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ARTICLE

Effect of Using Number Line and Tale Assisted Instruction in the Learning of Redox Reaction (Electrochemistry) in Senior Secondary School

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ABSTRACT

This research aimed to explore the impact of incorporating number line and tale assisted instruction on secondary school students in chemistry, specifically focusing on the topic of redox reactions. Additionally, the study investigated whether gender influenced student performance in learning environments utilizing these instructional methods. Employing a quasi-experimental design with a 3 x 2 factorial structure, the research involved 120 senior secondary school students (SSS II) drawn from three public secondary schools in Anambra State, Nigeria. Pre-test and post-test scores were analysed using Analysis of Covariance (ANCOVA). The results revealed that students exposed to either number line or combined number line and tale assisted instruction demonstrated significantly higher performance compared to those taught through conventional classroom instruction. Also, there was no notable disparity in performance between male and female students across the experimental groups. Drawing from these findings, recommendations were proposed to implement relevant tales assisted and number line methodologies into chemistry teaching practices within Nigerian secondary schools.

Keywords: Number line; Tale assisted instruction; Learning; Redox reaction, Electrochemistry; Senior secondary school

1. Introduction

Chemistry is a pivotal subject with widespread implications across various industries and aspects of daily life, yet many students exhibit a reluctance to engage with it, resulting in poor academic performance. This issue underscores the importance of exploring effective teaching strategies to enhance students' comprehension and appreciation of chemistry concepts. Numerous scholars have

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examined the critical role of chemistry in areas such as oil and gas, electricity, agriculture, health, environment, and more (Zuru, 2009).[17] However, despite these prospects, students continue to struggle with understanding and internalizing chemical concepts, leading to subpar performance in examinations (Ojokuku, 2012).[14]

Research indicates that the teaching methods employed in chemistry education significantly influence students' learning outcomes. Scholars have highlighted the need for educators to employ innovative and engaging teaching strategies to make chemistry more accessible and meaningful to students (Chikendu, 2022).[4] Additionally, challenges arise from students' misconceptions and difficulties in grasping fundamental concepts like redox reactions. These challenges necessitate a closer examination of teaching methods and resources to address students' learning needs effectively (Emendu, 2017;[7] Jonah J. Kyado et al., 2021).[12]

Redox reactions, in particular, serve as a cornerstone of chemistry education, yet they pose significant challenges for both students and teachers. The complexities associated with redox reactions, such as understanding electron transfer processes and balancing chemical equations, contribute to students' conceptual difficulties (Luciane et al., 2020).[13] Consequently, there is a need to explore innovative approaches to teaching redox reactions to enhance students' comprehension and engagement.

One promising avenue for improving chemistry education is the integration of storytelling and visualization techniques. Storytelling has been recognized as a powerful tool for enhancing learning experiences by fostering connections among students, ideas, and real-world applications. Through storytelling, educators can contextualize abstract concepts like redox reactions and make them more relatable and memorable for students. Furthermore, storytelling accommodates different learning styles, catering to auditory, visual, and kinesthetic learners alike.

Incorporating visual aids, such as number lines, also holds promise for enhancing students' understanding of abstract mathematical concepts, which are integral to chemistry education. Number lines serve as effective tools for developing students' number sense and operational proficiency (Factsheet, 2022).[8] By providing a visual representation of numerical relationships, number lines promote active engagement and intuitive reasoning among students (Jeffrey Frykholm, 2010).[11]

Moreover, the integration of number lines can complement storytelling techniques in teaching chemistry concepts like redox reactions. By using real-life examples, such as the role of redox reactions in lithium batteries and metal extraction processes, educators can connect abstract chemical principles with tangible applications, thereby enhancing students' motivation and comprehension (Hasan Amjad, 2022).[9] Additionally, storytelling can help elucidate complex scientific phenomena in a manner that resonates with students' personal experiences, facilitating deeper learning and retention.

The techniques for educating embraced by educators are solid determinants of accomplishment in learning. The unfortunate poor achievement of most students in science has many science instructors, educators, and guardians worried as well as the public authority. This has prompted an overwhelming quest for fitting instructing strategies that would best further develop accomplishment of science students. As per Adimoyemma (2010),[1] these techniques for showing science incorporates: Interpretive, conversation, project, exhibit, disclosure, request, individualized guidance, field trips, feeling, gaming, addressing and group educating. This suggests the utilization of number line and stories technique which includes pictorial portrayal of numbers on a straight line to reinforcing science students' psychological portrayals of number size, number connections, and numerical tasks with the goal that they could then perform and comprehend a logical peculiarity in science? This inquiry required this review into the impact of utilizing number line and stories in the instruction of redox response involving electrolysis as contextual analysis. The hope is that this strategy will militate the fear students have towards the learning of complex chemistry procedrues. Therefore, the purpose of this study was to investigate the affect of using number line and tale assisted instruction in the learning of electrolysis in senior secondary school chemistry.

Specifically, the study examined:

1. The difference in performance in chemistry of secondary school students taught using number line assisted instruction (NLAI), tale and number line assisted instruction (TNLAI), or those exposed only to conventional chemistry instruction (CI).
2. The influence of students' gender on their performance in chemistry, when they are exposed to number line assisted instruction or tale and number line assisted instruction.

Research Questions

1. Will there be any difference in the performance of chemistry students exposed to number line assisted instruction, tale and number line assisted instruction, or those exposed to only conventional chemistry instruction?
2. Does gender influence the performance of chemistry students taught chemistry with number line–assisted instruction?
3. Does gender influence the performance of chemistry students taught chemistry with tale and number line assisted instruction?

