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Effect of Conceptual Change Instructional Strategy on Chemistry Students' Performance in Acids and Bases Concepts

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ABSTRACTS

This study investigated the effect of conceptual change instructional strategy on Acid-Base concepts in the Zaria education zone in Kaduna, Nigeria. A quasi-experimental design was used for the study. The population of the study comprises 1434 chemistry students from 14 co-educational schools, a sample of 110 chemistry students was drawn from the population using a random sampling technique and was categorized into experimental and control groups. The findings of the study revealed that conceptual change instructional strategy effectively enhanced understanding of concepts and subsequently improved performance more than the lecture method. It was recommended that chemistry teachers in secondary schools should employ the use of conceptual change instructional strategy because of its impact on students' academic performance.

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1. INTRODUCTION

Science is a methodical endeavor that creates and organizes information in the form of testable explanations and predictions about the universe. Science educators such as Gabel (2019) had advocated for science instruction at all levels of education to focus on improving students' conceptual comprehension as well as greater standards of achievement in scientific inquiry, reasoning, and problem-solving. This position contradicts several global reform programs for mathematics curricula, science (particularly chemistry), and teaching practices. Learning science's fundamental goal is to provide a systematic, practical, and interconnected overview of the disciplines and to modify students' behavior through such knowledge.

Chemistry is a science that studies matter and its properties. Physical chemistry, organic chemistry, and nuclear chemistry are all crucial to the scientific world since the human industry depends on them. The physical part of chemistry entails the study of periodic table elements, chemical processes, the concept of energy, and the concept of acid-base (Erylmaz, 2018). Despite chemistry's core and significant position among other science topics, students' achievements in chemistry in the Senior Secondary School Certificate Examination (SSSCE) have constantly been very weak and unsatisfactory over the years. According to the West African Examination Council (WAEC) Chief Examiner report 2021, Nigerian students have consistently done poorly in chemistry at the Senior Secondary School Certificate Examination (SSSCE) level.

However, students arrive in the classroom having a variety of informal beliefs, the majority of which deviate from scientific concepts. Acid-base concepts are important concepts in Chemistry that must be taught thoroughly and coherently because they are crucial to a wide variety of responses (Godfred, 2019; Barke, 2023; Putri *et al*., 2022).

Students who grasp acid-base concepts will be capable of predicting and explaining the results of seemingly unconnected reactions. They'd be able to link and integrate seemingly disparate processes like proton transfer, transition metal coordination complexes, and organic reactions involving nucleophilic and electrophilic assault (Cooper *et al*., 2018). Nonetheless, students have difficulties or problems as they learn acid-base ideas, including misconceptions, the use of surface-level cues to identify acids and bases, and difficulties understanding how to use and move flexibly between acid-base models. Misconceptions are ideas pupils hold about acids and bases that differ from those accepted by chemistry educators.

Misconceptions are permanent cognitive constructs that influence learners' comprehension of scientific concepts and are extremely resistant to change (Barke & Buechter, 2023). Misconceptions are pupils' inaccurate reaction patterns, informal concepts, non-scientific interpretations, and conceptions that lead to disagreement with scientific perspectives. Misconceptions, according to Erylmaz (2018), can also be referred to as "preconceptions," whereas Ezenwa classified misconceptions as preconceived concepts, nonscientific views, conceptual misunderstanding, and so on. These kinds of misconceptions need considerable effort on the part of the teacher to rectify in the learner. According to Kikas (2020), this unusual or "unaccepted" scientific view of the learner has been termed variously by different scholars as alternative conceptions, preconceptions, micro theories, misconceptions, flawed conceptions, and so on.

Tacettin (2020) claimed that for successful conceptual change to occur, learners must grow unhappy with their previous ideas and the new concept must be demonstrated to be comprehensible, credible, and fruitful. The development of teaching methodologies based on

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this principle has been shown to assist students in changing their alternate perceptions (Chambers & Andre, 2021).

Misconceptions are ideas about occurrences that do not adhere to established scientific knowledge, and they emerge when a learner's prior knowledge required for processing new information is poorly communicated owing to inadequate bridging, resulting in confusion and poor reasoning (Godfred, 2020). However, many myths are extremely resistant to standard instruction. Thus, it is vital to develop a teaching technique that is highly appropriate to school education curricula, successful in correcting misconceptions, and appealing to the majority of pupils.

According to Osborne *et al.* (2019) research findings, a high majority of science teachers, including chemistry professors, still employ the traditional lecture technique rather than activity-oriented strategies such as demonstration, debate, experimentation, and so on. Diverse conceptual transformation tactics for teaching and learning approaches are required to increase conceptual comprehension and eradicate learners' misconceptions Francis and Baba (2023).

