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EFFECT OF CONCEPTUAL CHANGE TEACHING STRATEGY ON CHILDREN'S ACQUISITION OF SCIENTIFIC ATTITUDES

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Abstract
One of the major objectives for teaching science in Nigeria schools is for pupils to develop scientific thinking/attitudes. However, the traditional method of teaching in most classrooms has been found to be ineffective to achieve this objective. This study therefore investigates the effect of conceptual change teaching strategy on children's acquisition of scientific attitudes. It adopted the pre-test post-test control group quasi-experimental design. 143 primary six pupils from two public primary schools in Ibadan South west Local Government Area of Oyo State were involved on the study. Three self-developed and validated instruments were used for data collection: Scientific Attitude Questionnaire (SAQ), Teachers' Assessment Guide (TAG) and Operational Guide for Instruction (OGI). SAQ had Cronbach Alpha coefficient of 0.89 while TAG had Intra-class correlation coefficient of 0.86. The results revealed that the conceptual change teaching strategy was more effective in improving pupils' scientific attitude scores than the traditional chalk-and-talk method. This effect was sustained regardless of the pupils' gender. It was recommended that teachers should use this teaching method in the science class to help pupils develop scientific attitudes.

Keywords: Conceptual change, primary science, teaching strategies, scientific attitudes, activity-based teaching,

Introduction

Science is a discipline that has enabled humans not only to adjust to their environment but also to modify the environment to suit their needs. It is widely regarded as an essential instrument for industrial growth and national progress. Science and technology have become global cultures and ways of life, as they are continuously applied to address human challenges across the world. Consequently, any nation that neglects the quality of its science education will not only lag behind in technological advancement but will also continue to depend on countries that are more technologically developed.

Recognizing this reality, Nigeria, through the National Policy on Education (FGN, 2013), has identified the development of a strong foundation for scientific and critical thinking as one of the objectives of primary education. To achieve this objective, the government has included science as a compulsory subject in all primary schools. This demonstrates an understanding that primary education serves as the bedrock for higher levels of learning. The policy also emphasizes that teaching and learning at the primary school stage should be activity-based, investigative, and

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experimental in nature. These initiatives indicate an increasing recognition of the significance of effective science teaching in schools.

Despite these efforts, low enrollment in science courses at secondary and tertiary institutions (Aina and Adedo, 2013; Mbamara and Eya, 2015; Obiadazie, 2016; Aina and Ayodele, 2018), as well as poor performance in science subjects at the Senior Secondary Certificate level, continue to be reported (Anthony, 2021 and Amasuwa et al, 2022). The source of this challenge may be linked to ineffective science teaching at the primary school level, which forms the educational foundation. Studies have shown that science teaching and learning in Nigerian schools are largely carried out through the traditional, teacher-centered chalk-and-talk approach (Usman, 2020; James, 2020; Obiene, 2024). This method is often ineffective in engaging learners' interest and unproductive (Ede and Ugwuanyi, 2021; Onah and Agbo, 2020; Okate and Kpangban, 2026), particularly for average and slow learners.

For learning to be effective, particularly in the science class, teachers must recognize that pupils bring to the class certain strongly held, preconceived ideas which may actually be misconceptions about scientific knowledge. In fact, a large number of such misconceptions across several geographical locations have been discovered and reported (Aleknaviciute, Letinen and Sodervik, 2023). Traditional lecture method will not bring about a substantial change in their preconceived knowledge except the teacher uses more effective teaching strategies that will bring about conceptual change for deep understanding. These strategies are known as conceptual change approaches or strategies.

Conceptual change is important because if learners hold on to their misconceptions, the foundation for teaching and learning becomes shaky. They may be able to pass examinations through rote learning, but their understanding will be shallow. Conceptual change strategies take learners from shallow, surface-level learning to a deeper conceptual understanding which will enable them to think scientifically and critically, solve problems effectively, and apply knowledge in real-world situations.

