, current, and resistance, explain series and parallel circuits, understand how energy gets transferred and saved in electric systems, apply Ohm's Law not only mathematically but conceptually accurately and predict circuit behaviour on the basis of changes in components or configuration. Kesonen et al. (2021) stated that conceptual understanding allows students to explain phenomena like why a bulb lights up less in a series circuit than in a parallel circuit or why a fuse protects a circuit. Boateng and Essel (2019) observed that persistent misconceptions in electricity in Ghanaian classrooms are linked to lecture-dominant pedagogy and advocate for cooperative learning designs to promote conceptual understanding. Ogunleye (2021) notes that student-centred approaches in African science classrooms are associated with improved engagement and conceptual outcomes relative to traditional recitation.

Roberts and Bybee (2020) noted that science instruction should prepare learners for active citizenship in an age where there is constant exposure to technology, and electricity is one of the dominant characteristics of that preparation.

Electricity is part of modern life in the form of residential circuits, cellular phones, and renewable energy systems. Conceptual understanding enables individuals to make informed decisions about the consumption of energy, electrical safety, and technology.

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Conceptual knowledge works to deconstruct such misconceptions and reconstruct them with scientifically accurate models.

Barnett and Ceci, (2020) reported that students with strong conceptual knowledge can better solve and transfer knowledge in new contexts thus they can move beyond formula memorisation to interpret circuit diagrams, evaluate electric system modifications, and transfer principles in scenarios such as energy efficiency or electronics fault analysis.

Zydney et al. (2019) find that collaborative modules in physics produce superior conceptual understanding compared to individualised self-study, underscoring the value of peer interaction.

A sound understanding of electricity concepts is a requirement for advanced physics, engineering, robotics, and technology courses. Students who lack this requirement tend to find it difficult with upper-level courses where conceptual competence is taken for granted (Duit & Treagust, 2020).

2.3 Origin and Principles of the Jigsaw Model

The jigsaw learning method was initially developed by Elliot Aronson and his colleagues in Austin, Texas, in 1971. The process was devised in response to growing racial tensions within desegregated schools, more precisely to limit inter-group hostility and improve cooperation among different students (Aronson, 2002). The primary goal of the model was the creation of positive interdependence, whereby students rely on one another for goal attainment, thereby eliminating prejudice and building empathy.

In its initial application, the students were divided into small groups, and each was tasked with learning and subsequently teaching the other members of a different portion of the whole subject. Aronson (2002) cited that the model not only improved academic

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performance but also respect for diversity, interpersonal relationships, and self-concept. The model has since been expanded and widely applied across the globe in schooling environments, including in the instance of science, social studies, language learning, and teacher education (Yusof et al., 2020).

2.3.1 Core principles of the jigsaw model

The Jigsaw model is characterised by a unique structure that provides interdependence, participation, and accountability. Some of its core principles are:

1. **Positive Interdependence**: Each student becomes an "expert" on a subtopic and teaches it to their group members. The structure ensures each student's success relies on others' work (Johnson & Johnson, 2020).
2. **Individual Accountability**: It holds students responsible for mastering the entire material, not just their subtopic. It does so in establishing responsibility both in learning and teaching effectively (Kaya & Kaya, 2020).
3. **Balanced Participation:** With a different facet of a topic assigned to each student, the Jigsaw method avoids domination by some and encourages equal participation (Tran, 2022).
4. **Promotive Interaction:** Students actively support each other's learning through discussion, questioning, and responding. This enhances communication and group cohesion (Slavin, 2020).
5. **Development of Social Skills:** The model builds social skills of listening, empathy, cooperation, and tolerance for difference of opinion on social skills critical in inclusive and multicultural classrooms (Yusof et al., 2020).

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2.4 Implementation of the Jigsaw Model in Science

The Jigsaw cooperative learning model in the science classroom necessitates intentional orchestration to foster profound conceptual understanding, positive interdependence, and personal accountability. At its core, Jigsaw challenges each learner with a distinct piece of a science concept such as aspects of an electric circuit or steps of ecological succession which they first explore independently and then teach to others, so that learning the full idea only occurs through collective working together (Johnson & Johnson, 2020; Slavin, 2020). This design necessarily promotes positive interdependence: mastery on the part of individual students has to add to the collective understanding of the group (Johnson & Johnson, 2020). Before being taught by peers, students sit in "expert groups" to co-construct an understanding of their specific subtopic through carefully selected materials such as diagrams, simulations (such as PhET interactive models), data sets, and guided notes emphasizing primary principles and combating widespread misconceptions (Ainsworth, 2019; Wieman et al., 2020). These scaffolds facilitate the deep working needed to then articulate and defend their knowledge. These scaffolds provide the rigorous interaction that is needed to finally articulate and defend their comprehension.

Upon securing expert preparation, typically verified via a swift readiness test or preliminary evaluation for accuracy and certainty, experts return to their "home groups" and teach fellow members, enhancing promotive interaction, structured discourse, and enlightening questions that enable all group members to integrate their understanding into one cohesive model of the broader phenomenon (Gillies, 2019; Osborne et al., 2020). The social-constructivist foundation of Jigsaw, drawing on Vygotsky's emphasis on mediated learning, assumes that learners are instructed effectively when they engage actively in discussing and negotiating meaning with peers (Vygotsky, 1978). The

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teacher then functions as a facilitator rather than a pedagogue, circulating through groups to track conversation, push further definition, and clear up lingering misconceptions (Slavin, 2020).

Assessment in the Jigsaw method includes both formative and summative elements: readiness checks with high-knowledge groups, home-group synthesis products evaluation, and individual tests for all the subtopics to ensure accountability as well as wide conceptual coverage (Slavin, 2020; Johnson & Johnson, 2020). Jigsaw's collaborative approach fosters not only a grasp of material but also interpersonal skills such as active listening, turn-taking, and offering constructive feedback, so it is particularly well-suited to inclusive and diverse science classrooms (Gillies, 2019). Scientific thinking, mastery of content, and motivation of students are all improved by Jigsaw when it is implemented with fidelity, clear interdependence, rigorous expert training, accountability, and teacher facilitation research indicates (Tran, 2022). For example, in ecologic or physics contexts, students learn to build causal models or system accounts in groups, enhance capacity for generalization across settings, and realize gains in conceptual knowledge and motivation (Tran, 2022; NASEM, 2019).

The Jigsaw model of science relies on deliberate division of material, aided expert preparation, organized peer instruction, individuals' accountability, and facilitation by the teacher. If the above elements are harmoniously mixed together, student cooperation can be used by teachers to remake science learning from rote memorization to constructive, socially mediated, and sustained understanding of complex scientific ideas.

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2.4.1 Benefits of the jigsaw model

The Jigsaw Model, a cooperative learning technique developed by Aronson et al during the 1970s, is widely applied within science classrooms to enhance collaboration, promote understanding, and create equity. Its architecture within science education, in which students are first "experts" on multiple topics of an issue before teaching others, provides both cognitive and social advantages (Gillies, 2019; Slavin, 2020).

Smith et al. (2021) highlight that structured peer instruction improves conceptual performance in STEM when coupled with immediate feedback and well-designed prompts, aligning with cooperative routines used in jigsaw. Sharan (2019) reviews evidence that the jigsaw model advances both academic achievement and peer interdependence by assigning each student unique expertise that the group needs, thus raising accountability and engagement. Topping (2018) also synthesises peer learning studies and notes consistent benefits for comprehension and transfer when students teach content to one another which is a core feature of the jigsaw strategy.

One of the significant strengths of the Jigsaw Model in science is that it can enhance conceptual understanding. The model requires learners to work at a high level of cognition by explaining to others, which aligns with the social constructivist idea that learning is built by actively engaging (Vygotsky, 1978).

Studies have concluded that students in Jigsaw learn scientific concepts for extended durations and with greater precision than the conventional method of lecture-based instruction (Tran, 2022). In a physics class on electricity, for instance, Wieman et al. (2020) found that students in Jigsaw settings performed significantly better on problem-transfer tasks, which reflect greater conceptual integration.

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Johnson and Johnson (2020) noted that Science is inherently collaborative, and the Jigsaw Model captures that reality through its focus on teamwork and collaboration. The position of each student as an "expert" creates a sense of responsibility to express oneself in a comprehensible and effective way, listen to, and build on others' inputs. Gillies (2019) observes that this guided collaboration builds scientific discourse skills, such as questioning, elaborating, and defending ideas with evidence, that are crucial for scientific inquiry.

The Jigsaw Model's design ensures that each student contributes meaningfully to the learning experience, reducing the potential for domination by an individual or group (Gillies, 2019). In science lessons, disparities in participation often along gender or ethnic lines often limit participation (NASEM, 2019). The method achieves this by giving each learner unique, nonreplaceable information, ensuring that each voice matters, promoting equity and inclusivity in learning science (Tran, 2022).

Slavin (2020) explained motivation as a key to science attainment, and cooperative learning strategies like Jigsaw learning model have been proven to increase it through interdependence and ownership. Johnson and Johnson (2020) also highlighted that if learners know that their peers rely on them in learning a part of the material, there are greater opportunities for them to engage more with the material. Research further suggests that the interactive version of Jigsaw learning model fights the passivity that is characteristic of the lecture method, and it boosts more excitement regarding scientific subjects (Osborne et al., 2020).

Other studies indicated that Jigsaw learning model strategies in science go further than rote memorization in requiring students to synthesize, analyze, and apply information in order to solve problems. For instance, in the study of ecological systems, students

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may be required to bring together their "expert" contribution with that of others to build an integrated model of ecosystem interactions (NASEM, 2019). Such originality of activities enhances scientific reasoning and critical thinking, processes valued by higher STEM education and career (Wieman et al., 2020).

The Jigsaw Model aligns with today's science education reforms emphasizing inquiry, cooperation, and relevance to life. Through student-to-student knowledge sharing, Jigsaw enables hands-on experimentation, data analysis, and scientific argumentation (NASEM, 2019). The combination of cooperative learning and inquiry approaches makes it simpler for students to realize science is an active, interactive procedure, rather than a lifeless set of facts.

2.5 Instructional Challenges in Teaching Electricity

Teaching electricity comes with some instructional challenges that students carry with them to electricity courses strongly held intuitive conceptions. For instance, that electric current is "consumed," that a battery is an object of constant current, or that one wire can "deliver" current with no back path. These perceptions are coherent with students' informal reasoning and therefore stable unless instruction actively elicits, stimulates, and rebuilds them (Posner et al., 1982; Treagust & Duit, 2020). Conceptual change is also disrupted when instruction emphasizes answer-retrieval over sense-making such that students "overlay" equations on intact misconceptions (McDermott & Redish, 1999/2019). An old problem is to allow students to separate concepts (voltage and current) and relations among them (how potential difference and resistance both influence current; how energy and charge flow differ). Students are reported to assign flow-like properties to voltage and substance-like properties to current, leading to local but not system-level circuit thinking (Engelhardt & Beichner, 2004; Kautz et al., 2005;

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Treagust & Duit, 2020). Without representational work targeted explicitly at it (Kirchhoff reasoning, tracking energy, and charge flow models), students resort to part-wise explanation that breaks down in new arrangements.

Learning about electricity is based on representational competence with some external representations of circuit diagrams, graphs (I–V curves), vector/potential diagrams, and qualitative models like "traffic" or "water" analogies. Learners can be devoid of representational competence to map between these representations, and this limits conceptual integration (Ainsworth, 2019). Analogies may support or hinder: unless boundaries are represented, the "water" analogy, for example, may fix the "current depletion" conception (Kautz et al., 2005; Treagust & Duit, 2020).

Study conducted by McDermott and Redish, (1999/2019) reported that electricity acquisition frequently begins with algebraic manipulation of Ohm's law and series/parallel laws, masking conception gaps. They again stated that students can compute but perform no better than guess at predicting qualitative changes (e.g., brightness change) or considering energy and power. STEM education research warns that procedural fluency without concept is shaky knowledge with poor transfer reported by (Rittle-Johnson & Schneider, 2021).

Becker et al. (2020) and Treagust & Duit, (2020) stated that booklet problems induce local thinking (looking only "near the bulb" or "near the resistor") rather than systemic limitations (conservation, Kirchhoff's laws) and Over-coverage and pacing need to break up electricity into small topics current today, voltage tomorrow so that coherent mental models are not developed. Phenomenon or problem-led sequences are proposed but not applied (NASEM, 2019).

