Cognitive Conflict as Intervention Strategy in Enhancing Students' Achievement in Science and Technology

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Abstract— This study investigated the use of cognitive conflict as intervention strategy in enhancing students' academic achievement in science and technology education in Kogi State. The study was guided by two research questions and two hypotheses. The study adopted quasi-experimental design. The population of the study was all the 7180 senior school two students during the 2020/2021 academic session. The sample consisted of 292 SS two students (186 males and 106 females) drawn from six secondary schools using multi-stage sampling technique. Science Achievement Test (SAT) with reliability coefficients of 0.89 was used for data collection. Data collected were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA). The findings of the study revealed that there was significant difference in mean academic achievement among students taught S&TE using cognitive conflict and traditional instructional strategies. In addition, male and female students taught using cognitive conflict strategy differ significantly in academic achievement scores $F (1.292) = 24.409$; $p = 0.000 < 0.05$. Based on the findings, It was recommended that science teachers should be encouraged to use cognitive conflict as intervention strategy to teach science and technology education in secondary schools in order to enhance students' academic achievement among others.

Keywords— Cognitive Conflict, strategy, Academic Achievement, science and technology.

INTRODUCTION

The roll of science and technology in technological advancement cannot be over emphasized. The knowledge of science and technology is applied in the area of production of Electrical and electronic gadgets, ICT equipment and implements for mechanized agriculture. for any nation to develop, the study of science and technology education (S&TE) should be given to the various levels of her education. Nigeria as a developing nation appears to have been prepared to solve the issue of development in science and technology through her policy on education. The policy provides for a 60:40 admission ratio in the tertiary institution in favour of science and technology education (federal republic of Nigeria, 2014). Science as defined by Achor (2012) is an organized sbody of knowledge in form of laws, theories, principles, concepts and facts. It constitutes the systematic study of living (Biology) and non-living matter (Physics and chemistry), processes and products of energy absorbed or released. Science digs out facts which are effectively used in technology for improvement of economic and technological advancement. Technology refers to skills or knowledge for making, using and providing useful things, for the service of the society (Miller, 2013). Hence there is need to acquire its knowledge through quality instruction. In order to guarantee quality instruction at all levels of education, emphasis has been on the use of innovative teaching strategy such cognitive conflict strategy, that can enhance students' academic achievement in science and technology based disciplines.

Achievement can be defined as the act of accomplishing the set goal well. In this study, students' achievement in S&TE depends on their level of conceptual gain. This is because students' achievement is dependent on the level of their understanding of the concepts being taught by the teacher or discussed by the textbook authors. Students with naïve (alternative) conception may not usually perform well in both examinations conducted in the school and external bodies like West African Examinations Council (WAEC) and National Examinations Council (NECO). Students' achievement is a major determinant of the success or failure in an academic programme. Science educators, examination bodies and parents/ guardians all over Nigeria today complain of students' poor academic achievement in science subjects at Senior Secondary Certificate Examination (The academic achievement of secondary school students has continued to be a source of worry to those in the mainstream of science education in Nigeria SSCE).In this study it is believed that the use of innovative strategy such as cognitive conflict strategy can enhance students' academic achievement in S&TE.

Cognitive conflict strategy is a constructivist strategy of teaching using activity to motivate students and capture their attention in science and technology classroom, in which the teacher acts as a facilitator (Okeke, 2016). Cognitive conflict strategy can be defined as a strategy that destabilises student's confidence in their existing conceptions through contradictory experiences, such as discrepant invents and then enable student's to replace their inaccurate preconceptions with scientifically accepted conception (kempert, 2019). Cognitive conflict teaching strategy is a learner centred strategy that promotes change of exiting knowledge that contradicts scientific conception for meaningful learning that can enhance or boost academic achievements of both gender (Abuh, 2021). This calls for the use of student centred teaching strategies such as cognitive conflict strategy instead of using conventional method that have been found to be deficient in creating permanent and meaningful learning in students. This is because it provides basis for critical reasoning, reflecting, questioning and actively participating in the STE classroom. It therefore means that, to ensure qualitative instruction, the STE classroom must be properly managed to give students equal opportunity to participate in the classroom interaction irrespective of their gender.