According to Posner et al (1982), for conceptual change to occur, the teacher uses probing questions to diagnose learners' misconceptions in the topic of interest. Relevant experiments, activities, real life examples are then provided to test alternative conceptions, while encouraging learners to discuss their findings compared to their prior conceptions. In the light of the findings, learners become dissatisfied with their prior misconceptions and readily jetison them. Learners are now presented with opportunities to apply the newly acquired understanding to new situations in order to see that their new conception is fruitful in explaining related phenomena.

Many studies (Aleknaviciute, Letinen and Sodervik, 2023; Pacaci et al, 2023; Ginyigazi, 2024) have reported the effectiveness of conceptual change strategies in bringing about scientific thinking and deep understanding when compared with traditional methods. Since the learning of science in the primary school is expected to enhance scientific thinking (attitudes) in children, there is the need to investigate the effect of the conceptual change strategy in this regard, in addition to promoting deep conceptual understanding.

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According to Olasehinde & Olatoye (2014), scientific attitude is the ability to react rationally and objectively consistently, to a novel or problematic situation. This attitude enables one to act or make decisions based only on proven and verified facts. A person with good scientific attitude may not necessarily be a scientist but demonstrates traits that are characteristic of scientists including curiosity, rationality, suspended judgement, open-mindedness, honesty, critical-mindedness, humility and objectivity. As a result such a person is free from superstition, gullibility and opinions that lack empirical basis.

Ataha & Ogumogu (2013) investigated the scientific attitude among science students in senior secondary schools. The study revealed that the level of scientific attitudes among science students in senior secondary school was not significantly influenced by sex. They however recommended that continuous experimentation and laboratory activities were necessary interventions to ameliorate the dichotomy between theory and experimentation in science classes, and to enhance students' scientific attitudes.

Regardless of whether pupils continue to secondary education or not, science education should help develop scientific attitudes that will benefit them throughout their lives. Attitudes such as objectivity, open-mindedness, and logical reasoning can help children respond more intelligently to future changes and prepare them for leadership roles in society. According to the National Policy on Education, these attitudes should be nurtured from the primary school stage through effective science education. Therefore, for science teaching and learning in Nigerian schools to improve beyond the current situation, there is a need for teaching strategies, regardless of individual differences such as gender, which can foster scientific attitudes among learners. This study therefore investigated the effect of conceptual change teaching strategies on pupils' acquisition of scientific attitudes.

Objectives of the Study

This study is designed to investigate:

i) The main effect of treatment (conceptual change teaching strategies) on primary school pupils' scientific attitude.
ii) The main effect of gender on primary school pupils' scientific attitude.
iii) The interaction effect of treatment and gender on primary school pupils' scientific attitude.

Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

$H0_1$:- There is no significant main effect of treatment on pupils' Scientific Attitude

$H0_2$:- There is no significant main effect of gender on pupils' Scientific Attitude

$H0_3$:- There is no significant interaction effect of treatment and gender on pupils' Scientific Attitude

Scope of the Study

This study is delimited to primary six pupils in public primary schools in Ibadan South West Local Government Area of Oyo State. The strategy investigated is the conceptual change teaching strategy.

Methodology

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This study adopted a pre-test post-test control group quasi-experimental design. Intact classes were used for the study in order not to disrupt the school programme. The schools were however randomly assigned to the treatment and control groups.

Two public primary schools were randomly selected for the study from Ibadan South West Local Government Area of Oyo State. The sample was made up of all the primary six pupils in the selected schools. This gave a total of 190 pupils of which 95 were males and 95 were females. The mean age of the pupils was 12.36 while the standard deviation was 2.08. The participating schools were randomly assigned to the treatment conditions giving rise to one treatment group in each school.

For this study, three instruments were used. These are:

(i) Scientific Attitude Questionnaire (SAQ)
(ii) Teachers' Assessment Guide (TAG)
(iii) Operational Guide for Instruction (OGI)

All the instruments were developed by the researcher and duly validated.