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Multiple-choice tests on traditional pages do not typically expose reasoning but rather investigative tools like DIRECT (Determining and Interpreting Resistive Electric Circuits Test) and CSEM (Conceptual Survey of Electricity and Magnetism) bring typical patterns of misunderstanding into view, but most classrooms still employ numerical items that are rewarded by plug-and-chug routines (Engelhardt & Beichner, 2004; Maloney et al., 2001). Current work proposes explanation-focused prompts, two-tier items, and argumentation tasks to bring conceptual models into focus (Osborne et al., 2020; Sadler et al., 2020).

Research highlighted that practical circuits can be powerful tools for learning, but equipment diversity, hidden resistances, dead batteries, and safety constraints render frequent evidence impossible to obtain within class time. As experiments become recipe mode, students work with parts without making connections between observations and underlying principles (NASEM, 2019). Budget kits and scripted inquiry help but involve instructors in spending time debugging tasks and making data-to-theory connections.

Interactive simulations (e.g., PhET) are capable of representing unseen quantities (charge flow, potential) and enable effective experimentation, but unguided exploration can degrade into trial-and-error without conceptual payoff (Ainsworth, 2019; Zacharia & de Jong,2014). Sound designs incorporate predict-observe-explain cycles, explicit representation translation, and intentional prompts to prevent known misconceptions (NASEM, 2019; Ifenthaler & Yau, 2020; Tsai & Chai, 2021).

Teaching electricity entails Pedagogical Content Knowledge (PCK) in relation to student-sensitized common ideas, conceptual routes, and task orders that emerge and reorganize thinking. Teachers refer to uncertainty in regards to revealing

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misconceptions, organizing whole-class discussion of contradictory models, and balancing qualitative and quantitative work (Rollnick & Mavhunga, 2020). Teacher beliefs that emphasizing speed/coverage inadvertently reproduce formula-first approaches that undermine conceptual goals (Treagust & Duit, 2020).

2.6 Comparing the Jigsaw learning model and Traditional Teaching strategies

This section of the literature review compares the use of Jigsaw and the Traditional Teaching methods under the following sub-themes.

1. Learning Outcomes & Conceptual Understanding

The traditional approaches typically teacher-fronted lectures and direct teaching concentrates on procedural fluency and memorization by rote but might shortchange conceptual understanding (Slavin, 2020). The Jigsaw Model, however, engages students in teaching and clarification, which solidifies their mental structure and scientific concepts retention (Gillies, 2019). Evidence from physics classroom work shows that Jigsaw learners are more conceptually accomplished and transfer learning better than their conventionally taught counterparts (Tran, 2022; Wieman et al., 2020).

2. Student Engagement and Motivation

The conventional methods yield passive learning, especially for low-achieving or disengaged students who get overshadowed (Slavin, 2020). Conversely, Jigsaw strategy fosters positive interdependence because each student has responsibility for a unique part of the material, significantly increasing motivation, responsibility, and active engagement (Johnson & Johnson, 2020). The research indicates that even low-starting motivation students show increased participation and persistence in the Jigsaw groups (Tran, 2022).

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3. Communication & Collaborative Skills Development

Lecture-style learning will limit the potential for argumentation, discussion, and negotiation between peers, key to scientific thought (Osborne et al., (2020). The Jigsaw Model, on the other hand, embeds formal peer-to-peer interaction: students learn to summarise, ask clarifying questions, and synthesize different pieces of knowledge. The collaborative learning enhances scientific argumentation skills, such as developing evidence-based arguments and constructing conceptual models (Gillies, 2019; Osborne et al., 2020).

4. Classroom Equity and Inclusivity

In normal classrooms, strong students dominate conversation and marginalized groups can get silenced sometimes, leading to unequal learning dynamics (Gillies, 2019). Jigsaw, as a method, assigns every student a critical task, hence promoting more inclusion and self-efficacy on ability and demographic grounds (Gillies, 2019; NASEM, 2019). Evidence shows that Jigsaw has the ability to close achievement gaps and create more balanced peer relations (Tran, 2022).

5. Cognitive Load and Information Processing

Lectures and text-based instruction tend to introduce massive amounts of information in disconnected bits with high cognitive load on students and restricted processing (Slavin, 2020). Jigsaw subdivides content into bite-sized units, processes them thoroughly in "expert groups," and then asks students to rebuild the entire thing, thereby decreasing overload and increasing integration (Johnson & Johnson, 2020). The sequential stages of expert preparation, instruction, and synthesis facilitate cognitive consolidation.

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6. Teacher Role and Instructional Demands

Traditional instruction places the teacher at the centre as the sole source of information. Lesson planning and teaching become simple but limit student autonomy. In Jigsaw, the facilitative role is adopted by the teacher with peer teaching guided, class life supervised, and content fidelity ensured (Gillies, 2019; Slavin, 2020). While more challenging to organise, requiring careful grouping, prepared materials, and supervision, the teacher's burden produces deeper learning.

7. Use of Time and Pacing

Traditional teaching can fit more content into a shorter period since it is one-way in nature (Slavin, 2020). The Jigsaw Model, however, is time-intensive with time for expert group work, peer teaching, reinforcement, and assessment. Though coverage takes longer, depth and long-term retention of learning could justify the cost (Gillies, 2019; Tran, 2022).

8. Compatibility with Science Education Reform

Frameworks like the NGSS today focus on three-dimensional learning; integrating disciplinary core ideas, science practices, and crosscutting concepts based on inquiry, modelling, and argumentation (NASEM, 2019). Traditional methods lack this integration. Jigsaw has a natural fit for these practices through enabling student exploration, scientific dialogue, and conceptual integration in a collaborative setting (Johnson & Johnson, 2020; Osborne et al., 2020).

9. Scalability and Adaptation

Traditional lectures are easily scalable to class size and environment. Jigsaw requires careful planning and sorting and is therefore more challenging to implement in large or poorly resourced classes. That said, when well-supported with materials (expert

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packets, rubrics) and procedures, Jigsaw scales well and can even be developed for online or blended delivery (Tran, 2022).

2.6 Students' Attitudes toward Learning Science and Electricity

Students' attitudes towards science, that is, interest, perceived relevance, self-efficacy, and value, are strong predictors of persistence, achievement, and future STEM participation (Osborne et al., 2003; Potvin & Hasni, 2014). Large-scale research consistently reports that while most students begin school interested in the natural world, attitudes to school science can decline across the secondary years, especially where teaching emphasises coverage and recall instead of inquiry and sense-making (Bennett et al., 2007; Osborne & Dillon, 2008). Current frameworks, therefore, promote classrooms that integrate disciplinary core ideas with scientific practices and crosscutting concepts in order to sustain interest and good attitudes (National Academies of Sciences, Engineering, and Medicine [NASEM], 2019).

A consistent finding is the two-way relationship between pedagogy and attitudes. Active learning approaches through cooperative learning, problem-based questioning, modelling, and argumentation for performance improvement and also altering affective measures such as enjoyment, interest, and beliefs about learning science (Freeman et al., 2014; Osborne et al., 2020). Long, teacher-centred lecturing, however, can lead to passivity and lower perceived competence, particularly among students who are already uncertain of their competence in science (Slavin, 2020). Formative assessment and feedback practices are also significant: when assessment is about growth and meaning-making rather than high-stakes rightness, students report higher science self-efficacy and more favourable attitudes (Black & Wiliam, 2018; Glynn et al., 2011).

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Attitudes are both topic-specific and general. Electricity (DC circuits and introductory electromagnetism) is well documented as being conceptually challenging; students' tendency to confuse current, voltage, resistance, and energy can result in frustration and the view of physics as "hard" or insurmountable (Engelhardt & Beichner, 2004; Kautz et al.,2005). When instructional and learning procedural formulas like Ohm's law are presented before conceptual foundations, students may experience procedural success while retaining misconceptions of an experience, with the consequence of undermining confidence and interest (McDermott & Redish, 1999/2019). By contrast, conceptually oriented approaches featuring hands-on investigations, representational reasoning (for instance, energy tracking, Kirchhoff-like constraints), and discussion among peers have been found to produce both conceptual gains and more positive attitudes toward electricity (Dori & Belcher, 2005; Wieman et al., 2020).

Attitudes are measured using validated questionnaires that distinguish dimensions of interest, value, self-efficacy, and perceptions of the nature of science. Classic instruments are the Test of Science-Related Attitudes (TOSRA; Fraser, 1981) and the Science Motivation Questionnaire II (SMQ-II; Glynn et al.2011). Physics-specific questionnaires such as the MPEX (Maryland Physics Expectations Survey; Redish et al.,1998) and CLASS (Colorado Learning Attitudes about Science Survey; Adams et al., 2006) assess beliefs about learning physics (whether physics involves memorising formulas or understanding phenomena). Studies using these tools find that interactive engagement reliably leads to more expert-like ideas and improved affect, while traditional methods reliably lead to neutral or even negative shifts (Adams et al., 2006; Freeman et al., 2014).

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Technology-enriched contexts could be instrumental in electricity. Interactive simulations (e.g., PhET) visualise intangible amounts of charge flow, potential difference, and fields, which allow prediction, observation, and explanation cycles that reduce cognitive load and enable productive struggle. Combining simulations with collaborative work improves attitudes and learning if they are supplemented by questions that counteract previously identified misconceptions (Wieman et al., 2020; Zacharia & de Jong, 2014). Studio-based innovations (MIT's Technology-Enabled Active Learning in electromagnetism) similarly report increased engagement and more supportive attitudes compared to lecture-recitation approaches (Dori & Belcher, 2005).

Attitudes also overlap with equity. Meta-analyses record ongoing gender and socioeconomic gaps in interest and self-efficacy, particularly in physical sciences (Potvin & Hasni, 2014). Such gaps are not inescapable; when classrooms make inclusive discussion habits front and centre, collaborative planning (guided group roles), and culturally responsive events, differences narrow and engagement expands (NASEM, 2019; Osborne et al., 2020). In electricity, making links explicit to everyday contexts, such as home wiring, safety devices, and renewable power systems, boosts perceived relevance and reverses the impression of physics as abstract and far removed from life (Osborne & Dillon, 2008; NASEM, 2019).

Coherence within units impacts attitudes in the long term. Disconnected sequences (current week, voltage next) with no anchoring phenomenon can lead to students possessing disconnected facts and low perceived meaning. At the same time, narrative designs that circle back to a puzzling event (e.g., why the same bulbs light up differently series vs. parallel) create purpose, identity as sense-makers, and more stable positive attitudes (NASEM, 2019). Briefly, students' attitudes towards science in general, and

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electricity specifically, are strengthened when instruction emphasises sense-making with ideas, collaboration, representation-rich inquiry, formative feedback, and connection to everyday life; they are weakened when instruction emphasises rapid coverage, procedural islands, and high-stakes testing.

2.6.1 Influence of teaching strategies on students' attitudes

Instructional strategies strongly influence the attitudes of students toward learning, the subject matter, and the learning process as a whole. An effective instructional strategy not only guarantees the development of knowledge but also fosters positive dispositions such as motivation, curiosity, and confidence (Slavin, 2020). Ineffective strategies, conversely, could lead to disengagement, anxiety, and undesirable learning attitudes.

Instructional method impacts student engagement, which is inextricably linked with attitudes towards learning. Active instruction approaches such as cooperative learning, problem-based learning, and inquiry-based learning promote engagement, enhance collaboration, and create ownership of the learning process, thereby engendering more positive attitudes (Freeman et al., 2014). On the other hand, passive approaches like lengthy lecturing create low levels of interaction and reduced enthusiasm for the subject (Prince, 2021).

One fundamental consideration in shaping attitudes is to provide congruence of teaching strategies with the learning style and needs of students. Teaching strategies that allow for differentiation, such as using visual aids, group discussion, and experience-based learning, tend to increase the attractiveness of the subject in the minds of the students as well as their willingness to learn (Tomlinson, 2017). For example, when it comes to science instruction, the use of inquiry and experimental methods has

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been shown to make students better understand the subject and less apprehensive about complex issues (Osborne & Dillon, 2008).

Besides, social dynamics generated by some strategies influence attitudes significantly. Collaborative strategies, such as the Jigsaw method, promote peer interaction and reduce feelings of isolation, leading to increased motivation and belongingness (Aronson & Patnoe, 2011). If the students believe that the classroom environment is inclusive and supportive, then they will develop positive attitudes towards learning procedures and the subject under study (Wentzel, 2014).