Conceptual change instructional strategy is an instructional strategy in which the teacher acts as a facilitator by asking thought-provoking questions, conducting experiments, and leading guided discussions that help students think about constructing scientifically valid ideas. More specifically, it is a strategy that assists the student in distinguishing earlier conceptions and newly introduced scientific concepts, as well as how they impact each other as the learner quietly works out his ideas from the former idea and the newly introduced concept.

Conceptual change teaching as a learning approach that alters an existing conception, such as a belief, idea, or way of thinking. Conceptual change differs from other types of learning procedures in that it involves a shift or restructure of existing information and beliefs. Learning for conceptual change is more than just learning new facts or skills. An existing conception is significantly altered or even replaced in conceptual change, and this becomes the conceptual framework that students use to solve problems, explain phenomena, and function in their reality.

However, several instructional strategies exist for overcoming misconceptions for greater comprehension and meaningful learning, such as those proposed by Joan;

(i) Students' preconceived notions
(ii) Preconceptions are becoming increasingly inconsistent.
(iii) Dissatisfaction with preconceived notions
(iv) Moving on to new scientific concepts that must be: Intelligible, Plausible, and Fruitful
(v) A transition from preconception to new scientific conception, resulting in:
(vi) Accommodation of new scientific validated conception.

According to the paradigm, learning is a process in which a person transforms his or her conception by capturing new conceptions or trading existing conceptions for new conceptions.

Osborne and Cosgrove presented the Generative Learning Model of Teaching for conceptual change. The learner is an active participant in the learning process in the Generative Learning Model of Teaching (GLMT). Roth's conceptual strategy contains the following characteristics:

(i) Eliciting: The teacher begins by identifying and explaining typical misconceptions.
(ii) Focusing: By providing students with settings tailored to elicit a prediction based on their probing students' replies, their misconceptions are awakened.

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(iii) Probing: Introducing common misconceptions, followed by proof that they are correct or incorrect, challenges students' misconceptions.
(iv) Balancing: The instructor or teacher offers the correct scientific explanation after discussing the students' comments and scientifically recognized notions.

Lilly and Sirochman in Ukens *et al*. (2004) proposed the Powerful Ideas in Physical Sciences (PIPS) model has the following five phases

(i) Phase 1: Eliciting and elaborating the students' ideas.
(ii) Phase 2: Testing and comparing the ideas with nature.
(iii) Phase 3: Resolving the discrepancies between ideas.
(iv) Phase 4: Applying the ideas.
(v) Phase 5: Reviewing and summarizing ideas.

The relevant one to this study was the conceptual change model developed by Posner *et al*. in Özdemir and Clark (2007), described four necessary conditions (dissatisfaction, intelligibility, plausibility, and fruitfulness). Posner *et al.* in Özdemir and Clark (2007) proposed a model of conceptual change, which had four conditions, taking into cognizance the four conditions such as:

(i) Tearners must become dissatisfied with their existing conceptions - they must-have experiences, which lead them to lose confidence in the ability of their current conception to solve problems,
(ii) The new conceptions must be intelligible - the student must be able to understand sufficiently how experience can be structured by the new concept,
(iii) The new conceptions must appear plausible - any new concept adopted must at least appear to have the ability to solve the problems generated by its predecessors and,
(iv) The new conceptions must be fruitful - it should have the capacity to open up new areas of inquiry.

The model's main characteristic is that it is intended for the establishment of problem awareness, the management of cognitive dissonance, and cooperative work to ensure meaningful learning. The objective of the study is to determine the difference in the misconception mean scores in the Acid-base concept among chemistry students taught using Conceptual Change Instructional Strategy (CCIS) and those taught using the lecture method.

The research question is about the difference in the misconception mean scores in the concept of acids and bases among chemistry students taught using CCIS and those taught using the lecture method.

The research hypothesis is no significant difference in the misconception mean scores in the concept of acids and bases among chemistry students taught using CCIS and those taught using the lecture method.

2. METHODS

The research design for this study is Quasi-Experimental research design specifically pre-test and post-test. The population of the study comprised all SS 1 chemistry students in Government Senior Secondary Schools in the Zaria metropolis. There are 21 Government Senior Secondary Schools with a total number of 1434 out of which male 952 and female are 482. Seven out of the 21 schools are single-sex while 14 are co-educational (mixed school). G.S.S Magajiya with 45 chemistry students out of which males 26 and females are 19 while G.S.S Tudun Jukun with 65 chemistry students out of which males are 41 and females are 24 forms the sample for this study.

The two schools were sampled out of the 4 co-educational schools using ANOVA with the highest level of misconception when they were pre-tested. The result of the pre-test was

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analyzed using ANOVA to determine the level of difference between the schools. The result of the ANOVA indicates that there is a difference in the misconception between the students but was not significant to identify the school with a significant difference that was subjected to Scheff's test.