SAQ was made up of 10 items since the subjects were young children (primary six). Pupils were required to answer "Yes" or "No" to the items. "Yes" attracted a score of 1 mark while "No" was scored 0. Examples of the statements in SAQ include: "I enjoy finding out why things happen in nature" (curiosity); "I carefully look for reasons before making up my mind" (respect for evidence/skepticism); "I am willing to change my decision when I am given new and strong reasons to do so" (objectivity/open-mindedness), and many more. The reliability of this instrument was established with Cronbach Alpha coefficient of 0.89.

Intact classes were used for this study while the regular class teachers were trained to use the conceptual change strategy to reduce Hawthorne Effect. This also demonstrated the feasibility of the strategy for everyday use by teachers. OGI was used to train the regular teachers to teach selected science concepts (Simple Machines) as follows:

The teacher:

(i) through questioning, elicits the pupils' prior conceptions concerning the concept to be learnt.
(ii) presents hands-on activities which illustrate the new concept to be learnt.
(iii) discusses the results of the activities with the pupils in comparison with their prior conceptions.
(iv) asks pupils about their willingness to exchange their prior conceptions which were wrong with the new concept, based on their findings.
(v) tells the pupils to provide examples of the new concept in real world situations.

The training lasted two weeks after which the teachers were asked to use the strategy to teach a science topic that was not included in the study. Three (3) experts in science education were asked to assess the teaching of the regular teachers independently using 3-point rating scale with the following scores (no compliance-0, low compliance-1 and high compliance-2) to determine their compliance with the strategy. The intra-class correlation (ICC) yielded a coefficient of 0.86 indicating a high level of agreement between the raters.

The data collected were analyzed using Analysis of Covariance (ANCOVA) to determine the significant main and interaction effects with pre-test scores as covariates. This statistic was chosen because it takes into consideration the initial differences among the subjects especially since intact classes were used. Multiple Classification Analysis (MCA) was used to find the magnitude of the

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differences among the groups while Scheffe post-hoc analysis was employed to determine the sources of the significant treatment effects observed on the ANCOVA.

Results

Table 1: Summary of the analysis of covariance of post-test attitude scores

Source of variation	Sum of squares	Df	Mean square	F	Sig
Covariates (pre-test)	12.360	1	12.360	3.019	.084
Main effect	98.957	1	24.739	6.043	.000*
Treatment	45.488	1	22.744	5.555	.005*
Gender	19.114	1	19.114	4.669	.32
2 – way interactions	16.910	1	3.382	.826	.533
Treatment x gender	1.891	1	.946	.231	.749
Model	141.957	12	11.830	2.889	.001
Residual	724.653	177	4.094		
Total	866.611	189	4.585		

- Significant at P<0.05

This ANCOVA table examines the effects of treatment, gender, and their interaction on pupils' post-test attitude scores, while controlling for pre-test attitude scores (covariate). The pre-test attitude scores did not significantly influence post-test attitude scores after adjustment, since p = .084 > .05. This means that differences in pupils' initial attitudes were not statistically significant predictors of their post-test attitudes.

There was a statistically significant main effect of treatment on post-test attitude scores (F(4,177) = 6.043, p < .05). This indicates that the different treatment groups differed significantly in their adjusted post-test attitude scores. Therefore, the treatment administered had a significant influence on pupils' attitudes.

There was no significant main effect of gender on post-test attitude scores (F(1,177) = 4.669, p = .32 > .05). This implies that male and female participants did not differ significantly in their post-test attitude scores when the effects of treatment and pre-test scores were controlled.

The interaction between treatment and gender was not statistically significant (F(5,177) = 0.826, p = .533 > .05). This means that the effectiveness of the treatment did not depend on gender; treatment effects were generally similar across gender groups.

The overall ANCOVA model was statistically significant (F(12,177) = 2.889, p = .001), indicating that the variables included in the model collectively explained a significant proportion of the variation in post-test attitude scores.