Assessment strategies are also crucial in shaping attitudes. Formative assessment strategies, which emphasise feedback and improvement rather than punishing grading, have been shown to foster a growth mindset and positive learning attitudes (Black & Wiliam, 2018). In contrast, high-stakes summative assessment approaches have been shown to create performance anxiety and negative attitudes toward learning (Harlen, 2013).

Interestingly, the teacher's pedagogical content knowledge (PCK) and classroom adaptation capacity also influence student attitude. Good teachers with the ability to modulate styles to provide relevance, challenge, and support will be more successful in promoting a healthy and long-lasting disposition to learn (Shulman, 1986; Darling-Hammond et al., 2020).

In summary, instructional strategies are powerful determinants of student learning attitudes. Active, student-involving, inclusive, and feedback-oriented strategies tend to promote positive attitudes, while rigid, teacher-involving, and high-stakes strategies tend to encourage negative attitudes. Teachers' sensitivity and deliberate use of

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strategies responsive to the needs and preferences of learners are determinative in promoting positive attitudes towards education.

2.6.2 Research evidence on jigsaw and student attitudes

Research that has experimentally tested the effects of the Jigsaw method on student attitudes has consistently reported positive gains in motivation, participation, self-efficacy, and interpersonal climate in class when the method was implemented with integrity. Early reports of Jigsaw emphasised its social and affective objectives by reducing intergroup conflict and increasing empathy, along with cognitive benefits (Aronson, 2002). More recent empirical and review studies in education research and science classrooms have extended the argument further: structured peer teaching enhances students' feelings of relevance and responsibility, and this results in a more positive attitude towards learning (Johnson & Johnson, 2020; Gillies, 2019). Meta-analytic and synthesis reports of cooperative learning tend to indicate that strategies involving positive interdependence and individual accountability will likely increase not only achievement but also attitudes and interpersonal relationships; Jigsaw is a prototypical strategy to this genre and is aided by these benefits when the key components of the strategy are preserved (Slavin, 2020; Johnson & Johnson, 2020).

Osborne et al. (2003) observed that Attitudes encompass interest, motivation, confidence, and perceptions of relevance and also positive attitudes are linked with higher performance and long-term retention, while negative attitudes often deter students from pursuing advanced science learning.

Different classroom studies and case studies document attitude increases specifically attributed to Jigsaw. Tran's mixed-ability classroom study recorded increased participation, feelings of belonging, and readiness to participate after regular Jigsaw

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practice, with increases most substantial for students who were typically passive in whole-class discussion (Tran, 2022). Parallel classroom experiments in the STEM setting suggest that students who are exposed to Jigsaw-shaped tasks exhibit increased interest and motivation compared to control groups taught via lecture, particularly when expert-group preparation was focused on practical or simulation-based exercises that made material meaningful and tangible (Wieman et al., 2020; Freeman et al., 2014). These findings are in line with larger active-learning research that has shown that collaborative, student-driven practices will more likely produce more positive affective outcomes than passive lecture-based methods (Freeman et al., 2014).

Qualitative research also provides additional insights as to why Jigsaw supports attitudes. Data from interviews and observations indicate that the students enjoy the model's reciprocity knowing that people rely on them enhances ownership and pride, and that teaching others solidifies the learners' sense of themselves as competent knowers (Gillies, 2019; Osborne et al., 2020). The peer-to-peer aspect of the task tends to solidify peer relationships and reduce anxiety about voice, especially among more reserved or lower-status students who gain concentrated, critical roles in groups (Gillies, 2019; Tran, 2022). In science, where conceptual difficulty and the fear of mathematics can undermine confidence, these role- and social-defined traits appear particularly salient for improving attitudes toward challenging material (NASEM, 2019).

However, the evidence similarly indicates necessary moderators: Jigsaw's favourable attitudinal effect is not a fait accompli and depends heavily on implementation fidelity, teacher facilitation, and task and material design. Reviews indicate that when teachers provide fewer scaffolds, unclear roles, or superficial expert preparation, Jigsaw can

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degenerate into uneven participation, free-riding, or reinforcement of errors, thus outcomes harmful to attitude and motivation (Gillies, 2019; Slavin, 2020). Several empirical tests have shown minor or no attitude effects when the approach was applied without teacher training, without accountability mechanisms (individual quizzes), or in classrooms that lack positive peer interaction norms (Slavin, 2020; Johnson & Johnson, 2020). Fidelity of practice through explicit expert materials, preparedness checks, teacher monitoring, and planned talk moves is a determinant of attitudinal gains.

Contextual moderators also appear important. Evidence from cultural and ability contexts shows that Jigsaw can equalise participation gaps and promote inclusion when groups are heterogeneous and roles are rotated, but care is required where classes are big or provision is impoverished and expert preparation resources or synthesis time are constrained (Tran, 2022; NASEM, 2019). Supplemental use of technology (simulation activities or shared online expert centres) can enhance affective effects by rendering content more interactive and by facilitating asynchronous expert preparation. However, unguided online activities are unlikely to produce similar affective benefits in the absence of facilitation (Wieman et al., 2020).

Overall, the weight of evidence suggests that Jigsaw, when well structured and carefully led, has a positive effect on students' attitudes toward learning through heightened engagement, motivation, self-efficacy, and peer-relatedness. The social interdependence nature of the model and the fact that each student is tasked with teaching an essential part of the material seem to be responsible for these outcomes. Simultaneously, research cautions that poor implementation or lack of support can suppress or even undermine these benefits, making teacher preparation, measures of

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accountability, and intentional task design necessary to operationalise Jigsaw into improved student attitudes in the science classroom.

2.7 Retention of Learned Concepts

Retention of learned concepts refers to students' ability to store information in long-term memory and reproduce it accurately over time to utilise it in multiple situations (Baddeley et al., 2020). It is a significant indicator of meaningful learning, distinguishing rote memorisation from complex understanding (Bransford et al., 2018). Good retention ensures not just that students memorise facts but also apply concepts to solve problems and in real life in a flexible way.

Cognitive psychology research points out that retention is dependent upon the depth of processing during learning, frequency and quality of practice, and the level of suitability of material to the learner (Craik & Lockhart, 1972; Weinstein et al., 2018). When students process information in detail, question, and explain it, they encode concepts better, and it is then stored for retrieval over the long term (Fiorella & Mayer, 2016). This accords with constructivist learning theories in education, which point out that students learn more effectively when they build knowledge through social interaction and active engagement (Vygotsky, 1978; Mayer, 2021).

Retention of concepts like electricity, force, or energy tends to be difficult in science learning as the students learn to memorise definitions without actually placing them into a coherent conceptual framework (Duit & Treagust, 2019). Misconceptions regarding science are perpetuated when early learning is superficial or out of the context of previous knowledge. It has been found through research that retention is significantly increased with teaching methods that include addressing misconceptions and multiple attempts at using the learning across contexts (Hestenes et al., 2021; Chi, 2009).

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Learning strategies such as spaced repetition, retrieval practice, and cooperative learning have been shown to enhance retention more effectively than massed learning or passive receipt (Kang, 2016; Dunlosky et al., 2013). For instance, the Jigsaw cooperative technique facilitates retention by requiring students to explain to others, which involves retrieval, reorganisation, and explanation of activities known to consolidate memory traces (Gillies, 2019).

Roediger and Butler (2011) demonstrate the 'testing effect', retrieval practice consolidates knowledge and improves long-term retention; when cooperative tasks incorporate explanation and low-stakes quizzing, durable learning is enhanced.

Freeman et al. (2014) demonstrated that active learning reduced failure rates and promoted longer-term achievement across STEM.

Moreover, multimodal instruction, which combines visual, auditory, and kinesthetic displays, further maximises retention through engaging more than one cognitive channel (Mayer, 2021).

Motivation and affective engagement are also major contributors to retention. Students who view content as personally significant or affectively engaging are more likely to process it deeply and retain it for long periods (Immordino-Yang & Damasio, 2007; Pekrun, 2021). In STEM fields, problem-solving exercises, interactive simulations, and experiential experiments increase intrinsic motivation, leading to stronger learning outcomes (Wieman et al., 2020).

However, retention is not solely the product of student engagement; teacher support and formative testing contribute toward ensuring that material learned is repeated at frequent intervals (Black & Wiliam, 2018). Lacking any review and practice, even the

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initially well-learned material is at risk from the "forgetting curve" described by Ebbinghaus (1913), which demonstrates how memory decays exponentially as a function of lack of practice.

2.7.1 Effect of jigsaw learning model on retention

Retention of learned principles is a significant index of teaching effectiveness, reflecting the extent to which students can retain and apply knowledge in the long run (Sousa, 2017). Jigsaw Learning Model, one of the cooperative learning strategies developed by Aronson (1978), has been intensively explored for its impact on the ability of students to retain knowledge, particularly in science education. Through active participation, peer teaching, and collective problem-solving, the model facilitates deeper cognitive processing, to which long-term memory construction is highly connected (Slavin, 2020).

Research shows that the Jigsaw model promotes retention by active engagement of students in teaching and learning roles. By instructing others to learn about concepts, students engage in elaborative rehearsal, a process that is well-documented to consolidate neural pathways and aid long-term retention (Fiorella & Mayer, 2015). This is an example of learning-by-teaching, where preparing to teach and teaching others improve the quality and durability of learning (Duran, 2017).

Empirical studies have consistently shown positive effects of the Jigsaw technique on control versus retention, teacher-centred methods. For example, evidence was offered by Ghaith and El-Malak (2019) that students who studied through Jigsaw-based instruction fared better on post-delayed tests compared to students instructed by lecture-driven strategies. Similarly, Yadav et al. (2021) reported that Jigsaw class participants

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understood concepts in physics better over four weeks based on increased engagement and cooperative problem-solving.

Johnson and Johnson (2020) argue that group accountability and interdependence ensure repeated practice and deeper encoding of information. A second explanation of improved retention in Jigsaw learning is the distributed cognitive load among group members. By subdividing materials into smaller pieces that can be handled and allowing students to be "experts" on specific sections, the approach circumvents cognitive overload without sacrificing mastery over assigned topics (Kirschner et al., 2006). The procedure encourages learners to summarise information from multiple perspectives, strengthening conceptual connections and making it easier to recall.

The social interaction involved in Jigsaw learning also assists with retention as it constructs socially shared cognition. Through negotiating and discussing meaning, learners tend to encode information in more modalities (verbal, visual, and contextual), thus supporting retrieval in the long term (Vygotsky, 1978; Johnson & Johnson, 2017). This is particularly significant in science education, where abstract topics like electricity are supported by peer explanation and collaborative reasoning.

However, there are cautions from some research that Jigsaw's retention advantages are dependent on successful deployment. Poor group composition, lack of responsibility, or insufficient time to enable expert group deliberation may limit retention gain (Tran & Lewis, 2012). Mills and Alexander (2020) caution that if group processes are poorly structured, some learners may rely on peers without consolidating individual understanding; jigsaw mitigates this by assigning unique subtopic expertise to each student. Facilitation by teachers, group creation, and role clarification are thus needed to achieve the optimal retention capability of the model.

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2.7.2 Research on retention in electricity concepts

Retention of electricity is students' ability to remember and apply key concepts such as current, voltage, resistance, and circuit response over time after initial instruction (Dunlosky et al., 2013). Concepts in electricity are conceptual and prone to misconception, for example, a blend of current and voltage or a concept that the current is "used up" in a circuit that will go unchecked in the absence of targeted conceptual change strategies (Clement, 1982; Duit & Treagust, 2012). Research has validated that active learning approaches such as cooperative learning and inquiry-based experiments significantly boost long-term retention compared to traditional lectures (Kibirige & Tsamago, 2019; Zacharia & de Jong, 2014).

Repetition retrieval, real-world application, and multimodal teaching approaches are therefore essential to cementing memory and understanding in this field.

Ghaith and El-Malak (2019) found that learners using Jigsaw scored higher on delayed post-tests than those taught through traditional instruction. Yadav et al. (2021) reported that physics students retained conceptual understanding for at least four weeks when taught using Jigsaw.

Aprilia and Dwandaru (2025) found that Jigsaw enhanced retention in physics problem-solving tasks, attributing this to peer explanation and collaborative accountability. Nikolova et al. (2025) observed that Jigsaw promotes knowledge retention in mathematics and science by fostering enthusiastic engagement.

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CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This chapter covers the research process that was used in the study. It includes the research approach and design, population of the study, sampling procedures and sampling size, research instruments used for data collection, data collection procedure, data analysis, and ethical considerations.