Gender refers to all the characteristics of male and female, which a particular society has assigned each sex (Njoku, 2012). Musa (2017) opined that gender refers to social-cultural construct that shows the differentiated roles and responsibilities of men and women in a particular society. This implies that gender determines the role, which one plays in relation to general societal, cultural, political and economic system of the society. Njoku and Usman (2013) were in agreement that females perform lower than males in Mathematics and science subjects because the subjects are considered a male domain and that any female performing highly in the subjects is mostly treated with disdain by her female peers and with open hostility and aggression by her male peers. Thus females are not encouraged to do and perform well in S&T by the society. Similarly, Kajuru and Kauru (2016) reported findings that indicated that males perform better than females, in Science due to the fact that, there are some inherent abilities that have to do with thinking and reasoning that are found in males but seen to be deficient in females. The social cultural difference that exist between girls (females) and boys (males) demands that gender should be considered in the selection of the instructional strategy that is gender friendly (Ogunyemi, 2015). Okeke (2016) in a study discovered that interaction effect of gender and treatment has a significant relationship with students'

academic achievement. Achievement test results by Onekutu (2014) has shown that boys and girls in the early ages perform equally in all subjects including Mathematics, and science courses. Similarly, Denga (2013) reported that many comparism show average scores of boys and girls to be the same on general intelligence test. He said that girls do a little better than boys in Arithemetical ability, though with a great deal of over lapping.

Douglas (2018) held the opinion that girls do better at all levels than boys in achievement even in areas such as language and arithmetic where boys seemed to excel, girls seem to have better grades. It is obvious from the related literature reviewed that the role of gender in the academic achievement of students is a controversial issue, as the findings revealed that gender plays active role in students' academic achievement, while others revealed otherwise. There is therefore the need to find out if use of cognitive conflict strategy as intervention strategy and gender enhances students' achievement in science and technology education in Ankpa LG A.

Statement of the Problem

The quality of teaching and learning of S&TE in Nigeria is far from ideal expectations of all concerned citizen of the country. This concern is as a result of poor academic achievement and low enrolment in science subjects such as Physics, chemistry, biology and mathematics in tertiary institutions of learning. The teaching of sciences requires that the teacher should be knowledgeable in the various methods and strategies for teaching the subject. The application of appropriate methods will help the science teachers to achieve the desired learning outcomes. This calls for the use of innovative strategies such as cognitive conflict teaching strategy by science teachers. This could help for effective and efficient conceptual understanding that can enhance students' academic achievement. Hence, the problem of the study put in a question Form is what are the effect of cognitive conflict as intervention strategy in enhancing students' academic achievement in S&TE in kogi state?

Specifically, the objective of the study is to:
1. Determine the effects of cognitive and traditional instructional strategies on students' academic achievement in S&TE.
2. Find out if there is any difference in the effect of gender on SSII students' mean in achievement when taught using cognitive conflict strategy.

Research Questions
The following research questions guided the study:

1. What are the mean academic achievement scores of SSII students taught S&TE using cognitive conflict and traditional instructional strategies?
2. What are the mean academic achievement scores of male and female students taught using cognitive conflict strategy?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

- **HO₁:** There is no significant difference in the mean achievement scores of students taught S&TE using cognitive conflict and traditional instructional strategies.
- **HO₂:** There is no significant difference between the mean achievement scores of male and female students taught S&TE using cognitive conflict strategy.

Methodology

The design adopted for this study was quasi-experimental design. Specifically, pretest, posttest non-equivalent-control group design was used for the study. The design was used for the study because it involves experiment, control groups and the use of intact classes. In this type of design, the researcher cannot randomly sample the research subjects. Multi-stage sampling technique was used in this study. The total population of 7,180 physics students, from the 154 secondary schools were used for the study.