The sample of the study was 110 using the simple random sampling technique by drawing from the hat employed to assign the two sampled schools into experimental and control groups. This was done by assigning two persons to pick one folded paper with the name of the school written on it from the hat any school picked to stand for the experimental group while any school picked by the second person stands as a control group and G.S.S Magajiya was the Experimental group while G.S.S Tudun Jukun was the Control group. The acids and Bases Misconception Test (ABMT) were administered to both groups and Test re-test was employed on the scores obtained from the pilot test and the Pearson Product Moment Correlation Coefficient (PPMCC) was used to determine the Reliability Coefficient of ABMT. The reliability coefficient of ABMT was found to be r = 0.68

The ABMT was adapted from Lawal. It is a 20-item essay test on acids and base concepts with space provided for the answers. These questions were set to probe into the student's knowledge of the concepts of acids and bases. The answers written out by the students were then marked, scored, and analyzed to determine their initial conception of the concepts of acids and bases. The non-scientific statements formed the misconceptions. ABMT was given to experts, two senior lecturers with the rank of Ph.D. in the Science Education Department of Ahmadu Bello University, Zaria, and two chemistry teachers of senior secondary school level for validation.

Descriptive statistics of the mean and standard deviation of misconception mean scores were used to answer the research question while the hypothesis was analyzed using a one-way Analysis of Covariance (ANCOVA). The result is presented in **Tables 1 and 2**.

3. RESULTS AND DISCUSSION

Table 1 shows the misconception mean scores of the students in the experimental and control groups. The students taught using conceptual change instructional strategy in the post-test had mean scores of 28.92 and 23.72 respectively and standard deviations of 5.699 and 3.502 respectively. Students taught using the lecture method had mean scores of 27.40 in the post-test and standard deviations of 3.203. Students taught using CCIS had the highest mean score while those taught using the lecture method had the lowest mean score. The standard deviation scores for the post-test were not at much variance implying that the efficacy of the treatment is sustainable. To test if the difference is significant, hypothesis one was tested using ANCOVA.

Table 1. Mean Performance Misconception Scores of Students Exposed to Conceptual Change Instructional Strategy and Lecture Method

Group		Pre-test	Post-test	MD
	N	45.00	45.00	
CCIS	Std Deviation	5.69	3.50	5.20
	Mean	28.92	23.72	
	N	65.00	65.00	
Lecture Method	Std Deviation	3.20	3.49	5.86
	Mean	27.40	21.54	

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Table 2 shows the summary of the ANCOVA results in the ratings of students' misconceptions mean scores in acid-base concepts using conceptual change instructional strategy and those taught using the lecture method. The results indicated that the noted difference between the misconception mean scores of students taught acid-base using conceptual change instructional strategy is not significant at 0.05 alpha level. This means that CCIS has the same effect because f = 6.047 and p = 0.000 <0.05.

The null hypothesis that there is no significant difference in the misconception mean scores in the concept of acids and bases among chemistry students taught using CCIS and those taught using the lecture method is therefore accepted.

Table 2. ANCOVA Analysis for Misconception Scores of Students Exposed to Conceptual Change Instructional Strategy and Lecture Method

Source	Type III sum of squares	df	Mean squares	F	Sig.
Corrected model	453.349	3	151.116	11.349	0.000
Intercept	748.619	1	748.619	56.224	0.000
Posttest	247.610	1	247.610	18.597	0.000
Group	161.029	2	80.515	6.047	0.000
Error	1784.187	134	13.315		
Total	118733.000	138			
Corrected total	3312.123	137			

There was a significant difference between the mean misconception scores of students in CCIS and the lecture method in favor of CCIS. This implies that conceptual change instructional strategy can be used to teach acid-bases concepts to chemistry students. The finding is in agreement with Lawal, who thought that the conceptual change instructional strategy was more effective than the lecture method of instruction in improving students' misconceptions. Even though CCIS was used for the first time and within a limited period, the students from the experimental group still performed significantly better than those of the control group. This means that the conceptual change instructional strategy facilitated students understanding of scientifically valid concepts more compared to the lecture method.

In the same vein, Godfred (2020), disagreed that the use of CCIS only could not facilitate students understanding of the concept since misconceptions originate from an inaccurate mental structure that underlines one's ideas of a group of related concepts, therefore, suggestions to in cooperating other strategies was made.

4. CONCLUSION

The findings of this study revealed that the conceptual change instructional strategy effectively shifted misconception, enhanced understanding of concepts, and subsequently this improved performance more than the lecture method. Based on the findings and discussions, it was recommended that, for effective instruction, chemistry teachers in secondary schools should employ the use of conceptual change instructional strategy because of its impact on students' academic performance and helps shift misconceptions to scientifically valid ideas.

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5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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