3.1 Research Design

In analysing the effect of teaching methods across various schools and classrooms, utilising a quasi-experimental research design is more practical (Lee, 2025; Sims et al., 2023). This research employed a quasi-experimental design, where participants were not randomly assigned to groups; instead, they were grouped naturally or assigned for reasons other than sample randomisation. Quasi-experimental research design involves utilising pre-established groups without the random assignment of participants (Dewi et al.,2022).

As stated by Fraenkel et al. (2019) quasi-experimental design facilitates group comparisons while taking into account practical constraints in educational environments where random assignment might not be possible.

This design consisted of two groups, thus an experimental group and a control group. Before the intervention, both groups underwent a pre-test to confirm the students' homogeneity. The experimental group received the intervention using the jigsaw learning model strategy, while the control group was instructed through the conventional teaching method. Following the intervention, a post-test was administered to both groups to assess whether the jigsaw learning model affected students'

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performance and retention (dependent variable). A five-point Likert-scale questionnaire (quantitative tool) was also used to measure students' attitudes (dependent variable) towards the jigsaw model.

3.2 Population of the Study

Population refers to the total set of individuals to whom the research findings are intended to generalise (Fraenkel et al., 2019). In this study, the target population consisted of all 1,050 Form Two students and accessible population consisted 80 Form Two Visual Arts students in Mawuli School, Ho, in the Volta Region of Ghana. The researcher purposefully selected this population in accordance with academic relevance, developmental readiness, and the potential to benefit from the intervention under study, and the chosen topic to be treated aligns with the integrated science syllabus of the Ghana Education Service.

According to the Ghana Education Service (GES, 2022), the Integrated Science curriculum aims to develop critical thinking and problem-solving skills through inquiry and experiential learning.

In addition, Form Two students were selected as the target population because they are advancing where abstract reasoning and collaborative learning are beginning to mature (Piaget, as cited in Mayer, 2020). This age group is generally better positioned to benefit from structured cooperative learning activities, such as the jigsaw learning model, compared to their younger counterparts (Vygotsky, 1978; Slavin, 2020).

Moreover, recent studies in Ghana have stated that students in technical and vocational-related classes, such as Visual Arts, often perform below in integrated science subjects than those offering general science in science-based assessments (Owusu et al., 2021).

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As a result of the identification of this gap, the researcher adopted this innovative teaching strategy, which includes and adapts to the learning needs of all student groups, regardless of their academic abilities.

The researcher's decision to focus its findings on a single senior high school was due to logistical and administrative factors. Still, the selected school represents many urban public schools in Ghana in terms of student demographics, availability of resources, and curriculum implementation. As such, the population is considered appropriate for assessing the potential effect of the jigsaw learning model strategy on students' conceptual gains, attitudes, and retention in electricity.

3.3 Sampling Technique and Sample

Sampling refers to the process of selecting a subset of individuals from a larger population for the purpose of conducting research (Creswell & Creswell, 2018). Purposive sampling, a type of non-probability sampling, allows researchers to select participants who are exceptionally knowledgeable about or experienced with a phenomenon of interest.

In this study, a purposive sampling technique was employed to select a total of 80 Form Two students from the Visual Arts classes. The selected participants were divided into two intact classes, which were randomly assigned to either the experimental or control group. This design enhances internal validity by controlling for group differences at the outset (Fraenkel et al., 2019).

The sample consisted of 40 students from Visual Art 2A and 40 students from Visual Art 2 B. These students were selected based on researchers' accessibility, and the chosen topic to be treated is from the Form Two topic, which aligns with the integrated

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science syllabus of the Ghana Education Service. Achievability considerations, including instructional time, group management, and evaluation plans, informed the researcher's decision to limit the sample to 80 students.

Within this framework, the researcher used purposive sampling to focus on this group of students to ensure comparability in the implementation and evaluation of the jigsaw learning model.

In all, purposive sampling was selected due to its suitability for intervention-based educational research, allowing for targeted selection of participants best suited to provide reliable and relevant data regarding the effectiveness of the jigsaw learning model on conceptual gains, attitude, and retention.

3.4 Research Instruments for Data Collection

To collect valid and reliable data for this study, the researcher designed and utilised three distinct instruments. These included Student Achievement Tests (SATs), Student Attitude Questionnaire (SAG), and a Retention Test (RT). Each instrument was developed to align with the specific objectives of the study and underwent rigorous validation and reliability testing.

3.4.1 Student achievement test

There were two Student Achievement Tests (SAT 1 and SAT 2) with similar items were used to assess students' performance of the selected concept before and after the implementation of the jigsaw learning model. SAT 1 was used as the pre-test, and SAT 2 was used as the post-test. Both SAT 1 and SAT 2 were made of a thirty-item instrument, made up of multiple-choice questions with four response options, A-D. Each test item had one correct answer and three distractors. The multiple-choice test

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items were developed from the senior high integrated science teaching syllabus and units of the Senior high integrated science textbooks, which were taught during the intervention period of the study. Both tests lasted 45 minutes and were scored one mark for correct responses and zero marks for incorrect responses. The maximum and minimum scores were 30 and 0, respectively.

Three science education experts reviewed the instrument to establish content validity and revised it accordingly. The test was piloted on another group of students (not part of the study sample), and a reliability coefficient of 0.81 was obtained using the Kuder-Richardson Formula 20 (KR-20), indicating high internal consistency.

3.4.2 Student attitude questionnaire (SAQ)

A questionnaire was developed to collect quantitative data to assess students' attitudes in the experimental group towards the learning of electricity concepts using the Jigsaw learning model after its implementation. Since the jigsaw learning model was a novel teaching strategy introduced to the students, it was essential to find out from students who were exposed to this intervention their feelings towards this new strategy. The SAQ comprises of two sections; the first part was to get background information about the students while a second part consisted of 10 items based on 5point Likert-scale which focused on student' Enjoyment, Perceived Usefulness, Peer Interaction, and Motivation on the use of jigsaw strategy instruction with 'strongly agree', 'agree', 'neutral', 'disagree' and 'strongly disagree'. Scores of 1, 2, 3, 4, and 5 were assigned, respectively. For each item, students were requested to indicate their responses by ticking the appropriate column.

The SAQ was informed by previous instruments used in attitude assessment in cooperative learning contexts (Gillies, 2016) and was adjusted to fit the local school

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context. Curriculum specialists and educational psychologists reviewed the instrument for face and content validity. This was also piloted on students who are not part of the sample under study, and the test yielded a Cronbach's alpha of 0.87, indicating high reliability.

3.4.3 Retention test (RT)

The Retention Test was administered two weeks after the post-test to measure students' long-term retention of concepts taught during the intervention. The RT contained 30 multiple-choice questions with four answer options (A-D). Each test item had one correct answer and three distractors. The test items were parallel to SAT 2 but readjusted to reduce recall based on rote memorisation. It also lasted for 45 minutes and was scored one mark for correct responses and zero marks for incorrect responses. The maximum and minimum scores were 30 and 0, respectively. This approach followed recommendations by Semb and Ellis (1994) on effective measurement of knowledge retention.

The retention test was reviewed and validated by science education experts and aligned with the integrated science syllabus and instructional materials used during the intervention. The KR-20 coefficient was 0.79, indicating acceptable reliability.

3.5 Validity and Reliability of the Instruments

3.5.1 Validity procedures

Validity refers to the extent to which an instrument measures what it is intended to measure (Creswell & Creswell, 2018). To ensure the instruments used in this study were valid, different validation procedures were followed:

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3.5.2 Content validity

Each instrument was reviewed by a panel of three experts in science education and curriculum design. The experts examined the alignment of items with the learning objectives in the Integrated Science syllabus and the constructs being measured (electricity concepts, attitude, and retention). Revisions were made based on their feedback to improve clarity, relevance, and coverage.

In addition to formal reviews, continuous consultation with university research supervisors and experienced educational evaluators aids in restructuring the instruments to meet academic research standards.

According to Fraenkel et al. (2019) this process ensured that the instruments were representative of the domain content.

3.5.3Face validity

The instruments were reviewed by two senior Integrated Science teachers who assessed the overall appearance, clarity of instructions, and student comprehensibility. Their feedback aids the researcher in refining item phrasing and format to enhance user-friendliness, particularly for the Student Attitude Questionnaire.

These steps contributed to enhancing the validity of the data collection instruments, thereby strengthening the internal and external validity of the research findings.

3.5.4 Reliability of instruments

Reliability refers to the consistency and stability of measurement over time. It is an essential aspect of instrument development to ensure that results are dependable and replicable (Fraenkel et al., 2019). The reliability of the SAT 1 and SAT 2 was established through pilot testing with 30 students of the same academic background.

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The internal consistency was measured using the Kuder-Richardson Formula 20 (KR-20), which is suitable for dichotomously scored items (correct/incorrect). The KR-20 value was 0.81, indicating high reliability.

Student Attitude Questionnaire (SAQ): For the SAQ, internal consistency reliability was computed using Cronbach's alpha, which measures how closely related a set of items is as a group. A reliability coefficient of 0.87 was obtained, which is above the 0.70 threshold commonly accepted for psychological scales, indicating strong reliability. The Retention Test also underwent reliability testing using the KR-20 method. A coefficient of 0.79 was obtained, which is considered acceptable for educational assessments, especially those involving cognitive domains.

These reliability coefficients attest that the instruments produced stable and consistent results during the pilot testing session. Due to that, the instruments were considered for use in the main study.

3.6 Data Collection Procedure

The data collection procedure followed a structured process to ensure consistency and minimise biases. The procedure was conducted in four segments over a period of eight weeks, including pre-intervention, intervention, and post-intervention. The procedure was carefully designed to align with the study's objectives, ensuring the collection of valid, reliable, and meaningful data to assess students' performance in electricity concepts, their attitudes, and retention levels under the influence of a conventional teaching strategy and the Jigsaw learning model.

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3.6.1 Pre-intervention (week 1)

Before the collection of data began, the researcher sought permission from the headmaster, head of departments, and other colleague teachers. Verbal and written informed consent were obtained from students, with a clear explanation that participation was voluntary and responses would be kept strictly confidential. The researcher informed the participants of their anonymity and their right to withdraw at any time. The researcher now informed students of the purpose of the study.

After the introduction, the researcher administered the Student Achievement Test (SAT 1), which comprises thirty multiple-choice questions with four answer options (A-D), to all participants, both the control and experimental group, to measure their prior knowledge in electricity concepts. The test items covered electricity concepts such as current, voltage, resistance, Ohm's Law, series and parallel circuits, and the daily application of electricity. The test (SAT 1) was designed in alignment with the senior high integrated teaching syllabus. Each test item had one correct answer and three distractors. The test (SAT 1) lasted for 45 minutes with strict invigilation to ensure fairness and standardisation. Students' scripts were thereafter collected for assessment. Each test item was scored one mark for correct responses and zero marks for incorrect responses. The maximum and minimum scores were 30 and 0, respectively. The results were recorded, coded, and analysed. After collecting scripts from students in the experimental group, the researcher assigned students to jigsaw learning groups based on stratified purposive sampling to ensure a mix of abilities and gender. As stated by Slavin (2014), this approach helps to ensure diversity and balance in each group.

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3.6.2 Implementation of intervention (Weeks 2–5)

The intervention involved four weeks of instruction with an instructional plan designed for both the Experimental Group and the Control Group. Each week focused on specific electricity concepts aligned with the Integrated Science teaching syllabus. Weekly lessons were structured based on the following syllabus objectives:

Objective 1: Identify and describe current, voltage, and resistance.

Objective 2: Explain and apply Ohm's Law.

Objective 3: Differentiate between series and parallel circuits.

Objective 4: Apply electricity in daily life and solve fundamental circuit problems.

3.6.3 Intervention activities

Instructional activities for the control group (conventional teaching strategies)

In this context, the researcher served as the facilitator.

Introduction activities:

i. The facilitator writes the topic on the board.
ii. The facilitator asks the participants (students) questions to get information on their relevant previous knowledge (RPK) of the topic.
iii. The students answer the questions asked by the facilitator.
iv. The facilitator establishes a link between their appropriate responses and the lesson to be taught for the day.

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Presentation Activities

i. The facilitator describes, defines, and explains the concept to be taught to students.
ii. The facilitator demonstrates to the students how each concept will be processed.
iii. The students observe and listen to the facilitator's demonstration and explanation of the concept and make comments on their observations.

Evaluation activities:

i. The facilitator summarises the lesson by asking students what they have learnt during the teaching period.
ii. ii. The facilitator assesses students on the concept taught by giving samples of questions to answer.