The sample for the study comprised 292 science students (186 males and 106 females) from six senior secondary schools inAnkpa LGA of Kogi state using multi-stage sampling technique. The instrument namely Science Achievement Test (SAT) was used to collect data. The SAT comprised 50 objective questions developed by the researcher from standardized West African Examination Council (WAEC) past questions from 2010 to 2020.The questions were modified to suit the variables in the study. The instrument SAT was subjected to face and content validity by 5 experts, two in science education, one in measurement and evaluation and one each from physics, chemistry, biology and mathematics education. A trial test was conducted in two schools outside the area of study. This was to avoid bias and test-wise effect on the subjects. Twenty copies of the instruments were used for the pilot test. After the trial testing, the reliability of SAT was determined using Kurder Richadson (K-R21) formula. The choice of this reliability estimate was because the instruments is dichotomously scored. With this Kurder Richardson (K-R21), the reliability coefficient of TPPT was calculated to be 0.89. the reliability index of 0.89 shows that SAT is reliable. Data were collected with the help of the six research assistants, permission was sought from the principal of the selected schools for the use of teachers, schools and students.

The students in the experimental group were taught using cognitive conflict strategy while the control group were taught using discussion method for six weeks. The instrument was administered on the students before and after they were taught in a classroom setting as pretest and posttest. This is to determine students' prior knowledge or conception before treatment. With the help of the research assistants the instruments were collected and scored. Analysis was done using mean and standard deviation to answer research questions while ANCOVA statistics was used to test the hypotheses at 0.05 Alpha level.

RESULTS.

Research Question One

What are the mean academic achievement scores of SSII students taught using cognitive conflict and traditional instructional strategies?

Table 1: Mean Achievement Scores of SSII Students taught S&TE using Cognitive Conflict and Traditional Instructional Strategies

METHOD		PRESAT	POSTSAT	MEAN GAIN
Cognitive Conflict Instructional Strategy	Mean	43.67	88.78	45.12
	N	149	149	
	Std. Deviation	11.67	13.58	
Traditional Instructional StrategyMean Difference	Mean	43.29	62.77	19.48
	N	143	143	
	SD	10.88	12.89	25.70

The table shows that 149 SSII students were taught S&TE using cognitive conflict strategy while 143 students were taught using traditional strategy. The table reveals that the mean achievement score of students taught STE using cognitive conflict strategy is 43.67 with a standard deviation of 11.67 during pre-test and 88.78 with a standard deviation of 13.58 in post test. The mean achievement score of students taught STE using traditional instructional strategy is 43.29 with a standard deviation of 10.88 during pre-test and 62.77 with a standard deviation of 12.89 in post test.

The table further shows that the mean gain for cognitive conflict instructional strategy is 45.18, while that of traditional instructional strategy is 19.48, with mean difference of 25.70 in favour of those taught using cognitive conflict strategy.

Research Question Two
What are the mean academic achievement scores of male and female students taught STEusing cognitive conflict strategy?

Table 2: Mean Academic Achievement Scores of Male and Female Students Taught using Cognitive Conflict Strategy

GENDER		PRESAT	POSTSAT	MEAN GAIN
Male	Mean	48.43	85.89	37.46
	N	186	186	
	Std. Deviation	9.67	12.36	
Female	Mean	38.54	70.37	31.83
	N	106	106	
	Std. Deviation	10.56	11.89	
Mean difference				5.79

The table 2 reveals that the mean achievement scores of male students taught STE using cognitive conflict strategy is 48.43 with a standard deviation of 9.67 during pre-test and 85.89 with a standard deviation of 12.36 in posttest. On the other hand, the mean achievement scores of female students taught STE using cognitive conflict strategy is 38.54 with a standard deviation of 10.56 during pre-test and 70.37 with a standard deviation of 11.89 in post- test, the table further shows that the mean gain of male students that were taught STE using cognitive conflict strategy is 37.40 and that of female students taught STE using cognitive

conflict strategy is 31.83. The difference between the mean gains of male and female students taught using cognitive conflict strategy is 5.79 in favour of male students.

Test of Hypotheses
Hypothesis One
There is no significant difference in the mean achievement scores of students taught STE using cognitive conflict and traditional instructional strategies.

