ENHANCING OSUN STATE SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN BASIC SCIENCE THROUGH COGNITIVE APPRENTICESHIP AND CRITICAL EXPLORATION TEACHING STRATEGIES

A.M. Olagunju & V.O. Animasahun
Department of Teacher Education
University of Ibadan, Ibadan.
E-mail: animarotimi@yahoo.com and
masahuntoyin@yahoo.com
Phone: 08068058702

Abstract

Several researches have shown that students record low achievement in basic science. This has been attributed to conventional lecture method commonly used by science teachers. Scholars have thus recommended the use of other innovative strategies that could facilitate the teaching and learning of basic science. Two of such strategies are Cognitive Apprenticeship and Critical Exploration Teaching Strategies. There is paucity of research on effects of these two strategies on students' achievement in basic science. This study therefore, used Cognitive Apprenticeship Strategy (CAS) and Critical Exploration Teaching Strategies (CES) to enhance students' achievement in basic science in Osun State. The study adopted a pretest-posttest control group quasi-experimental design using multi-stage sampling technique to select two hundred and seventy JSS students from nine junior secondary schools in three local government areas of Osun state. The schools were randomly assigned to experimental (CAS and CES) and control (CS) groups, and treatments lasted for 12 weeks. Validated instrument titled: "Basic Science Students Achievement test (r=0.81) was used in the study. One hypothesis was tested at 0.05 level of significance. Data were analysed using ANCOVA and Duncan Post hoc test. The result showed that there was significant main effect of treatment on students' achievement in basic science ($F_{(2,257)}$ =66.56; $\tilde{\eta}^2$=.34). Cognitive Apprenticeship Strategy students ($\bar{x}$=13.35) performed better than Critical Exploration Strategy ($\bar{x}$=13.23) and Conventional Strategy ($\bar{x}$=7.90). Cognitive Apprenticeship and Critical Exploration teaching strategies greatly enhanced students' academic achievement in Basic science. It was recommended that *curriculum developers and basic science teachers should adopt the two activity-based strategies for the improvement of students' achievement in basic science.*

Keywords: Cognitive Apprenticeship Strategy, Critical Exploration Strategy, Achievement in Basic science.

Introduction

Basic science is the major science subject offered in the Junior Secondary school; others include Agricultural Science, Introductory Technology, and Home Economics. Basic science helps students to develop their physical skills such as the proper handling of objects and equipment such as microscope; measuring solid, liquid and gases such as mass, volume of water in litre and gases in kilogram. It also helps students to develop their natural curiosity through opportunities to carry out scientific investigations like observation of objects and equipment, classifying objects into living and non-living things, into solid, liquid and gas, into plants and animals, into metals and non-metals, and also through experimentation. Science also helps students to explain events in nature, enabling them to identify those beliefs that are superstitions. For example, scientists cannot come up and say a mango fruit that drops from a tree will move upwards rather than downwards. That would not be consistent with the law of gravity. Science helps students to think and reason in a logical manner- that is inductive reasoning. It helps students in learning how to solve simple problems they encounter on daily basis. It enables students to develop their social skills, for example, establishing friendship while working co-operatively in groups. It helps to prepare students for future careers in medicine, pharmacy, engineering and so on. It helps students to understand, use and control their environment. It helps build a solid foundation for production and employment. It brings about improvement in our economy and also makes living more meaningful with the application of scientific knowledge (Millennium Development Goals, 2012).

Science has played significant role in the development of nations. Scholars have identified it as a potential instrument for solving socio-economic problems such as unemployment, hunger, poverty, population explosion and environmental degradation, which are problems confronting developing countries like Nigeria (Adesoji, 2003; Afolabi & Audu, 2007). Donkor (2006) and Seweje (2001) defined science as the organized study of natural phenomena presumed to have been a main pursuit since the first attempt to harness the forces of nature. They stressed further that science is usually regarded as the "know why". The type of science where emphasis is placed on the fundamental unity of science is referred to as integrated science. This is different from the old fashion of separating science where emphasis is placed on division into Physics, Chemistry and Biology.