In summary, the ANCOVA results show that:

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1. Treatment had a significant effect on pupils' post-test attitude scores.
2. Gender had no significant effect on post-test attitude scores.
3. Pre-test attitude scores did not significantly predict post-test attitudes after adjustment.
4. There was no significant interaction between treatment and gender, indicating that treatment effects were consistent across genders.
5. The overall model was statistically significant.

Therefore, treatment significantly influenced pupils' attitudes, while gender and the interaction of treatment and gender did not.

Table 2: Multiple classification analysis of post-test attitude scores
Grand mean = 7.168

Variable + category	N	Unadjusted variation	Eta	Adjusted for independent + covariates deviation	Beta
Treatment		-.24			
Conceptual change	44	.83		1.91	
			.72		.73
Conventional	99			-.92	
Gender					
Male	72	.41	01	-.32	.05
Female	71	-.41		-.32	
Multiple R^2					.628
Multiple R					.858

The Multiple Classification Analysis (MCA) was conducted to determine the relative influence of treatment and gender on pupils' post-test attitude scores after controlling for the effects of other variables and covariates. The grand mean of the post-test attitude scores was 7.168, representing the average attitude score of all participants. The treatment variable consisted of two groups: Conceptual Change Strategy and Conventional Method.

- Pupils exposed to the Conceptual Change Strategy had an unadjusted deviation of –0.24 from the grand mean, while those in the Conventional Method group had an unadjusted deviation of 0.83**.**
- After adjusting for the influence of other independent variables and the covariate, the Conceptual Change group had an adjusted deviation of 1.91, whereas the Conventional group had an adjusted deviation of –0.92.
- The Eta value (.72) indicates that treatment had a strong relationship with pupils' attitude scores.
- The Beta value (.73) shows that treatment contributed strongly to the prediction of post-test attitude scores even after controlling for other factors.

This suggests that treatment had a significantly high influence on pupils' scientific attitudes scores.

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- Male pupils had an unadjusted deviation of 0.41, while female pupils had an unadjusted deviation of –0.41 from the grand mean.
- After adjustment, both groups showed deviations of approximately –0.32.
- The Eta value (.01) indicates negligible relationship between gender and post-test attitude scores.
- The Beta value appears to be approximately .05 (or much lower than that of treatment), indicating that gender contributed much less/intangibly to the prediction of post-test attitude scores than treatment.

Thus, gender had an intangible influence on pupils' attitudes, compared to that of treatment.

- The Multiple R^2 value of .628 indicates that treatment and gender jointly explained 62.8% of the variance in pupils' post-test attitude scores.
- The Multiple R value of .858 indicates a high relationship between the predictor variables (treatment and gender) and post-test attitude scores.

In summary, the MCA results reveal that:

1. Treatment was the stronger predictor of pupils' post-test attitude scores, as reflected by its higher Beta value.
2. Gender contributed minimally to variations in attitude scores.
3. Together, treatment and gender accounted for 62.8% of the variation in pupils' post-test attitudes.
4. The remaining 37.2% of the variation in attitude scores may be attributed to other factors not included in the model.

This implies that treatment was the most important factor influencing pupils' attitudes, while gender made a much smaller contribution.

Table 3: Summary of Scheffe post-hoc multiple range comparison of the post-test attitude mean scores

Means	Teaching strategies	Conceptual change	Conventional
7.93	Conceptual change		*
4.18	Conventional	*	

- Denotes pairs of groups significantly different at <0.05 level

Table 3 presents the results of the Scheffé post-hoc test conducted to determine which treatment groups differed significantly in their post-test attitude scores following the significant main effect of treatment found in the ANCOVA.

The results show that pupils exposed to the Conceptual Change Strategy obtained a higher mean attitude score **(**Mean = 7.93**)** than those taught using the Conventional Method **(**Mean = 4.18**).** The asterisks (*) indicate that the difference between the two groups is statistically significant at the

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0.05 level**.** This means that the observed difference in attitude scores is unlikely to have occurred by chance.