Instructional activities for the experimental group (Jigsaw learning model strategy)

The researcher who serves as the facilitator informed students about the day's lesson.

Formation of Home Groups

i. Students were placed into four heterogeneous jigsaw groups consisting of 10 students each. Students' academic ability, gender, and age are taken into account.
ii. A student from each group was chosen to be a leader.
iii. The facilitator shares the objectives of the lesson with each group.
iv. The leader instructed each student to learn and also conduct more research on the objectives assigned to them.

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Performance of Task by Students

i. Students were given instructions and enough time to read around their assigned objectives to become more equipped with them.
ii. Students carried out the activities given to them.
iii. Students write down the standard features, properties, and solve mathematical problems where necessary.
iv. They analyse the components of the activities before them and write down the various aspects of their section.
v. Students brought up different ideas and new knowledge about what they learnt.

Formation of Expert Groups

i. Expert groups were temporarily formed by taking one student from each jigsaw group to join other students assigned to the same section.
ii. Students in the expert group were given enough time to discuss the main points of their section and fully prepare to present their findings to home groups and the whole class.
iii. Students in the expert groups now return to their home groups, and each of them is asked to present his or her findings to the home group and the class.
iv. The rest of the students in the class were encouraged to ask questions in order to get more clarification.
v. Summary Activity
vi. The facilitator summarises the relevant points after the presentation by the students.
vii. Evaluation Activities

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viii. The facilitator gives a test on the material so that students can quickly come to realise that they have performed well and that their performance is not just for fun and games but really counts. The facilitator takes note of the students' answers and rewards them accordingly.

3.6.4 Post-intervention stage (Week 6-8)

After the completion of the intervention, a post-test administration was conducted by the researcher for students in both experimental and control groups using the instrument (SAT 2) to examine the differences in conceptual understanding between students taught electricity concepts using the jigsaw learning model and those taught using traditional instructional strategies.

The test items in SAT 2 were similar to those in SAT 1. SAT 2 also comprises thirty multiple-choice questions with four answer options (A-D). The test (SAT 2) follows the duplicate content in (SAT 1). The test (SAT 2) was also designed in alignment with the senior high integrated teaching syllabus. Each test item had one correct answer and three distractors. The test (SAT 2) also lasted for 45 minutes with strict invigilation in order to ensure fairness and standardisation. Students' scripts were thereafter collected for assessment. Each test item was scored one mark for correct responses and zero marks for incorrect responses. The maximum and minimum scores were 30 and 0, respectively. The results were recorded, coded and analysed.

After the test (SAT 2), the researcher administered the Student Attitude Questionnaire (SAQ) to students to assess their attitudes towards the jigsaw learning model following the intervention. Students were given 20 minutes to complete the questionnaire. Thereafter, the questionnaire papers were collected.

Two weeks after the post-test, the Retention Test (RT) was administered by the

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researcher to assess students' long-term retention of the electricity concepts. This test also comprised thirty multiple-choice questions, based on SAT 2. The questions were reframed and adjusted to avoid rote memorisation. Students were not aware of this test (RT); therefore, they had to be taught the content naturally to recall it. The scoring was the same as the SAT 2. This schedule was based on recommendations by Semb and Ellis (1994), who emphasise the importance of delayed assessment in measuring proper retention.

All data were collected solely by the researcher to maintain consistency and minimise bias. The entire process was designed to uphold ethical research standards and ensure the credibility of the findings.

3.7 Data Analysis Techniques

Data analysis is the process of breaking down and carrying out statistical calculations of raw data to find a solution to the questions initiating a particular study. Statistical Package for Social Science (SPSS) software was used to analyse data obtained from the research findings.

In analysing research question one and three, descriptive statistics were employed to examine the differences in conceptual understanding between students taught electricity concepts using the jigsaw learning model and those taught using traditional instructional strategies, as well as the effect of the jigsaw learning model on students' retention of the electricity concept. The pre-test, post-test, and retention test scores obtained from both the control and experimental groups were compared in terms of mean scores and standard deviation. Inferential statistics, specifically a paired sample t-test with a coefficient alpha level of 0.05, were employed to determine if there was a statistically significant difference in the implementation of the jigsaw learning model

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strategy before and after. An independent sample t-test was also used to find out whether there was any statistically significant difference between the post-test and retention test scores of both the control group (conventional teaching strategy) and the experimental group (jigsaw learning model strategy).

Research question two was analysed using data collected from 10 structured questionnaires items completed by students in the experimental group after the post-test. This analysis aimed to answer the research question "What is the attitude of students towards learning the concepts of electricity when taught using the jigsaw learning model strategy?" The five Likert-scale questionnaires focused on students' Enjoyment, Perceived Usefulness, Peer Interaction, and Motivation on the use of the jigsaw strategy instruction.

3.8 Ethical consideration

Ethical guidelines such as informed consent, tolerance for anonymity and confidentiality, data storage and privacy were followed by the researcher. The researcher sought ethical approval from the Science Education Department of the University of Education, Winneba, which was sent to the schools to obtain their consent to conduct the study. All of the participants were issued informed consent forms to fill out and sign. Only respondents who agreed to participate in the study were included. Conducting the research in the schools was approved and endorsed by the school management. The researcher communicated with the school authorities, teachers and students with respect to the purpose and nature of the study. All protocols in the data collection were explained to the respondents.

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CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

This chapter presents the demographic of participants, results and discussion of findings of the study that investigated the use of the jigsaw learning model strategy as a tool to address senior high school students' conceptual understanding, attitude, and retention in electricity concepts. Data were collected using a pre-test, a post-test, a retention test, and an attitude questionnaire. The data obtained were organised and presented using descriptive statistics, standard deviation, means, and inferential statistics, including independent sample t-test and paired sample t-test. The findings were analysed using the literature, noting whether these were consistent with or divergent from the existing body of knowledge.

4.1 Presentation of Results and Discussion

Table 1: Demographic presentation of participants

Age	Frequency	Percentage
15-16	20	25
17-18	48	60
19-20	12	15
Total	**80**	**100**

The age distribution shows that majority of participants (60%) were between 17 and 18years, Students aged 15-16 years constituted (25%) of the sample,while 15% were between 19-20 years. The relatively narrow age range suggest that participants were at comparable developmental stages which support internal validity and analysis of the study.

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4.1.1 Research question 1

What is the difference in conceptual understanding between students taught electricity concept using the jigsaw learning model and those taught using traditional instructional strategies?

To answer research question 1, a descriptive and inferential statistics of pre-test and post-test of both experimental and control group was computed in the tables below.

Table 2: Descriptive statistics of students taught using the jigsaw learning model strategy and those taught using traditional instructional strategies

Group	Number	Test	Mean	Std Deviation
Experimental	40	Pre-test	14.55	1.55
		Post-test	27.08	1.42
Control	40	Pre-test	13.40	1.03
		Post-test	18.20	1.04

Table 2: compares the pre-test and post-test results of students in both the experimental and control groups. In the experimental group, the results indicated an improvement in students' conceptual understanding of electricity concepts in the post-test.

The mean score of students in the pre-test was 14.55, while that of the post-test was 27.08, with a mean gain of 12.53. In contrast to the control group, the mean score of students in the pre-test was 13.40, while that of the post-test was 18.20, with a mean gain of 4.80. This showed that in the post-test, every student's conceptual understanding increased slightly in the control group. To determine if the observed difference in means is statistically significant, an independent sample t-test and a paired samples t-test were conducted to examine whether there is a substantial difference in the conceptual

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understanding of students taught using the jigsaw learning model strategy compared to those taught using traditional Instructional strategies.

Table 3: Results of independent sample t-test comparing pre-test scores of experimental and control groups

Group	Test	Mean	Std Deviation	T	df	Sig(2-tailed)
Experimental	Pre-test	14.55	1.55	3.91	78	0.001
Control	Pre-test	13.40	1.03			

P<0.05 = significant

In table 3, a t (3.91) score with 78 degrees of freedom was found to be significant p = 0.001 with alpha level (p<0.05). this result indicated that there was a significant difference between students taught with jigsaw learning model and those taught with traditional instructional strategies. It was again observed that the mean score of experimental group (M =14.55, SD =1.55) was higher than that of control (M =13.40, SD = 1.03) with a marginal mean difference. This indicated that the experimental group had slightly conceptual understanding of electricity concept than the control group.

Testing null hypothesis H_{01}: There is no significant difference in mean conceptual understanding scores between students taught electricity concepts using the Jigsaw model and those taught using traditional instructional strategies.

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Table 4: Results of Independent Sample t-test Comparing Post-test scores of Experimental and Control Groups

Group	Test	Mean	Std Deviation	T	df	Sig (2-tailed)
Experimental	Post-test	27.08	1.42	31.84	78	0.001
Control	Post-test	18.20	1.04			

P <0.05 = significant

In Table 4, it was observed that the t (31.84) score with 71.55 degree of freedom was related to the difference between the post-test scores of both experimental and the control group was found to be significant p =0.001 with alpha level (p <0.05) which indicated that there was a significant difference between the two variables. Again, in table 4, experimental group had a mean (M = 27.08, SD = 1.42) scored which is higher compared to the control group (M = 18.20, SD = 1.04). This result indicated that students taught with the jigsaw learning model achieved greater conceptual understanding than those taught using traditional instructional strategies. This again showed that the jigsaw model had a significant positive effect on students' conceptual understanding of electricity concepts.

Table 5: Results of Paired Sample t-test Comparing Pre-test and Post-test Scores Experimental Group

Test	Mean	Std Deviation	T	df	Sig (2-tailed)
Pre-test	14.55	1.55	-42.74	39	0.001
Post-test	27.08	1.42			

p <0.05 = significant

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Regarding the experimental group, the paired sample t-test results showed the mean score (M = 14.55) had increased to (M =27.08) between the post-test and pre-test. The results showed that after students were taken through the intervention, their conceptual understanding of electricity has improved. Thus, the jigsaw learning model strategy had a positive effect on students' conceptual understanding of electricity concepts. The results from Table 4.4 showed a statistically significant increase in students' conceptual understanding with t (-42.74) and $p < 0.001$ at alpha level ($p< 0.05$). This indicated that the jigsaw learning model strategy had a significant effect on student conceptual understanding.

The results from the fidings revealed that the jigsaw learning model strategy had effects on students conceptual understanding of electricity concepts. There were significant difference in students' conceptual knowledge in the two intervention groups with jigsaw learning model strategy have the higher positive effects while traditional instructional strategies had lower positive effect. Since the p-value was below the 0.05 alpha level, the null hypothesis which stated that there is no statistically significant difference in conceptual understanding between the two groups, was rejected. Rejecting the null hypothesis confirms that the jigsaw learning model strategy promoted conceptual understanding of students in the concepts of electricity than those taught with traditional instructional strategies even though there was a slight improvement in their post-test results.

This finding agrees with the work of Chi and Wylie (2019) who argue that deep conceptual learning arises when learners actively explain and restructure knowledge rather than merely receiving information. According to Treagust & Duit (2020) Traditional teaching often leads students to memorise formulas without grasping the

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underlying concepts. This helps explain why students in the control group made only marginal gains. Vygotsky (1978) reported that the collaborative and student-centred nature of the jigsaw strategy created opportunities for learners to operate within their zone of proximal development, where peers scaffolded each other's understanding.

Fredriksson and Peltonen (2023) and Engelhardt and Beichner (2004) also reported that students identified electricity as one of the most conceptually challenging areas in physics, with the notion that current is something that is "consumed" as it flows, and batteries are constant current sources. Duit & Treagust (2018) noted that these notions of students persist even after instructions with traditional strategies. The current study findings demonstrate that the jigsaw learning model strategy is an effective pedagogical strategy in addressing deeply ingrained student misconceptions. By requiring students to become "experts" and explain their assigned subtopics to colleagues, this process encourages students to confront and articulate their reasoning, which in turn exposes and corrects misconceptions.

This finding also aligns with the work of Kesonen et al. (2021), who reported that Finnish secondary school students engaged in cooperative learning displayed fewer notions about electric circuits than those taught traditionally. Chiu and Chung (2018) similarly found that Taiwanese students taught electricity through collaborative learning strategies demonstrated stronger conceptual understanding and fewer errors in problem solving. Both studies affirm that the peer interaction central to cooperative learning strategies, such as the jigsaw learning model, provides students with fertile ground for conceptual reconstruction.