Research Hypotheses

The following research hypotheses were tested in the study.

Ho_1, there is no significant difference in the performance of students in chemistry when they are exposed to (i) number line assisted instruction, (ii) tale and number line–assisted instruction, and (iii) conventional chemistry instruction.

Ho_2, there is no significant difference between the performance of male and female students in chemistry when taught chemistry with number line assisted instruction.

Ho_3, there is no significant difference between the performance of male and female students in chemistry when they are taught chemistry with tale and number line assisted instruction.

2. Methodology

The study employed a quasi-experimental research design, specifically a pre-test, post-test, non-counterparts, non-randomized, control group design. The design incorporated a 3x2 factorial plan, involving three treatment groups: number line assisted instruction (experimental group 1), tale and number line assisted instruction (experimental group 2), and conventional chemistry instruction (control group), with a factor of two gender levels (male and female).

The experimental groups were sampled from secondary seniors chemistry students from Community High School (CHS) Nsugbe (Anambra State, Nigeria) and Nwafor Orizu College of Education Demonstration Secondary School Nsugbe (Anambra State, Nigeria). The control group was sampled from Fr. Joseph Memorial Secondary School Aguleri (Anambra State, Nigeria). Each group consisted of 40 students, with varying gender distributions. The sampling strategy aimed to align the intervention with the researchers' teaching assignments.

Research instruments included the treatment instrument, an experienced chemistry teacher, and the test instrument, Chemistry Achievement Test (CAT). The treatment involved self-instructional, interactive packages focusing on numeracy using number line and redox reactions, while the control group received conventional chemistry instruction. The CAT is comprised 30 multiple-choice questions drawn from past West African Examination Council (WAEC) chemistry papers.

Data collection involved pre-test assessments using CAT for all groups, followed by treatment implementation over five weeks. Post-test assessments were conducted using the rearranged CAT. Lesson presentations covered oxidation and reduction concepts, including mnemonic devices, models, and examples to facilitate understanding.

The development of the instructional package followed methodological phases of analysis, design, implementation, and validation. Analysis considered students' cognitive skills and evaluation instruments, while design focused on defining lesson topics. Implementation incorporated teacher input, and validation involved review by chemistry experts.

Lesson presentations emphasized conceptual clarity through questions, explanations, and mnemonic devices. Examples illustrated oxidation and reduction processes, highlighting the roles of oxidizing and reducing agents. Reduction and oxidation half-equations were explained, reinforcing understanding through practical examples.

Week 2: Numeracy using number line (for experiment class only)

The researcher introduced empty number line for addition problems in other to encourage multiple and efficient strategies of mental computation by activating and extending mental partitioning. Compensation, complementary addition, counting on are also considered. Addition commutativity and bridging through 10 reviewed.

The researcher explained relative scaling (arbitrarily mark a number, then draw a series of scaled 10's and 1's). When asked what is different about this number line, and scaffold responses appropriately.

The researcher gave the following examples:

"16+28=?" on the board above a new empty number line.

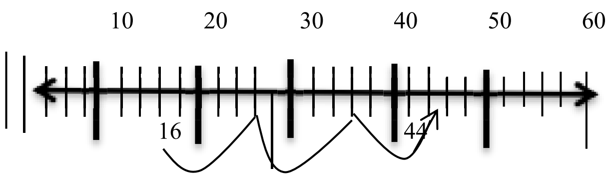


Fig. 1

"How can we solve this addition problem using an empty number line (ENL)?"

Additional examples demonstrated various strategies of adding 8 and 32 on ENL, using the following solutions and ensuring consistent scaling of the jumps: 8+(3x10)+2 (noting conversion of 30 into five 10's); 8+30+2.

The researcher asked, "If anyone can mentally add 8 + 30 prior to adding the 2?"

Explicitly add the sum of the jumps to check each solution. At this point, remind students of additive commutativity, e.g.: "When we add two numbers, is the order important? For example, 2+5 is 7, and so is 5+2, correct?"

-3 + 8

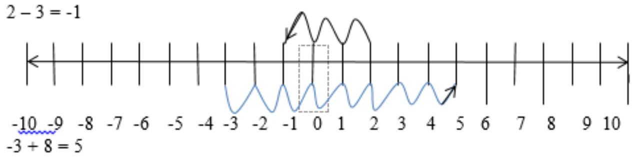


Fig. 2

Week 3: Oxidation number

In view of past information, the students were asked of the importance from the oxidation number. Students gave answers which incorporated the oxidation number as the nuclear number of the molecule. The analysts made sense of the significance of oxidation number. The oxidation condition of a component relates to the quantity of electrons (e-) that a particle loses, gains, (contrasted with its unbiased, uncombined structure) or seems to utilize while getting together with different iotas in compounds when it responds to frame particles or atoms. The valency (oxidation number) of the reactant changes as it losses or gains electron(s). With the guide of a graph, the chemist utilized the response among sodium and chlorine to make sense of how the compound was formed. For monatomic particles, for example, Na^+ or Cl^-, the oxidation number is equivalent to the charge, +1 and −1, for the sodium cation and chloride anion, separately. The chemist made sense of the guidelines administering how to relegate oxidation numbers to components as follows.