Hence, the inclusion of Basic Science as a core subject in the junior secondary school curriculum calls for a need to teach it effectively. It is expected that teaching of Basic Science should result in the acquisition of basic science knowledge, skills and attitudes necessary to solve everyday problems. Regrettably, the annual performance of students in the subject showed a decline in cognitive achievement. The performance of students in science generally is a major concern to science educators as students' performance in science subjects is low in both national and state examinations. A number of factors can be identified as the causes of poor performance of students in sciences. These include the science curricula, teachers' methods of teaching, parents, government, lack of science facilities and others (Ahiakwo, 2003). Survey from schools revealed that inadequacy of good instructional materials, equipment and laboratory facilities in the schools also negatively affect the effective learning of Science in the schools. Students' perform poorly in sciences globally because they are not involved in the teaching and learning activities right from the beginning of any new concept to be taught. Also, other factors are lack of qualified teachers as well as experiences in teaching, and unavailability and/or insufficiency of materials in the laboratories (Ajayi, 2007).

Researchers like Danmole and Adeoye (2004) as well as Alebiosu and Bamiro (2007) have identified reasons for low enrolment and underachievement in the sciences to include ill-equipped laboratories, teacher and gender factors and insufficient funding. Various studies have shown that most of the teachers of integrated science are not qualified and this in turn affects achievement (Odetoyinbo, 2004). Therefore, students learning outcome remains not so encouraging, despite all these efforts and innovations at ensuring qualitative teaching and learning of basic science at the junior secondary level (Adeyemi, 2006; Ajagun, 2006 and Ozoji, 2008).

A cursory look at the performance of students in basic science in Osun state between 2006 and 2013 reveal the percentage of students with distinction and credit passes as follows: 52.34% for 2006; 49.77% for 2007; 51.20% for 2008; 49.31% for 2009; 57.71% for 2010; 61.46% for 2011; 48.82% for 2012 and 56.15% for 2013 (Ministry of Education, Osogbo. Osun state, 2013). This shows that the average good performance for the whole period is 53.3. This is not the best for students who will become future scientists and contribute maximally to the scientific and technological development of the nation.

Students' poor performance in Basic Science has attracted educators' comments and concerns (Seweje, 2001; Adeyemi, 2006; Duyilemi, 2014), and various reasons have been adduced for this problem. Ajayi (2007) associated this with shortage of qualified instructors, while Erinosho (2004) attributed it to poor understanding of scientific concept by the students. The Science Teachers' Association of Nigeria (2010) attributed it to lack of commitment among the science teachers, while Duyilemi (2014) attributed it to poor method of teaching.

In spite of all the efforts towards improving students' performance, using some teaching strategies which include, demonstration, discussion, project, field trip, group discussion and lecture methods, the performance of students is still very low. Of all these, lecture method is the most popular, commonest and mostly used in Nigerian classrooms (Duyilemi, 2005). Ogunsola-Bamidele (2012) remarked that lecture method is the most abused of all teaching methods and the least effective in many respect. This implies that the aims and objectives of teaching Basic Science cannot be attained with lecture method; hence, there is the need for more involving methods of instruction.

The persistent low performance in the subject has therefore created the need for further search for alternative strategies for teaching Basic Science. In Nigeria, attempts have been made to investigate the usability of cognitive apprenticeship and critical exploration as teaching strategies. For instance, Agommuoh and Ifeanacho (2013) in their investigation of secondary school students' Assessment of Innovative Teaching Strategies in Enhancing

Achievement in Physics and Mathematics in Umuahia, Abia State of Nigeria, found that inquiry method, discovery learning, discussion, role play, simulation, games, team teaching, brainstorming, and other similar strategies which include cognitive apprenticeship and critical exploration were agreed to be teaching strategies that can enhance achievement in Physics and Mathematics. They recommended that Physics and Mathematics teachers should be encouraged to use these teaching strategies when teaching Physics and Mathematics. Furthermore, the necessity for the use of cognitive apprenticeship and critical exploration teaching strategies in Nigeria was advocated by Madu (2004), who vehemently opposed the lecture-based instruction, which he referred to as teacher- centered and full of passive acquisition of knowledge by students, who do not have conceptual understanding but memorize the learning content. He therefore advocated the use of innovative teaching strategies in the teaching of science subjects by the science teachers, so as to enable students to learn and acquire positive attitudes and values, process skills, and problem- solving skills. In the light of this, this study examines the effects of cognitive apprenticeship and critical exploration-teaching strategies in enhancing students' achievement in Basic science, in nine selected junior secondary schools in Osun State, Nigeria.