Table 3: ANCOVA of Mean Achievement Scores of Students taught using Cognitive Conflict and Traditional Instructional Strategies: Dependent Variable: PostSAT

SOURCE	TYPE III SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.	PARTIAL ETA SQUARED
Corrected Model	36336.248	2	18168.124	149.920	.000	.608
Intercept	29739.418	1	29739.418	277.859	.000	.489
PreSAT	16067.896	1	16067.896	150.125	.000	.341
Method	31144.448	1	15572.224	145.493	.000	.501
Error	32038.827	289	107.030			
Total	1494926.000	292				
Corrected Total	86176.939	291				
a. R Squared = .608 (Adjusted R Squared = .604)						

Table 3 reveals that $F(1, 292) = 145.493$; $p = 0.000 < 0.05$. Since the p value is less than 0.05, the null hypothesis is thus rejected. This implies that there is significant difference in the mean achievement scores of students taught STE using cognitive conflict and traditional instructional strategies.

Table 4: ANCOVA of Mean Achievement Scores of Male and Female Students Taught using Cognitive Conflict Strategy | Dependent Variable: PostSAT

SOURCE	TYPE III SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.	PARTIAL ETA SQUARED
Corrected Model	8496.912a	2	4248.456	35.315	.000	.421
Intercept	30221.862	1	30221.862	295.623	.000	.753
PreSAT	1590.327	1	1590.327	17.073	.000	.150
Gender	2273.671	1	2273.671	24.409	.000	.201
Error	9035.433	289	93.149			
Total	636401.000	292				
Corrected Total	15614.590	291				
a. R Squared = .421 (Adjusted R Squared = .409)						

Table 4 reveals that $F(1,292) = 24.409$; $p = 0.000 < 0.05$.since the p-value is lee than 0.05, the null hypothesis is rejected. This implies that there is significant difference between the mean achievement scores of male and female students taught STE using cognitive conflict strategy.

DISCUSSION OF FINDINGS

The finding revealed that there is significant difference in the mean achievement scores of students taught STE using cognitive conflict and traditional instructional strategies. The bivariate comparisons of the methods of teaching STE and its effect on the mean achievement scores of students confirmed the rejected null hypothesis. This means that S&TE could be better taught using cognitive conflict strategy than traditional instructional strategy. The finding agrees with that of Madu (2008) and Agomouh (2010) that constructivist based instruction is efficacious in enhancing students' conceptual change for understanding of science and technology based disciplines. The finding also revealed that there is significant difference between the mean academic achievement scores of male and female students taught science and technology based disciplines using cognitive conflict strategy. This implies that the use of cognitive conflict strategy is not gender friendly. The result agrees with Obiekwe (2011) that 7ES model of constructivist instructional strategy was more effective in arousing students' attention and achievement among male and female than conventional method in ecological concepts in Biological sciences.

Hypothesis Two
There is no significant difference between the mean achievement scores of male and female students taught STE using cognitive conflict strategy.

The study revealed that the instructional approach arouses the attention of male students more than female students. The finding also agrees with that of Baser (2009) that there is significant difference between experimental and control group on gender, in favour of the females. That means cognitive conflict based instructional strategy favours female students more than male folks. However, the finding disagrees with Ma-Naim, Bar and Zinn (2012) that cognitive conflict does not depend on gender that means cognitive conflict favours both male and female students.

CONCLUSION

It was concluded that students' achievement in learning S&TE were greatly influenced by cognitive conflict strategy and significantly higher than when traditional instructional strategy was used. The study revealed that the male students taught S&TE based courses using cognitive conflict strategy showed greater and significant achievement by male students. Students taught with cognitive conflict strategy had significant achievement than those taught with traditional strategy.

RECOMMENDATIONS

The following recommendations were made in the light of the findings of this study:

- To maximize ahievement of students in S&TE, science teachers are encouraged to use cognitive conflict strategy that is learner-centered with

hands-on activities as conceptual change teaching strategy.

- School administrators should adequately provide science learning facilities to schools to facilitate teaching and learning of science subjects. This is important because meaningful learning cannot be advanced by constructivist based teaching strategy if learning facilities are not available in secondary schools.

- Science teachers should be trained on how and when to use cognitive conflict strategy to foster students' achievement in science subjects by organizing workshops, seminars, conferences on its use by government and stakeholders in education.

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