In deciding the oxidation condition of an iota, there are seven rules to keep: 1. The oxidation condition of a singular molecule is 0; 2. The complete oxidation condition of all particles is 0 or equivalent to the particle's charge; 3. Gathering 1 metals have an oxidation condition of +1 and Gathering 2 metals have an oxidation condition of +2; 4. The oxidation condition of fluorine is - 1; 5. Hydrogen usually has an oxidation condition of +1; 6. Oxygen usually has an oxidation condition of - 2; 7. In double metal mixtures, Gathering 17 components have an oxidation condition of - 1, Gathering 16 components of - 2, and Gathering 15 components of - 3. The chemist utilized the above rules to make sense of the response oxidation condition of particles and mixtures. Students were approached to compose the ionic image for the different iotas sodium, potassium, calcium, oxygen and fluorine. Find the oxidation number of the underlined components, HNO_3, H_2SO_4, SO_2, $CaCO_3$ and NO_2. Independently, chemistry students found the oxidation quantities of components, showing each step they made to find the response. Two by two, they evaluated each other's responses. The examination took up right responses with the whole class.

For the number line experimental group (I)

The researchers introduced the lesson by asking the students to state the seven guidelines in determining the oxidation state of an atom. The researcher then wrote some equations on the board; reminding the chemistry students that electrons are negatively charged, and then asked the acceptance of electron(s) will move the state of the reactant towards which direction in the number line? The learners gave answers which include to the left.

Elements undergoing chemical reaction either gain or lose electrons. Since electrons involved in chemical reactions are negatively charged, number line can help the learners to understand this phenomenon. The researchers introduced the lesson by drawing a number line on the board with zero at the center and asked the learners the following questions?

- Moving right along the number-line is it positive or negative? Learners gave answers which included, positive.
- If a negative number is added to any point on the number line, which direction will the new position move? Learners gave answers which included, to the left..

The researcher presented the topic by explaining oxidation as the loss of electrons by species and reduction as gain of electrons by species. In Mathematics, negative multiply by negative is **positive**, while negative added to negative is **negative.** Therefore, in using number line, electron being negative when removed from a specie means a negative is subtracted, that is, - - which means (- x - = +). Hence, removal of electron moves towards positive direction. On the other hand, addition of electron means - + - = - (negative plus negative = negative), this means that the addition of electron will move towards the negative direction. Anything moving towards the negative direction is reducing hence, reduction. Oxidation-reduction reaction can be demonstrated using the reaction of sodium (Na) and fluorine (F) in number line.

$2Na(s) \quad + \quad F_2(g) \quad \rightarrow \quad 2NaF(s)$

Na has eleven (11) electrons while fluorine has nine (9) electrons before the reaction and after the reaction; Na has ten (10) electrons while F has ten (10) electrons.

From the direction of the arrow, it can be seen that fluorine accepted an electron to move one step left, that is, reducing from -9 to -10, hence reduction. Sodium moved -11 to -10, that is a shift to the right thus oxidation. The sodium which donates electron to the fluorine has reduced fluorine from -9 to -10; thus, sodium is a reducing agent and the fluorine that accepts the electron from sodium increasing Na from -11 to -10 is the oxidizing agent.

$2Na+ \quad Cl_2 \quad \rightarrow \quad 2NaCl$

In the above reaction, sodium atom (Na) from the guide is in the oxidation state of zero while chlorine atom is also in the oxidation state of zero (0) equally.

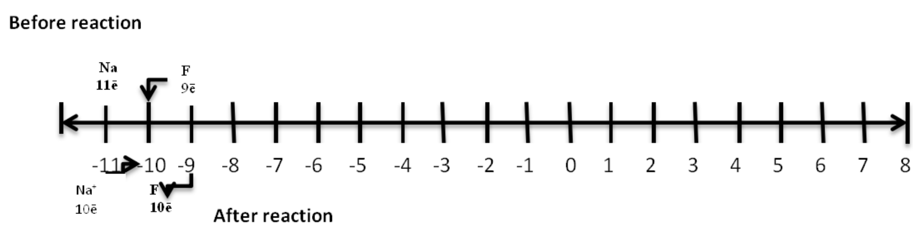


Fig. 3

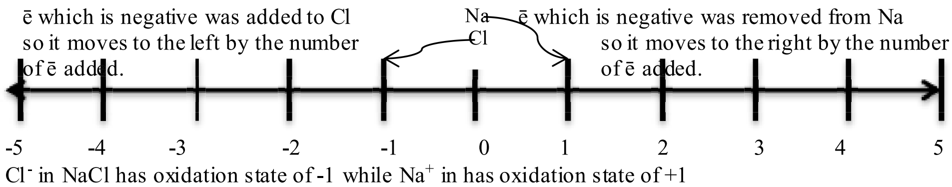


Fig. 4

The oxidation state of Na has increased from zero to +1; that is, it has been oxidized by Cl because of the increase in the oxidation number. Hence Cl is the oxidizing agent. The oxidation state of Cl has reduced from zero to -1; that is, it has been reduced by Na because of the decrease in the oxidation number. Hence Na is the reducing agent.

In the reaction, zinc (Zn) atom being higher in the electrochemical series (more electropositive) donates two (2) negatively charged particles (ē) to copper (Cu) in $CuSO_4$. Because two negative (-ive) particles were removed, Zn moves two places to the positive (+ive) direction (right direction). Moving to the positive direction is oxidation.

Negative Reduction positive Oxidation (NEGRED–POXY)

$Fe_2O_3(s)+2Al(s)\rightarrow Al_2O_3(s)+2Fe(s)$

-ē means loss of negatively charged particle (electron) while +ē means addition of electron. When negative values are being added to something, its positive value decreases, that is reduces; but when negative values are being removed from something, its positive value increases, that is, oxidized.