The significant difference in favour of the Conceptual Change Strategy suggests that this instructional approach was more effective in promoting more scientific attitudes among pupils than the Conventional Method. Pupils who experienced the Conceptual Change Strategy developed more scientific attitudes, possibly because the strategy actively engaged them in learning, challenged their misconceptions, and encouraged meaningful understanding of concepts.

The Scheffé post-hoc analysis revealed a significant difference between the two teaching strategies. Pupils taught using the Conceptual Change Strategy (Mean = 7.93) demonstrated significantly more scientific attitudes than those taught using the Conventional Method (Mean = 4.18). Therefore, the significant treatment effect observed in the ANCOVA can be attributed to the superiority of the Conceptual Change Strategy in enhancing pupils' attitudes, indicating that the Conceptual Change Strategy was more effective in improving pupils' scientific attitudes than the Conventional Method.

Discussion of Findings

The finding that the conceptual change teaching strategies was better than the conventional chalk— and talk method for science teaching is corroborated by Aleknaviciute, Letinen and Sodervik, 2023; Pacaci et al, 2023 and Ginyigazi, 2024. It also reveals the superiority of the conceptual change strategy in enhancing pupils' scientific attitudes. This is because unlike the general belief that pupils come into class like empty slates, they may possibly have prior conceptions about the topic to be learnt. The teacher should, by questioning, find out the pupils' prior conceptions. This will guide on the appropriate activities to use to reveal to the pupils that their prior conceptions are wrong (if so), and make it easy for them to adopt the correct information instead.

The conceptual change teaching strategy involves the use of various science activities to show pupils their prior misconceptions so that they can willingly replace them with accurate information. This is probably another reason why the strategy was able to enhance the pupils' scientific attitude because when an activity based teaching strategy (such as conceptual change teaching strategy) is used, pupils are active, and their interest is aroused and sustained. Moreover, the activities expose them to science processes and skills, which help them to acquire such scientific attitudes as curiosity, objectivity, rationality, suspended judgment and open-mindedness.

The fact that the effectiveness of the treatment did not depend on gender; but was generally similar across gender groups implies that the conceptual change strategy holds promise in enhancing scientific attitudes for both male and female. The findings of Ataha & Ogumogu (2013) also corroborated the fact that the acquisition of scientific attitudes did not depend on gender. The use of the conceptual change teaching strategy could therefore bridge the gender gap observed in the participation of females in science courses and as well help the girls to acquire scientific attitudes.

Conclusion

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This study has been able to show the superiority of the conceptual change teaching strategy over the traditional chalk-and-talk method because the strategy had a significant effect on pupils' scientific attitude scores. It also revealed no significant main effect of gender and no significant interaction effect of treatment and gender on pupils' scientific attitude scores. This implies that the effect of conceptual change teaching strategy in helping pupils to acquire the attitudes of science holds true, regardless of their gender.

Recommendations

In the light of the findings of this study, the following are recommended:

Science teaching should always start with the teacher encouraging pupils to make their own pre-conceptions known, rather than assuming that the pupils have no prior knowledge of the topic. The teacher then presents learners with experiments and activities which challenge these pre-conceptions (if wrong) and encourages the generation of accurate alternative ideas.

Teachers should also provide a variety of science activities for pupils which will expose them to the cognitive gains as well as the skills and attitudes of science.

There is the need to give equal chances to both boys and girls to excel in the sciences and to adopt the scientific attitude. This could be achieved through the use of conceptual change teaching strategy for science teaching because this strategy has been found to profit all pupils irrespective of their gender. Parents should also endeavor to buy scientifically stimulating toys for their girl-child (instead of dolls all the time), which could enhance her scientific attitude and put her at par with her male counterparts in the science class.

Government through the Ministry of Education should organize training workshops for in-service teacher on the use of conceptual change teaching strategy for science teaching.

Teacher training institutions should also train science student-teachers on the use of the Conceptual change teaching strategy. This will enable them acquire the requisite skills to use the strategy to teach pupils after the completion of their training.

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