Moreover, conceptual change theory emphasises that students' notions cannot simply be replaced with correct knowledge but rather experience cognitive conflict and

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reconstruct their mental models (Posner et al., 1982). The jigsaw learning model creates precisely such conditions, as students are confronted with alternative explanations from peers, which encourages reflection and restructuring. This agrees with Treagust and Duit (2020), who noted that conceptual change requires social negotiation and opportunities for learners to test the adequacy of their own ideas. Wieman et al., (2020) highlighted that students taught with interactive engagement strategies performed better than those taught using traditional instructional strategies. Likewise, Chi et al. (2018) found that active learning improved students' reasoning and transfer of knowledge in STEM, reinforcing the present finding that interactive learning is important for developing conceptual understanding. Cooperative learning is increasingly being recognised as a necessary antidote to rote-based instruction. Similarly, Ogunleye (2021) found that Nigerian secondary students developed a deeper conceptual understanding of current and resistance when taught using peer-learning methods. These findings are directly aligned with the outcomes of this study, showing that jigsaw learning has relevance and efficacy in West African classrooms.

Further evidence from Zydney et al. (2019) also stated that collaborative modules improved conceptual understanding in physics more effectively than individualised learning. These findings extend the applicability of cooperative strategies beyond secondary schools, confirming that the benefits persist across educational levels.

4.1.2 Research Question Two

What is the attitude of students towards learning the concepts of electricity when taught using the jigsaw learning model strategy?

Students' attitude towards learning electricity concepts in the experimental group after the intervention were analysed using descriptive statistics. Table 6 showed the

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descriptive statistics of attitude questionnaire scores obtained by students in the experimental groups after the implementation of the intervention.

Table 6: Descriptive Statistics for Students' Attitudes Toward Learning Electricity Concepts using the Jigsaw Learning Model

statements	items	SD	D	N	A	SA
I enjoyed participating in the Jigsaw learning activities during electricity lessons	E1	0(0%)	0(0%)	10(25%)	10(25%)	20(50%)
Learning about electricity through the Jigsaw method was fun and interesting.	E2	0(0%)	0(0%)	15(37.5%)	10(25%)	15(37.5%)
The Jigsaw strategy helped me understand electricity concepts better than traditional teaching methods.	U1	0(0%)	0(0%)	10(25%)	15(37.5%)	15(37.5%)
Working in groups helped me grasp difficult electricity topics more easily.	U2	0(0%)	0(0%)	13(32.5%)	13(32.5%)	14(35%)
The Jigsaw method helped me apply electricity concepts to real-life situations	U3	0(0%)	0(0%)	15(37.5%)	15(37.5%)	10(25%)
I learned a lot from my peers during the group discussions	P1	0(0%)	1(2.5%)	15(37.5%)	12(30%)	12(30%)
The group work encouraged me to actively listen and share ideas	P2	0(0%)	0(0%)	10(25%)	12(30%)	18(45%)
The Jigsaw approach made me more interested in learning about electricity	M1	0(0%)	0(0%)	10(25%)	12(30%)	18(45%)
I was motivated to study electricity topics to contribute meaningfully to my group	M2	0(0%)	0(0%)	15(37.5%)	13(32.5%)	12(30%)
I would like to use the Jigsaw method in other science topics as well	M3	0(0%)	0(0%)	12(30%)	13(32.5%)	15(37.5%)

Key words: SD=Strongly Disagree, D=Disagree, N=Neutral, SA=Strongly Agree and A=Agree

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Across all ten attitude items, the results revealed positive attitudes toward the jigsaw method. Notably, no student selected “Strongly Disagree” for any item, and only one student (2.5%) selected “Disagree” across the entire questionnaire items. This suggests that there was no negative attitude towards the jigsaw learning model strategy.

The “Neutral” category accounted for a moderate proportion of responses across items, ranging from 25% to 37.5%. This indicates that while many students expressed positive attitudes, some of the students remained undecided about some aspects of the jigsaw learning model approach. Interaction and motivation recorded the highest positive attitudes. For item P2, “The group work encouraged me to actively listen and share ideas,” 45% strongly agreed and 30% agreed. Similarly, in item M1, where 45% strongly agreed that “the Jigsaw approach made me more interested in learning about electricity”. The higher percentages highlighted the social and motivational strengths of the jigsaw learning model, which relies on teamwork, accountability, and shared responsibility. Items measuring enjoyment and usefulness also demonstrated high positive responses. For item E1, 50% of students strongly agreed and 25% agreed that “I enjoyed participating in the Jigsaw learning activities during electricity lessons”. Same as, items U1 and U2 showed that over 70% of students agreed or strongly agreed that “The Jigsaw strategy helped me understand electricity concepts better than traditional teaching methods and working in groups helped me grasp difficult electricity topics more easily”.

Although items such as U3 (25% strongly agree), M2 (30% strongly agree), and M3 recorded slightly lower agreement level, majority of students responses still fell within positive range. These results indicated that the jigsaw learning model had positive effect on student attitude towards learning of electricity concepts.

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The results revealed that the jigsaw learning model strategy changed the classroom environment into one that was more collaborative, enjoyable, motivating and relevant. Such a strong affective response provides evidence that the jigsaw learning model not only promotes cognitive outcomes but also creates the kind of supportive learning environment necessary for sustained engagement and long-term success in science education.

The findings of this study are in alignment with research evidence that cooperative learning fosters engagement, motivation, and positive dispositions toward learning of science (Gillies, 2019; Slavin, 2020). Tran (2022) and Freeman et al. (2014) also conducted similar studies and observed that the Jigsaw learning model increases participation, belonging, and enjoyment among students who are otherwise passive recipients in traditional instructional classrooms.

Engelhardt & Beichner (2004) also noted that students viewed electricity as an abstract and complex topic, leading to negative attitudes in many students when taught using traditional instructional strategies. Osborne et al., (2020) argue that student-centred strategies sustain positive attitudes by linking learning with social interaction and usefulness. The strong attitude outcomes in this study confirm the affective benefits of active and cooperative strategies over teacher-centred strategies.

The results agree with research that students' affective responses strongly influence their persistence, engagement, and future career pathways in STEM (Osborne et al., 2020). In Ghana,Ntow (2019) reported that many students approach physics topics, particularly electricity, with apprehension and low confidence due to the challenging and mathematical nature of the concepts. The positive responses observed in this study

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suggest that the jigsaw learning model approach modifies this problem by fostering a more supportive, collaborative, and enjoyable classroom climate among students.

Theoretically, these findings can be explained by the Social Interdependence Theory (Johnson & Johnson, 2013), which states that when students recognise that their success depends on the success of their peers, they develop stronger bonds, intrinsic motivation, and a sense of shared responsibility. This is in alignment with the current study, where students expressed enjoyment and motivation, likely because they were not passive receivers of knowledge but active contributors. Slavin (2020) supports this by noting that cooperative learning enhances students' self-efficacy and sense of belonging, which leads to vital affective outcomes of students.

Studies conducted by Gillies (2019) stated that cooperative learning structures enhance students' willingness to participate and foster more respectful interactions among peers, leading to positive classroom experiences. Similarly, Freeman et al. (2014) conducted a meta-analysis of STEM classrooms and reported that active learning strategies reduced failure rates and significantly improved student satisfaction and engagement. In a physics-specific context, Topping (2018) found that peer tutoring increased academic confidence and positive attitudes, mirroring the current study's results on peer interaction. Furthermore, Tran (2022) confirmed that students in jigsaw classrooms expressed more enjoyment and lower anxiety levels in science learning. These findings agree strongly with the high enjoyment and motivation scores observed in the study.

Ogunleye (2021) noted that science learners in sub-Saharan Africa often view physics as difficult and complex. However, students develop more positive attitudes when teaching methods integrate collaboration and relevance. The present study provides evidence that this principle applies directly to Ghanaian classrooms, in which the jigsaw

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learning model made electricity concepts feel more approachable and helpful to students. From a psychological perspective, Self-Determination Theory states that motivation flourishes when learners' needs for autonomy, competence, and relatedness are met. The jigsaw learning model structure satisfies these needs where students exercise autonomy by preparing as "experts," build competence through mastering subtopics, and experience relatedness through interdependent group work. This theoretical alignment explains why motivation scores were particularly high in this study.

It is worth noting, however, that not all literature uniformly supports cooperative learning approaches like the jigsaw learning model. For instance, Smith et al. (2021) reported that cooperative strategies sometimes make some students not participate because the more dominant students take control over the discussions while quieter peers contribute less. Similarly, Sharan (2019) cautioned that teamwork could occasionally underline existing differences among students without careful teacher facilitation. These concerns highlight that cooperative learning is not automatically effective in enhancing students' conceptual understanding, but rather depends on how well it is structured, facilitated, and monitored. Despite these cautions, the overwhelmingly positive attitudes observed in the present study suggest that such problems were effectively modified. With scaffolding of roles in the jigsaw learning model, where each student becomes an "expert" responsible for a subtopic, all participants were ensured to be accountable and empowered to contribute. This is in alignment with the recommendations of Johnson and Johnson (2013), who reported that positive interdependence and individual accountability must be deliberately embedded in cooperative learning designs. Thus, while the literature acknowledges potential

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challenges, the current study demonstrates that these limitations can be overcome with thoughtful implementation to yield highly positive outcomes.

4.1.3 Research Question Three

What is the effect of the jigsaw learning model strategy on students' retention of the concepts of electricity?

To answer research question 3, paired sample t-test was used to compare the post-test and retention test of students in the experimental group. Table 7 shows the analysis results.

Table 7: Paired sample t-test to compares post-test and retention test scores for experimental group

Test	Mean	SD	t-value	df	Sig(2-tailed)
Post-test	27.08	1.42	5.72	39	0.001
Retention test	25.95	1.26			

$p < 0.05$ = significant

A t-test was used to explore whether there were differences between the scores of post-test and retention test in the experimental group. The t-test value pertaining to differences in post-test and retention test given to students two weeks after the post-test was found to be significant at a level of 0.001 ($p<0.05$). When the table was analysed, it was observed that retention test mean ($M = 25.95$, $SD = 1.26$) was slightly lower than the post-test mean ($M = 27.08$, $SD = 1.42$).

This result showed a modest decline in scores over the retention period.

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Though there was a slight decrease compared to the post-test, the retention test scores remained significantly higher than pre-test scores in experimental group, confirming that the jigsaw method is not only effective for immediate learning but also beneficial for maintaining knowledge over time.

This result conforms to the findings of Bransford et al., (2018), who emphasise that knowledge acquired through active engagement and meaning-making is more resistant to forgetting than rote memorisation. Duit & Treagust (2018), who noted that retention of knowledge has long been a challenge in science education, particularly in complex domains like electricity, where students often revert to misconceptions over time. The durability of learning observed in this study suggests that the jigsaw model promotes deeper conceptual connections that persist beyond the initial learning episode.The findings can also be understood through Fiorella and Mayer's (2015) generative learning theory, which proposes that students retain more when they actively explain, elaborate, and teach knowledge. In the jigsaw approach, learners had to study their assigned subtopic, explain it to group peers, and later integrate it into a collective understanding. These elaboration, retrieval, and reconstruction processes are known to strengthen memory consolidation, which explains why retention remained high in this study.

The findings of this study again support the theoretical assertion that active, socially mediated learning leads to stronger encoding in long-term memory (Vygotsky, 1978; Mayer, 2021).

Studies conducted by Ghaith and El-Malak (2019) reported that Lebanese secondary physics students taught with the jigsaw model demonstrated significantly better long-term recall than those taught traditionally. Similarly, Yadav et al. (2021) found that

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cooperative learning approaches led to improved retention of challenging science topics among Indian high school students, attributing this to the frequent peer dialogue and repeated explanation inherent in group learning. In a meta-analysis, Chi et al. (2018) confirmed that active learning strategies consistently improved conceptual understanding and retention across STEM fields.

In Ghana, Boateng and Essel (2019) argued that peer scaffolding in cooperative classrooms allows students to revisit concepts multiple times, reinforcing their long-term understanding. The results of the present study strongly agree with these findings.

It is also important to note how the jigsaw model differs from traditional instruction in fostering retention. According to Treagust & Duit (2020), under traditional instructional-based teaching, students often rely on memorisation of facts and formulas, which decays quickly without application or elaboration. In contrast, the jigsaw method requires learners to repeatedly engage with the material first as individuals, then in expert groups, and finally in home groups. This repeated exposure mirrors the principles of spaced retrieval practice (Roediger & Butler, 2011), a strategy shown to enhance long-term retention.