For the reaction: $Zn_{(s)} + CuSO_{4(aq)} \rightarrow Cu(s) + ZnSO_{4(aq)}$

For the reactants	Oxidation state	For the products	Oxidation state
Zn	0	**Zn**SO_4	+2
CuSO_4	+2	**Cu**	0

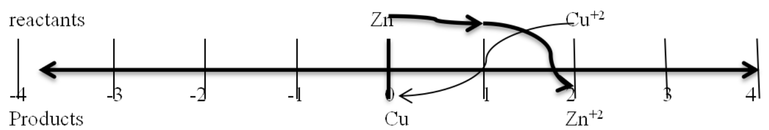


Fig. 5

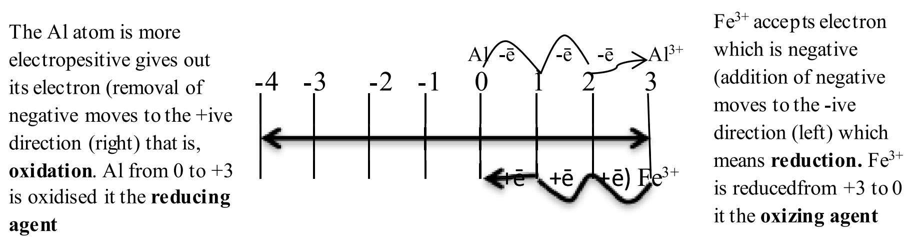


Fig. 6

For the number line and tale experimental (group II).

The researchers introduced the lesson by telling the learners story about one Mr. Camsi who had eight (8) children and later gave birth to set of twins. This twin have negative influence on Mr. Camsi, because he had used his energy in training the first eight children and now was unable to firmly get hold of this twins. There is also another man Mr. Ozojim who is desperately looking for child. When Mr. Camsi and Mr. Ozojim met, Mr. Camsi who was unable to hold his twins firmly, did not hesitate to give out the twin to Mr. Ozojim, who has the power to accept the twins. Mr. Camsi became more positive because of the removal of his negatively influenced twins; while Mr. Ozojim became more negative because of the acceptance of the negatively influenced twins but more stable because he has found the children he had been looking for.

Relating this story to oxidation number, Mr. Camsi may be likened to calcium (Ca) which is in group two (II) and is very willing to donate (remove) the two (2) electrons that are negatively charged (which may also be likened to as the negatively influenced twins) in its valence shell. As Ca is donating its negatively charged electrons (as Mr, Camsi removed the negatively influenced twins) it becomes more positive (Mr, Camsi now has more rest of mind) while Mr. Ozojim who is accepting the negatively influenced twins is likened to as oxygen (O) which is in group six (vi) and is very willing to accept the two (2) electrons that are negatively charged (which may also be likened to the negatively influenced twins). If each of this negatively influence twins cost 96500 Colos (C), it means that the cost of two twins is 193000C.

The researcher evaluates the lesson by asking the students the following questions based on previous knowledge. Among the characters in the story, who is a reducer (reducing agent)? Give reason for your answer.

The reducing agent is Mr. Camsi because he is removing his negatively influenced twins to Mr. Ozojim who now spends more on the twins in terms of speech, finance and so on thereby reducing him to the more negative side than he was; Hence Mr. Camsi is a reducing agent.

Week 4: Balancing of redox equation

The researcher facilitated interactive sessions with students to demonstrate how to balance redox equations using the Half-Equation Method. Through examples like the reaction between Cu and Ag ions, learners were guided to identify oxidation and reduction half-reactions. The process involved assigning oxidation states and recognizing changes in oxidation states to determine redox reactions. The Half-Equation Method was then introduced, outlining steps to balance redox reactions by separating them into oxidation and reduction half-equations and adjusting coefficients accordingly.

To practice the method, sample questions were provided, such as balancing the reaction between Cu+ ions and Fe metal. Students followed steps to separate half-reactions, balance electrons, and combine equations to obtain a balanced overall equation. Through individual presentations and class discussions, learners reinforced their understanding and corrected any misconceptions.

For the number line experimental group (I)

The researcher used the number line to explain only the oxidation and reduction that involves the exchange of electron.

For the reaction $3Cu^{+}(aq) + Fe(s) \rightarrow Fe^{3+(}aq) +3 Cu(s)$;

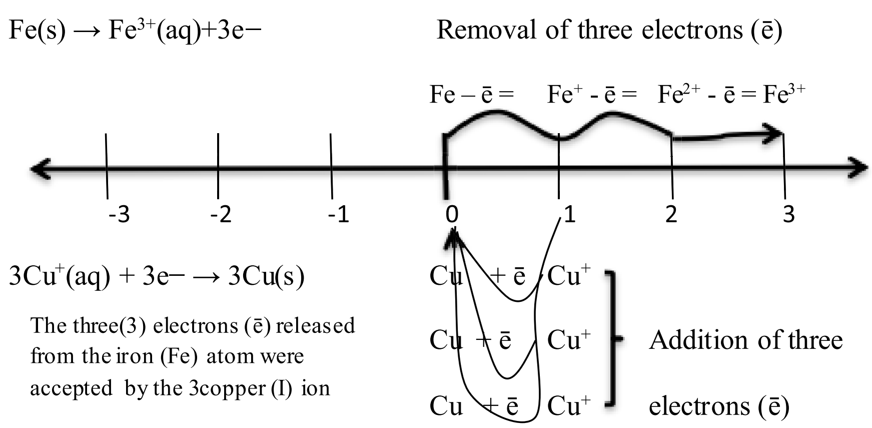


Fig. 7

For the number line and tale experimental group (II)

Week 5: Laws of electrolysis

The researcher introduced the lesson by revising the previous lessons. The researcher reminding the students that in their previous lessons of redox reactions, that they have been studying about the formation of compounds through the donation and acceptance of electron to form a new compound. The movement of these electrons is what brings about electricity (electric current). This week we are going to study how these compounds that were formed, can be decomposed (disintegrated), and how the charge on the ion formed affects the charge quantity of product liberated.

The specialist characterize electrolysis as separating an ionic compound (either liquid or in arrangement) into less difficult substances by utilizing an electric flow or the decay of a synthetic compound (electrolyte) achieved by the section of direct flow through the terminal. Electrolysis is the cycle where in electrical energy is utilized to make a nonspontaneous compound response happen.

The positive cathode is known as the anode. The negative terminal is known as the cathode (positive anode, negative cathode: - PANC). The electrolyte is the substance going through electrolysis (It is an ionic compound either liquid or in arrangement). Electrolysis includes the development of particles towards the cathodes (Particles can't move in a strong). Positive particles are known as cations, move towards the negative cathode during electrolysis. Negative particles are known as anions move towards the positive anode during electrolysis. Cations are shaped by loss of electron by a component while anions are framed by gain of electron as it has been exhibited in redox response. The positive charged particles are the cations, and they move towards the negative cathode (feline) while the adversely charged particles, the anions moves towards the positive anode (an). Power is being conveyed by electrons in the outside circuit, yet by the development and release of particles in the electrolyte. This can work assuming you have particles which are allowed to move. For that reason an electrolyte must be an ionic compound, either liquid or in arrangement.

During electrolysis, the compound formed during the redox reaction split to go back to its original stable form. For instance, sodium reacts with chlorine to form sodium chloride.

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

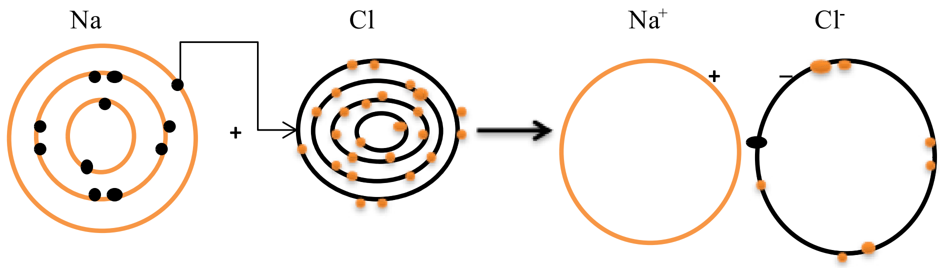


Fig. 8

In the product only the valence electron was used to represent the structure of Na^+ and Cl^-. During electrolysis the electrolysis of molten sodium chloride (Na^+Cl^-), the chloride ion (Cl^-), releases the electron it accepted from the sodium atom (to bond to the sodium) at the anode which is positively charged. The electron released from the Cl^-, passes through the external circuit and enters into the electrolyte through the cathode and the Na^+ now regained (accepted) the electron it donated to chlorine to form sodium chloride. Hence, the cathode that received the negatively charged electron is negatively charged while the anode from where the negatively charged electron leaves the electrolyte is positively charged.

Chlorine exists as diatomic molecule not as mono atomic molecule. Looking at fig. 8, only one atom of chlorine was used; therefore another atom of sodium will be required to react with the second chlorine atom. This gives chemical equation as:

$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

At the anode OH^- being less electronegative than the SO_4^{2-} will migrate to the anode to lose electron which moves through the external circuit to the cathode and H^+ which is the only cation present migrates to the cathode to accepts the electron.

Anode (anodic half reaction)

$Cl^- \rightarrow \bar{e} + Cl$
Chloride releases electron
Chlorine atom cannot exist alone,
Hence another Cl^- releases electron
$Cl^- \rightarrow \bar{e} + Cl$
→ Cl_2

Cathode (cathodic half reaction)

$Na^+ + \bar{e} \rightarrow Na$
sodium ion accepts the electron
and another sodium ion accepts the electron.
$Na^+ + \bar{e} \rightarrow Na$
→ 2Na

Overall reaction is: $2Na^+Cl^- \longrightarrow 2Na + Cl_2$

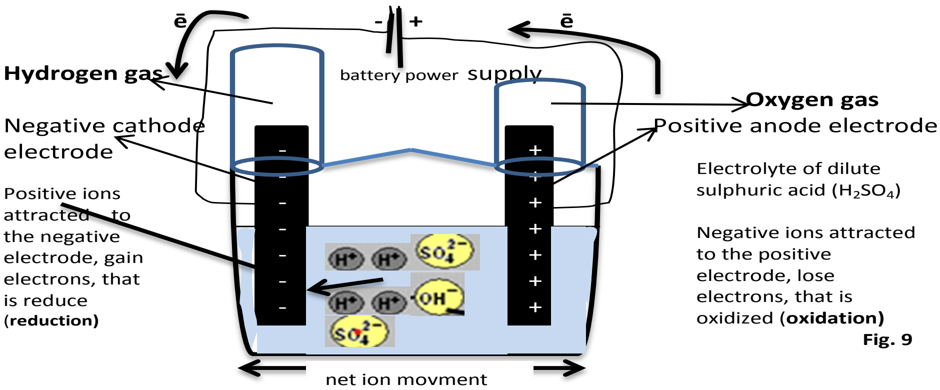


Fig. 9

Diagram for the electrolysis of acidified water

The ions present in the electrolytes are:-

$H_2O \rightarrow H^+ + OH^-$

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

Oxidation and reduction in electrolysis

At the Anode

$OH^- \rightarrow \bar{e} + OH$
OH is not a stable molecule,
another $OH^- \rightarrow \bar{e} + OH$
$OH + OH \rightarrow H_2O + O$
O is not stable it is diatomic so the whole process repeats again
$OH^- \rightarrow \bar{e} + OH$
OH is not a stable molecule,
another $OH^- \rightarrow \bar{e} + OH$
$OH + OH \rightarrow H_2O + O$
$O + O \rightarrow O_2$