However, as with attitudes, not all literature is uniformly supportive. Kirschner, Sweller, and Clark (2006) argued that minimal guidance approaches may overload learners' working memory, leading to poorer retention of some concepts. Similarly, Mills & Alexander (2020) found that team-based learning can sometimes result in unequal knowledge acquisition among students, as they rely heavily on peers without consolidating individual understanding. These concerns raised by research underscore that cooperative learning does not guarantee automatic retention of concepts, but its effectiveness depends on thoughtful design and scaffolding. In the present study, the

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careful forming of expert and home groups appears to have modified these challenges, ensuring that all students engaged in both independent and collaborative processing of knowledge.

Taken together, the evidence showed that the jigsaw learning model promotes retention of electricity concepts by engaging students in active, generative processes that strengthen memory traces. The durability of learning observed here underscores the power of cooperative, constructivist approaches in overcoming one of the most persistent challenges in science education.

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CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the findings of the study, the conclusion, recommendations based on the findings, and suggested areas for future research.

5.1 Summary of findings

This study examined the effect of the jigsaw learning model on senior high school students' conceptual understanding, attitudes, and retention in the study of selected electricity concepts. Three objectives guided the research; to examine the differences in conceptual understanding between students taught electricity concepts using the jigsaw learning model and those taught using traditional instructional strategies; to find out students' attitudes toward learning electricity concepts when taught using the jigsaw learning model; and to assess the retention of conceptual understanding of electricity concepts among students after instruction using the jigsaw learning model.

A quasi-experimental research design was used, involving 80 Form 2 Visual Arts students (40 Visual Arts 2A and 40 Visual Arts 2B) who were purposively assigned to two intact groups: the experimental group, which received instruction through the jigsaw learning model, and the control group, which was taught through the traditional instructional strategies. The intervention lasted four weeks. A 30 multiple-choice test item was used as the pre-test, post-test, and retention test to assess students' conceptual understanding. Additionally, a 10 Likert-scale attitude questionnaire measured students' attitudes towards using the jigsaw learning model in learning electricity concepts. Data collected were analysed using SPSS Version 27, employing independent samples t-tests, paired samples t-tests and descriptive statistics.

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From the findings, it can be highlighted that students taught using the jigsaw learning model strategy achieved significantly higher scores on the post-test (M = 27.08, SD = 1.42) than those taught using traditional instructional strategies. This result indicates that the jigsaw learning model strategy is effective in fostering deeper learning, which leads to a deeper understanding of concepts among students.

The second research objective's findings indicate that students express positive attitudes towards learning electricity concepts through the jigsaw learning model strategy, with higher attitude scores.

The third research objective also indicates that the jigsaw learning model promotes long-term retention of the electricity concepts. Even though there was a slight decrease compared to the post-test result, the retention test remained significantly higher than the pre-test result, indicating students learned the concepts not just for examination purposes but for future purposes.

5.2 Conclusion

In conclusion, the study found that the jigsaw learning model was effective in improving students' conceptual understanding of electricity concepts compared to traditional instructional strategies. The effectiveness of this strategy was observed with a significant improvement in the experimental group's post-test result.

Additionally, the study found that students express higher positive attitudes towards learning electricity concepts through the jigsaw learning model, and the strategy also helps them retain more content for a longer period.

Overall, the study's findings suggest that the jigsaw learning model strategy could be valuable for teaching electricity concepts to enhance students' conceptual

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understanding. The results also provide evidence for the efficacy of active learning strategies, indicating that students may benefit from more engaging and interactive strategies in instruction.

5.3 Recommendation

1. Integrated Science and physics teachers in Mawuli school in Ho, should adopt the jigsaw learning model when teaching electricity concepts, since it has improved students conceptual understanding.
2. Jigsaw learning model strategy has the ability of developing students' communicative, collaborative skills and their skills of accessing information and utilizing it. Hence it should be adopted as one of the fundamental instructional strategies of teaching electricity concepts in Mawuli school.
3. The study indicated that the jigsaw learning model strategy improved students long-term retention of electricity concepts. Therefore, Mawuli school administrators should support the effective implementation of the jigsaw learning model.

5.4 Suggested Areas for Further Research

1. A similar investigation can be conducted in privately owned secondary schools and also involve more local government schools.
2. Other moderating variables aside from attitude and retention should be used in future studies.
3. The study should be replicated on subjects other than physics and integrated science in the same manner by adopting the two instructional strategies as used in the study.

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4. Investigate how the jigsaw model can be applied to other subtopics in electricity, such as electromagnetism or electrical power, to test its broader applicability within the electricity strand.
5. Explore how the jigsaw model affects different categories of students apart from Visual Art when learning electricity concepts.
6. Assess how integrating the jigsaw model with other interactive strategies (such as inquiry-based learning) could further enhance students' conceptual understanding of electricity.
7. Investigate challenges teachers face in implementing the jigsaw model, specifically in electricity lessons, and strategies to overcome them.

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APPENDICES

APPENDIX A

SAT 1 (PRE-TEST QUESTIONS)

STUDENT ACHIEVEMENT TEST (SAT 1)

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF INTEGRATED SCIENCE EDUCATION

The aim of this test is to find out your basic knowledge about electricity. Please respond to each item to the best of your knowledge.

Please read the following statements carefully and circle the correct answer.
School……..……
Name…….

Sex……..…
Time: 45 minutes

SECTION A [Multiple-Choice Objective Test]
Instruction: *Each question in this section is followed by four options lettered 'A' to 'D'.*
that
answer,

1. The unit of electric current is:
   A. Volt
   B. Ampere
   C. Ohm
   D. Watt

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2. Voltage is defined as:

A. The flow of charges per unit time

B. The opposition to the flow of current

C. The energy per unit charge

D. The product of current and resistance

3. Which instrument is used to measure current in a circuit?

A. Voltmeter

B. Ammeter

C. Galvanometer

D. Ohmmeter

4. Resistance in a circuit depends on:

A. Length, material, and cross-sectional area of the conductor

B. Voltage applied

C. Type of current (AC or DC)

D. Position of the ammeter

5. When resistance increases while voltage remains constant, current:

A. Increases

B. Decreases

C. Stays the same

D. Becomes zero

6. Which of the following is a correct symbol for a resistor?

A. ~

B. ——///——

C. ⊕⊖

D. ≅

7. A circuit with high resistance will:

A. Allow more current flow

B. Use less energy

C. Overheat quickly

D. Have zero voltage

8. Ohm's Law can be expressed mathematically as:

A. R = V/I

B. V = IR

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C. I = V/R

D. All of the above

9. If a current of 2 A flows through a resistor of 5Ω, the voltage across it is:

A. 2.5 V

B. 10 V

C. 7 V

D. 1 V

10. A graph of current against voltage for a metallic conductor produces:

A. A curve through the origin

B. A straight line through the origin

C. A horizontal line

D. A vertical line

11. Which of these devices obeys Ohm's Law?

A. Diode

B. Filament lamp

C. Copper wire

D. Thermistor

12. If V = 12 V and I = 3 A, the resistance is:

A. 0.25 Ω

B. 4 Ω

C. 15 Ω

D. 36 Ω

13. Which of the following is NOT a limitation of Ohm's Law?

A. It applies only to metallic conductors.

B. It is invalid at very high temperatures.

C. It cannot be applied to semiconductors.

D. It is only valid for AC circuits.

14. The slope of the V–I graph gives:

A. Current

B. Resistance

C. Voltage

D. Power

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15. In a series circuit, current is:

A. Different across components

B. The same at all points

C. Highest at the battery

D. Zero

16. The total resistance in a parallel circuit is:

A. Greater than the largest resistor

B. Equal to the sum of all resistors

C. Less than the smallest resistor

D. The product of all resistors

17. If one bulb goes off in a series circuit, the others:

A. Continue to glow

B. Go off as well

C. Get brighter

D. Flicker

18. Household wiring is done in:

A. Series

B. Parallel

C. Series-parallel

D. None of the above

19. The advantage of parallel connection of appliances is that:

A. Current is conserved

B. Each device receives full voltage

C. It requires fewer wires

D. Resistance increases

20. A circuit has three resistors in series: 2Ω, 4Ω, and 6Ω. The total resistance is:

A. 2Ω

B. 12Ω

C. 24Ω

D. 0.33Ω

21. In a parallel circuit, the current:

A. Splits among branches

B. Is the same in all branches

C. Flows only in one branch

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D. Stops at the junction

22. The effective resistance of two 4Ω resistors connected in parallel is:

A. 8Ω

B. 4Ω

C. 2Ω

D. 16Ω

23. A fuse is used in an electric circuit to:

A. Increase voltage

B. Regulate current

C. Protect appliances

D. Store energy

24. Which device converts chemical energy to electrical energy?

A. Generator

B. Motor

C. Dry cell

D. Transformer

25. Which of the following is a safety device in home wiring?

A. Switch

B. Fuse

C. Circuit breaker

D. All of the above

26. A toaster rated 1000 W, 220 V is used. The current it draws is:

A. 2.2 A

B. 4.5 A

C. 5 A

D. 10 A

27. A student connects a 12 V battery across a 6Ω resistor. The power dissipated is:

A. 12 W

B. 24 W

C. 6 W

D. 144 W

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28. Which of these reduces the risk of electrocution?

A. Earthing

B. Fuses

C. Low resistance wiring

D. Thick insulation

29. A lamp rated 60 W, 240 V consumes less power when:

A. Voltage is reduced

B. Connected in series

C. Resistance decreases

D. Current increases

30. Electricity is important in daily life because it:

A. Powers appliances

B. Provides light

C. Facilitates industry

D. All of the above

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APPENDIX B

SAT 2 (POST-TEST QUESTIONS)

STUDENT ACHIEVEMENT TEST (SAT 2)

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF INTEGRATED SCIENCE EDUCATION

Dear Students,

This test is aimed at assessing your fundamental knowledge in electricity. This is to enable your teacher adopt the most appropriate teaching approach to help you get the best

confidentially.

Name of Student: ……

Sex ……

School: ……

TIME: 45 minutes

SECTION A [Multiple-Choice Objective Test]

Instruction: *Each question in this section is followed by four options lettered 'A' to 'D'.*

that

answer,

1. Which instrument is used to measure current in a circuit?
   a) Voltmeter
   b) Ammeter
   c) Galvanometer
   d) Ohmmeter
2. The SI unit of resistance is:
   a) Coulomb
   b) Volt
   c) Ohm
   d) Ampere
3. Which of the following best describes electric current?
   a) The rate at which charge flows through a conductor
   b) The force that drives electrons through a circuit
   c) The opposition to the flow of electrons
   d) The energy consumed in a circuit

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4. If the potential difference across a bulb is 12 V and the current passing through it is 2 A, what is the resistance?

a) 6 Ω

b) 24 Ω

c) 0.17 Ω

d) 10 Ω

5. Which of the following correctly matches quantity and unit?

a) Current → Volt

b) Voltage → Ampere

c) Resistance → Ohm

d) Power → Coulomb

6. The flow of electrons in a metallic conductor is due to:

a) Movement of protons

b) Movement of neutrons

c) Movement of free electrons

d) Movement of ions

7. A 9 V battery supplies a current of 3 A. What is the resistance of the circuit?

a) 27 Ω

b) 3 Ω

c) 6 Ω

d) 12 Ω

8. Voltage is defined as:

a) Charge per unit time

b) Energy per unit charge

c) Current per unit resistance

d) Resistance per unit current

9. Ohm's Law states that:

a) $V = I/R$

b) $I = V/R$

c) $R = IV$

d) $V = IR^2$

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10. A wire has a resistance of 5 Ω. If a current of 2 A flows through it, what is the voltage across it?