At the Cathode

$H^+ + \bar{e} \rightarrow H$
H is not also a stable molecule therefore,
another $H^+ + \bar{e} \rightarrow H$
$H + H \rightarrow H_2$

$H^+ + \bar{e} \rightarrow H$
H is not also a stable molecule therefore,
another $H^+ + \bar{e} \rightarrow H$
$H + H \rightarrow H_2$
$H_2 + H_2 \rightarrow 2H_2$

$OH^- \rightarrow \bar{e} + OH$
$OH^- \rightarrow \bar{e} + OH$
$OH^- \rightarrow \bar{e} + OH$
$OH^- \rightarrow \bar{e} + OH$
$4OH^- \rightarrow 4\bar{e} + 2H_2O + O_2$

Anodic half reaction
The OH groups are not stable, so, they are not added. The oxygen atoms are not stable also, hence, they are not equally added.

$H^+ + \bar{e} \rightarrow H$
$H^+ + \bar{e} \rightarrow H$
$H^+ + \bar{e} \rightarrow H$
$H^+ + \bar{e} \rightarrow H$
$4H^+ + 4e \rightarrow 2H_2$

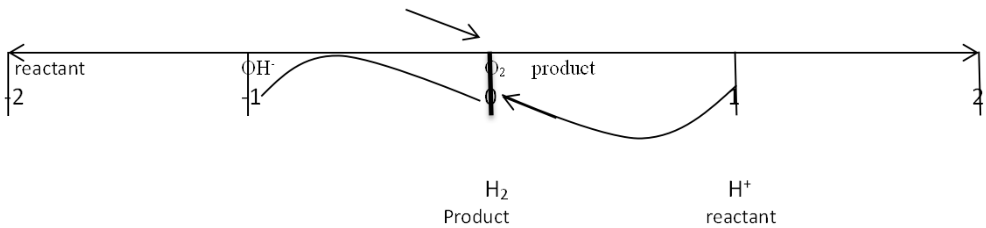
Cathodic half reaction
The H atoms are not stable. Thus, not added

The hydrogen ions are gaining electrons. Gain of electrons is reduction (RIG). The reaction happening at the cathode is reduction. The hydroxide ions are losing electrons. The loss of electrons is oxidation (OIL). The reaction happening at the cathode is reduction.

For the number line experimental group (I)

The ions migrating are OH^- ion and H^+ ion. The OH^- ion is losing electron and the H^+ ion is gaining. Representing this in number line:

The H^+ ion made movement to the left, that is, negative direction, hence reduction (NEGRED: Negative reduction). The OH^- ion made movement to the right, that is, positive direction, hence oxidation (POXY: Positive oxidation). The OH^- ion was oxidized, therefore it is the reducing agent. The H^+ ion was reduced, thus, it is oxidizing agent.



Faraday's Laws of electrolysis

Faraday's first law of electrolysis states that the mass (m) of an element discharged during the electrolysis of an electrolyte is directly proportional to the quantity of electricity (Q) passing through it. Thus,

$M \alpha Q$ But $Q = It$ Therefore, $Q \alpha It$

Hence $M = EIt$ or $M = EQ$

M = mass in gram (g)

I = current in Amperes (A)

t = time in seconds(s)

Q = quantity of electricity in Coulomb (C)

E = Electrochemical equivalent in gA^-s^- or gC^-

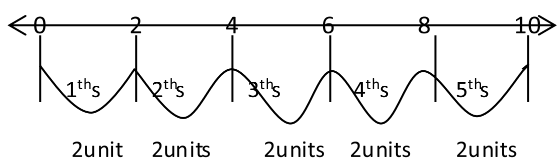
For a particular electrolytic process at different time, Faraday's first law of electrolysis can also be expressed as

$M_1Q_1 = M_2Q_2$ or $M_1/I_1t_1 = M_2/I_2t_2$

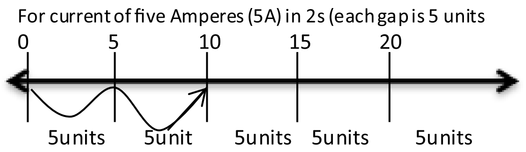
For the number line and experimental group (I)

Taking for instance in the electrolysis of a particular electrolyte, in two different experiments (i) and (ii) in which the duration of the experiment differs, such as five seconds (5s) and ten seconds (10s) respectively and the current (I) was kept constant at 2 amperes (A).

In experiment (i): The current of two amperes occurred for five (5) times which is the time (t). Each gap represents two amperes which occurred for five times.

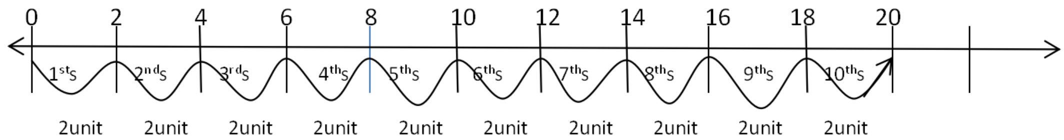


The quantity (Q) is ten Coulomb (10 C).



The same quantity of is 10 C but in a shorter time.

In experiment (ii): The current of two amperes occurred for ten (10) times which is the time (t). Each gap represents two amperes which occurred for ten times.



The quantity (Q) is twenty Coulomb (20 C).

For the number line and tale experimental group (II)

The researcher introduced topic by narrating this story to the learners. In certain spring water in my village, there are two holes from where water comes out of the ground. In one of the holes, the hole is big and the amount of water comes out very fast. When measured, it was found that the quantity of water flowing out of this hole is 1000 cm^3 of water per second. Two persons that went to this hole to fetch water and one of them (A) fetched for three seconds (3 x 1000) and the other (B) fetched for eight seconds (8 x 1000); the quantity of water each fetch depends on the time. This is likened to electrolysis. Here the volume of water fetched represents the mass of element deposited is dependent on the time.

In the second hole, the flow is at the rate, 500 cm^3s^{-1}; from this hole, for A to fetch the same quantity of 3000cm^3, it will take a longer time, six seconds. Hole B will take 16 seconds to fetcher volume of 8000cm^3. This can be likened to the first law of electrolysis which states that the mass (m) of an element discharged during the electrolysis of an electrolyte is directly proportional to the quantity of electricity (Q) passing through it. While the volume of water fetched represents the mass deposited, the flow rate of the water represents the magnitude of the current passed and the time used in fetching represents the time of passage of electricity. The higher the time of flow, the bigger the quantity deposited or fetched; also, the higher the current or flow rate, the more the quantity deposited or fetched.

In the explanation of Faraday's second law of electrolysis, the researcher narrated another story of a philanthropist in his community who donated forty (40) artificial hands to those with amputated hand(s). The researcher grouped these persons into two equal groups: those with only one amputated hand, twenty (20) persons, and those with two amputated hands also twenty (20) in number. The forty (40) artificial hands were shared equally between the two groups, that is, twenty (20) artificial hands per group. Those with one amputated hand will give twenty (20) complete persons while those two amputated hands will give only ten (10) complete persons.

In relating this story to the Faraday's second law of electrolysis which states when the same quantity of electricity is passed through different electrolytes, the relative number of moles of the elements discharged is inversely proportional to the charges on the ions of the elements. The two groups represent the different electrolyte, the electrolyte with one amputated hand represents electrolytes with one charged element, while that with two amputated hand represents electrolytes with two charged element. The equal sharing of the artificial hand to the two groups represents the same quantity of electricity passing through different electrolyte with different charges on the ions of the elements. Those with lesser charge, that is, those with one amputated hand discharged more that is 40; while those more charge, that is, two amputated hands discharged lesser that is 20. With this the inverse proportionality is explained.

3. Results

The scores of students in the three groups were analysed using ANCOVA. The analysis was done using the three research hypotheses stated for the study. The results of the analyses and discussions are as stated below.

HO_1, there is no significant difference in the performance of students in chemistry when they are exposed to (i) number line assisted instruction, (ii) tale and number line–assisted instruction, and (iii) conventional chemistry instruction.

To determine the relative effectiveness of the three instructional treatments, the students' scores were analysed using ANCOVA and the result is as shown in Table 1.

Table 1. Analysis of Covariance of Mean Score of students Exposed to (NLAI), (TNLAI) and (CI)

Source of Variation	Sum of Squares	df	Mean square	F	Significance of F
Covariates (Pre-test)	981.571	1	981.571	433.589	.000
Main effect (treatment)	167.160	2	83.580	36.920	.000
Explained	1148.731	3	382.910		
Residual	262.604	116	2.264		
Total	197.465	119	11.8599		

Denotes F is significant at 0.05 alpha level.

An assessment of Table 1 uncovers that a F (2, 117) = 36.920, α = 0.000 for the primary impact (treatment) was huge. This shows a statistical difference between (NLAI), (TNLAI), and the traditional chemistry instruction (CI) on the post-test execution of understudies when the covariate impact (pre-test) was measurably controlled. A subsequent Scheffe test was directed to find where the differences existed among the three mean scores of the three treatment bunches as demonstrated in Table 2.

The information in Table 2 reveals that there exists a statistical differences in the post test mean scores of chemistry students NLAI (X=17.8750) and TNLAI (X =20.0500), those instructed with story and number line helped guidance (TNLAI). It additionally shows a statistical difference in the post test scores of chemistry students instructed with TNLAI (X = 20.0500) compared with students instruction with CI (X = 14.0500).

Ho_2, there is no significant difference between the performance of male and female students in chemistry when taught chemistry with number line assisted instruction.

Analysis of covariance (ANCOVA) was used to find out the effect of the main treatment (NLAI) on the performance of the male and female student. The result is presented in Table 3.

Table 2. Scheffe Test of Significance on the Mean Scores of Students Exposed to (NLAI), (TNLAI), (CI)

Groups	Mean Scores	Group 1 (CAI)	Group II (CCAI)	Group III (CCI)
Group I (NLAI)	17.8750		*0.014	*0.000
Group II (TNLAI)	20.0500	* 0.014		*0.000
Group III (CI)	14.0500	*0.000	*0.000	

*The mean difference is significant at the 0.05 level.