a) 2.5 V

b) 5 V

c) 10 V

d) 7 V

11. Which graph correctly represents Ohm's Law for a metallic conductor?

a) A straight line through the origin

b) A curve starting from the origin

c) A horizontal line

d) A vertical line

12. A bulb of resistance 6 Ω is connected across a 12 V battery. What current flows through the bulb?

a) 2 A

b) 3 A

c) 6 A

d) 0.5 A

13. If the current in a circuit doubles while resistance remains constant, the voltage will:

a) Halve

b) Double

c) Remain the same

d) Reduce to zero

14. Which of the following devices obeys Ohm's Law most accurately?

a) Diode

b) Filament lamp

c) Metallic resistor

d) Thermistor

15. A 20 Ω resistor is connected across a 100 V supply. The current is:

a) 0.2 A

b) 2 A

c) 5 A

d) 10 A

16. In a series circuit, the current:

a) Increases as more bulbs are added

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b) Decreases as more bulbs are added

c) Remains the same through all components

d) Becomes zero

17. The total resistance in a parallel circuit is always:

a) Greater than the largest resistance

b) Equal to the average resistance

c) Less than the smallest resistance

d) The same as the largest resistance

18. Which of the following is an advantage of parallel circuits over series circuits?

a) Cheaper to connect

b) Components operate independently

c) Current is always the same in each branch

d) Easier to calculate resistance

19. Two resistors, 4 Ω and 6 Ω, are connected in series. Their total resistance is:

a) 2.4 Ω

b) 10 Ω

c) 12 Ω

d) 1.5 Ω

20. Two resistors, 4 Ω and 6 Ω, are connected in parallel. Their total resistance is:

a) 2.4 Ω

b) 10 Ω

c) 12 Ω

d) 1.5 Ω

21. In a household wiring system, appliances are connected in:

a) Series

b) Parallel

c) Combination of series and parallel

d) None of the above

22. A series circuit has three identical bulbs. If one bulb is removed, the others:

a) Become brighter

b) Remain the same

c) Go off

d) Explode

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23. In parallel connection, the voltage across each branch is:

a) The same

b) Different

c) Zero

d) Increasing with resistance

24. A fuse in an electrical appliance is used to:

a) Reduce voltage

b) Prevent overheating

c) Measure current

d) Store charge

25. Which of the following appliances uses a heating effect of current?

a) Refrigerator

b) Electric iron

c) Ceiling fan

d) Radio

26. The unit of electrical energy consumed in homes is:

a) Joule

b) Watt

c) Kilowatt-hour

d) Volt

27. Which safety device disconnects a circuit automatically when current is too high?

a) Capacitor

b) Transformer

c) Circuit breaker

d) Switch

28. A 60 W bulb and a 100 W bulb are connected to the same voltage supply. Which consumes more energy per second?

a) 60 W bulb

b) 100 W bulb

c) Both consume the same

d) Cannot be determined

29. The cost of using a 2000 W heater for 2 hours at a tariff of GH₵0.50 per kWh is:

a) GH₵1.00

b) GH₵2.00

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c) GH₵3.00

d) GH₵4.00

30. Which of the following is NOT a safe practice in electricity use?

a) Using dry hands to plug in appliances

b) Covering sockets when not in use

c) Using appropriate fuses

d) Avoiding overloading of sockets

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APPENDIX C

STUDENTS' ATTITUDE QUESTIONNAIRE (SAQ)

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF INTEGRATED SCIENCE EDUCATION

This questionnaire aims to find out the attitudes of students towards Electricity concepts. Please respond to each item to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. Your responses will be kept confidential and will not affect your examination result anywhere; it will be used only for research purposes. Thank you for taking time to complete this questionnaire.

Name of Student: …….

Sex ……..

School……..

Instruction: Each question in this section is followed by four options. Choose the most appropriate option for your answer by ticking (√) the box that corresponds to your chosen option with a pencil. If you decide to change your answer, erase the first one completely and re-tick your new choice.

Please indicate the degree to which you agree or disagree with each of the following statements.Use the scale below to respond:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

E1. I enjoyed participating in the Jigsaw learning activities during electricity lessons.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

E2. Learning about electricity through the Jigsaw method was fun and interesting.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

U1. The Jigsaw strategy helped me understand electricity concepts better than traditional teaching methods.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

U2. Working in groups helped me grasp difficult electricity topics more easily.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

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U3. The Jigsaw method helped me apply electricity concepts to real-life situations.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

P1. I learned a lot from my peers during the group discussions.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

P2. The group work encouraged me to actively listen and share ideas.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

M1. The Jigsaw approach made me more interested in learning about electricity.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

M2. I was motivated to study electricity topics to contribute meaningfully to my group.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

M3. I would like to use the Jigsaw method in other science topics as well.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

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APPENDIX D

RETENTION TEST (RT)

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF INTEGRATED SCIENCE EDUCATION

Dear Students,

This test is aimed at assessing whether the electricity concepts learned has been retained. This is to enable your teacher adopt the most appropriate teaching approach to help you get the best tuition in integrated science in subsequent days. Results of this test will be treated confidentially.

Thank you.

Name of Student: ……

Sex ……

School: ……

TIME: 45 minutes

SECTION A [Multiple-Choice Objective Test]

Instruction: *Each question in this section is followed by four options lettered 'A' to 'D'. Choose the most appropriate option for your answer by circling around the letter that corresponds to your chosen option with a pencil.* ***If you decide to change your answer, erase the first one completely and re-circle your new choice.***

1. Which device is designed to measure the amount of current passing through a conductor?
   a) Ohmmeter
   b) Galvanometer
   c) Voltmeter
   d) Ammeter
2. The standard unit used to express electrical resistance is:
   a) Volt
   b) Ohm
   c) Coulomb
   d) Ampere

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3. Electric current in a conductor is best defined as:

a) Energy per unit charge

b) Opposition to charge flow

c) Flow of charge per unit time

d) Charge stored per unit voltage

4. If a 24 V potential difference produces a current of 4 A, what is the resistance?

a) 96 Ω

b) 6 Ω

c) 20 Ω

d) 12 Ω

5. Which pair correctly matches an electrical quantity with its SI unit?

a) Resistance → Ampere

b) Voltage → Volt

c) Current → Ohm

d) Power → Coulomb

6. The flow of electricity in metals is due mainly to:

a) Motion of free electrons

b) Movement of positive ions

c) Flow of neutrons

d) Transfer of protons

7. A circuit carries a current of 1.5 A when connected to a 6 V battery. The resistance is:

a) 9 Ω

b) 4 Ω

c) 2.5 Ω

d) 3 Ω

8. The potential difference between two points in a circuit refers to:

a) Current per unit resistance

b) Energy transferred per unit charge

c) Resistance per unit time

d) Power per unit voltage

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9. Which of the following expresses Ohm's Law?

a) V = IR

b) R = IV

c) I = R/V

d) P = VI

10. A conductor of resistance 8 Ω carries a current of 3 A. The potential difference is:

a) 11 V

b) 24 V

c) 2.7 V

d) 5 V

11. The current-voltage relationship for an ohmic conductor is shown by:

a) A straight line through the origin

b) A curve rising from the origin

c) A flat horizontal line

d) A vertical line

12. A lamp of resistance 4 Ω is connected to a 20 V source. The current flowing is:

a) 80 A

b) 0.2 A

c) 5 A

d) 10 A

13. When the resistance of a circuit is constant, doubling the voltage will:

a) Reduce current by half

b) Increase current twofold

c) Leave current unchanged

d) Make current zero

14. A device that most closely follows Ohm's Law is:

a) Diode

b) Filament bulb

c) Metallic resistor

d) Thermistor

15. A 50 V supply connected across a 25 Ω resistor will produce a current of:

a) 0.5 A

b) 2 A

c) 5 A

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d) 10 A

16. In a series circuit, the size of current through each resistor is:
    a) The same
    b) Different
    c) Zero
    d) Increasing with resistance
17. The effective resistance of a parallel circuit is always:
    a) Greater than the highest resistor
    b) Equal to the average resistance
    c) Smaller than the least resistor
    d) Equal to the greatest resistor
18. A major advantage of wiring home appliances in parallel is that:
    a) It reduces cost of wiring
    b) Devices work independently of each other
    c) Current is identical in all devices
    d) It requires fewer wires
19. The combined resistance of a 3 Ω and a 5 Ω resistor connected in series is:
    a) 15 Ω
    b) 8 Ω
    c) 2.1 Ω
    d) 1.7 Ω
20. The combined resistance of a 3 Ω and a 6 Ω resistor connected in parallel is:
    a) 2 Ω
    b) 9 Ω
    c) 18 Ω
    d) 4.5 Ω
21. Household wiring systems use which type of connection?
    a) Series
    b) Parallel
    c) Series-parallel
    d) Random

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22. If one bulb is removed from a series circuit containing three bulbs, what happens?

a) The other bulbs glow more

b) The other bulbs go off

c) The other bulbs glow dimmer

d) The other bulbs remain unchanged

23. In parallel connection, the voltage across each branch is:

a) Equal

b) Increasing with resistance

c) Decreasing with resistance

d) Zero

24. The main function of an electric fuse is to:

a) Reduce current

b) Protect appliances from excess current

c) Store electrical energy

d) Convert electricity to magnetism

25. Which of the following devices makes use of the heating effect of electricity?

a) Electric fan

b) Electric heater

c) Electric bell

d) Radio set

26. The standard unit used by electricity companies to charge households is:

a) Joule

b) Watt

c) Ampere

d) Kilowatt-hour

27. Which device disconnects a circuit automatically if current exceeds a safe value?

a) Transformer

b) Circuit breaker

c) Resistor

d) Capacitor

28. A 40 W lamp and a 100 W lamp are connected to the same voltage supply. Which lamp uses more electrical energy in 1 hour?

a) 40 W lamp

b) 100 W lamp

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c) Both consume the same

d) Cannot be determined

29. The cost of running a 1500 W electric kettle for 4 hours at a rate of GH₵0.60 per kWh is:

a) GH₵1.80

b) GH₵3.60

c) GH₵2.40

d) GH₵5.40

30. Which of the following is an unsafe electrical practice?

a) Avoiding overloading of sockets

b) Using circuit breakers

c) Inserting wet hands into sockets

d) Covering sockets not in use

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APPENDIX E

MARKING SCHEMES

PRE-TEST

1. B	2. B
3. C	4. B
5. B	6. A
7. D	8. B
9. A	10. B
11. A	12. C
13. B	14. C
15. B	16. A
17. C	18. B
19. B	20. A
21. B	22. B
23. A	24. B
25. B	26. C
27. B	28. B
29. B	30. B

POST-TEST

1. B	2. B
3. C	4. B
5. B	6. A
7. D	8. B
9. A	10. B
11. A	12. C
13. B	14. C
15. B	16. A
17. C	18. B
19. B	20. A
21. B	22. B
23. A	24. B

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25. B	26. C
27. B	28. B
29. B	30. B

RETENTION TEST

1. D	2. B
3. C	4. B
5. B	6. A
7. D	8. B
9. A	10. B
11. A	12. C
13. B	14. C
15. B	16. A
17. C	18. B
19. B	20. A
21. B	22. B
23. A	24. B
25. B	26. D
27. B	28. B
29. B	30. C

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APPENDIX F

WORKSHEET FOR HOME AND EXPERT GROUPS

OBJECTIVE 1. IDENTIFY AND DESCRIBE CURRENT, VOLTAGE, AND RESISTANCE.

1. Define current, voltage, and resistance in simple terms, and what are their SI units?
2. Using a diagram, explain how an ammeter and voltmeter are connected in a circuit. Why?
3. Discuss what happens to the current when the resistance of a conductor increases while the voltage remains constant.
4. Compare conductors, semiconductors, and insulators in terms of resistance to current flow.
5. Why are metals good conductors of electricity while rubber and plastic are not?

OBJECTIVE 2. EXPLAIN AND APPLY OHM'S LAW.

1. State Ohm's Law in your own words and express it mathematically.
2. Draw and explain the graph of current against voltage for an ohmic conductor.
3. A resistor of 10 Ω is connected across a 20 V source. Calculate the current.
4. Why do some devices like diodes or filament lamps not obey Ohm's Law?
5. Design a simple classroom activity to demonstrate Ohm's Law.

OBHECTIVE 3. DIFFERENTIATE BETWEEN SERIES AND PARALLEL CIRCUITS.

1. What happens to the current in a series circuit when more resistors are added?
2. Compare the brightness of bulbs in series and parallel circuits. Why do they differ?
3. Two resistors of 4 Ω and 6 Ω are connected (a) in series, (b) in parallel. Calculate the total resistance in each case.
4. Why is household wiring done in parallel rather than series?
5. Explain, with an example, what happens if one bulb is removed in a parallel vs. series circuit.

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OBJECTIVE 4. APPLY ELECTRICITY IN DAILY LIFE AND SOLVE BASIC CIRCUIT PROBLEMS.

1. Why is it dangerous to overload sockets at home?
2. Explain how a fuse and circuit breaker protect electrical appliances.
3. An electric iron rated 1000 W is used for 3 hours daily. How much energy does it consume in one week (in kWh)?
4. Why does a 100 W bulb consume more energy than a 40 W bulb when both are connected to the same supply?
5. Discuss two common unsafe electrical practices in your community and propose safe alternatives.