Table 3. Analysis of Covariance of Mean Scores of Male and Female Students Exposed to Treatment

Source of variation	Sum of squares	df	Mean squares	F	Significance of F
Covariates (Pre-test)	213.621	1	213.621	85.793	*0.000
Main Effect Gender	1.074	1	1.074	0.431	**0 .515
Explained	214.695	2	107.348		
Residual	92.129	37	2.490		
Total 306.8 39	7.8672				

** denotes F is not significant at 0.05 alpha level.

An assessment of Table 3 shows that a F (1, 37) = 0.431, α = 0.515 for the primary impact (treatment) was not critical at 0.05 alpha level. This outcome shows that the male and female chemistry students' achievement, when taught using number line and tale assisted instruction, were not statistically different when the covariate (pre-test) was applied.

Ho_3, there is no significant difference between the performance of male and female students in chemistry when they are taught chemistry with tale and number line assisted instruction.

Analysis of Covariance (ANCOVA) was used to find out the effect of TNLAI (the main treatment) on the performance of female and female students. The result is presented in Table 4.

An assessment of the outcomes in Table 4 shows that a F (1, 37) = 0.115 α = 0.737 for the primary impact (treatment) was not critical at 0.05 alpha level. The outcome shows that the mean scores of the male and female chemistry students were not statistically different, when the covariate (pre-test) was applied.

4. Discussion of Findings

The analysis of covariance (ANCOVA) conducted on the academic performance of chemistry students across different instructional settings yielded significant findings. Students taught using number line assisted instruction (NLAI), tale and number line assisted instruction (TNLAI), and conventional classroom instruction exhibited notable differences in performance. This finding aligns with previous research highlighting the efficacy of innovative instructional approaches in enhancing student learning outcomes (Adu-Gyamfi, 2016;[2] Bilatam-Mayeem et al, 2023;[3] Ibole, 2015).[10]

Specifically, the Scheffe test revealed a significant difference in performance between students exposed to NLAI and TNLAI, with the latter demonstrating superior performance. This result suggests that incorporating storytelling alongside number line assisted instruction may contribute to better comprehension and retention of chemistry concepts (Chikendu, 2022).[4] In contrast, students in the NLAI group, although still outperforming the control group, exhibited slightly lower performance compared to those in the TNLAI group. This discrepancy underscores the potential added value of narrative-based instructional methods in facilitating conceptual understanding and engagement (Elena & Natalia, 2021;[6] Emendu et al, 2017).[7]

Moreover, when comparing the experimental groups (NLAI and TNLAI) with the control group (conventional instruction), significant differences favoring the experimental groups were evident. This outcome corroborates findings from previous studies highlighting the effectiveness of innovative instructional approaches, such as incorporating technology and storytelling, in improving student learning outcomes across various disciplines (Vanessa, 2017;[15] Darshana, 2023).[5] The results underscore the importance of adopting pedagogical strategies that cater to diverse learning needs and preferences to optimize student achievement in Chemistry education.

Regarding the influence of gender on academic performance, hypotheses two and three examined potential differences in student performance based on gender within the experimental groups. The ANCOVA results indicated no significant gender disparities in academic performance for students

Table 4. Analysis of Covariance on Mean Scores of Male and Female Students Exposed to TNLAI

Source of variation	Sum of squares	df	Mean squares	F	Significance of F
Covariates (Pre-test)	487.626	1	487.626	225.108	0.000
Main effect (Gender)	0.249	1	0.249	.115	**.737
Explained	487.875	2	243.938		
Residual	80.149	37	2.166		
Total	568.024	39	14.565		

** denotes not significant at 0.05 level.

taught using NLAI and TNLAI settings. These findings suggest that instructional approaches integrating number line assistance and storytelling are equally effective for both male and female students in facilitating learning and comprehension in Chemistry (Jonah et al, 2021;[12] Bilatam et al, 2023).[3]

This finding is consistent with existing literature emphasizing gender-neutral instructional practices that prioritize inclusivity and equitable learning opportunities for all students (Adimoyemma, 2010).[1] It highlights the importance of creating classroom environments that foster gender equity and minimize potential biases in educational settings (Walanda et al, 2017).[16]

5. Conclusion

In conclusion, the findings of this study highlight the significant impact of using number line and tale assisted instruction in enhancing the learning of redox reactions, particularly in the context of electrochemistry, among senior secondary school students. The results indicate that incorporating innovative teaching strategies, such as storytelling and visual aids like number lines, contributes to improved comprehension, engagement, and overall academic achievement in chemistry education.

However, it is important to acknowledge the limitations of this study. Firstly, the research did not explore alternative delivery methods, such as utilizing the internet for course content dissemination, which could have provided additional insights into effective instructional approaches. Additionally, the focus of the curriculum content was limited to redox reaction topics within the broader chemistry curriculum, potentially limiting the generalizability of the findings to other areas of chemistry education.

Moving forward, several recommendations emerge from this study. Firstly, educators are encouraged to adopt innovative teaching strategies, such as incorporating storytelling and interdisciplinary approaches involving mathematics, to enhance students' understanding of fundamental principles in chemistry. Furthermore, parents play a crucial role in supporting their children's learning journey by fostering a conducive environment for exploration and discovery at home, thereby promoting the development of cognitive skills essential for academic success.

Additionally, it is recommended that teachers actively participate in professional development opportunities, such as seminars and conferences, to exchange experiences and insights into effective teaching and learning strategies. By staying abreast of advancements in pedagogy and educational research, educators can continually refine their instructional practices to meet the evolving needs of students and optimize learning outcomes.

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