Cognitive apprenticeship is an instructional model derived from the metaphor of the apprentice working under the master craftsperson in traditional societies, and from the way people seem to learn in everyday informal environments (Lave, 2002). This method rests on a somewhat romantic conception of the "ideal" apprenticeship as a method of becoming a master in a complex domain (Brown, Collins and Duguid, 2003). Cognitive apprenticeship is especially appealing to designers of web-based learning environment, who are embracing a more constructivist approach to learning and instruction. Cognitive apprenticeship is a process by which learners learn from a more experienced person by way of cognitive and metacognitive skills and processes. It is an apprenticeship process that utilizes cognitive and metacognitive skills and processes to guide learning (Ogbonna, 2007; Carter, Ferzi and Wiebe, 2007; Martins, 2009}.

Critical exploration is a teaching approach adapted by a learning theorist, Eleanor Duckworth (2001 and 2006) from Jean Piaget's (developmental psychologist) clinical method. It is a method whereby discussion centres on a specific intellectual challenge that has been represented in concrete form; most often, a reliable material and proven ground, against which students can develop and evaluate their own ideas. Duckworth (2006) proposed that the two components of critical exploration are curriculum development and pedagogy. In this method, teachers find ways to encourage their students to explore the subject-matter and express their thought on the material. Teachers critically explore students' learning through project in poetry, sciences, mathematics, history, spelling, or any other part of the curriculum. As students struggle through a problem, the teacher puts them at ease, invites them to talk about and keep thinking about their ideas, and reacts to the substance of their answer without judging them. In these, the teacher refrains from signaling to students what she wants them to say, because doing so will sacrifice the opportunity to know what the students actually think. Rather than being expected to provide a certain answer, the students reveal their own understanding through their responses. This does not mean that the teacher's own curricular goals are pushed aside. On the contrary, a teacher's knowledge in the subject matter and skill as an educator would be simultaneously put to work as she deepens students' understanding and helps them to develop their own thought further.

Critical exploration are experiences in teaching and learning which a teacher conducts so as to engage learners in a subject matter that is real and may be physically present in a classroom. With its fullness of detail, the reality of such a subject accommodates plenty of leeway across which learners may exercise curiosity, actions, observations, conjectures and thought. Theirs are the eyes noticing something about that subject they had never seen before; theirs is the mind perturbed enough by it to ask a question, or want to try something out, or express spontaneous reactions; theirs are hands constructing something or modifying an apparatus or wielding a paint brush. By their own agency on and with the subject, learners develop in their awareness and understanding of it, and in their capacity for action.

Cognitive Apprenticeship and Critical Exploration developed from Constructivists' theory focus on hands-on minds-on activities, whereby learners are actively involved in the learning process. Confucius' pedagogical methods also supported this view in which a teacher poses questions, cites passages from the classics, or uses apt analogies, and waits for his students to come to their own understanding. The origins of Cognitive Apprenticeship and Critical Exploration can be traced to the early philosophies of Plato. Plato believed that we learn about the world in two different ways. We get useful information through our senses, like sight and touch, but we reach the level of truth by using a higher thinking ability, which he called reason. Plato said that our senses give us imperfect knowledge, because they relate specific objects. But our reason produces truth, or perfect knowledge, because it relates ideas. Both Plato and Aristotle believed that as humans develop, there are qualitative changes in their ability to think logically about experiences. The importance of critical thinking was also evident in the beginning of the modern era of education in the writings of Dewey (1909/1997). He described the ability to think critically as a way to find meaning in the world in which we live, but the processes by which learning occur, (cognitive adaptation and social mediation) are believed to be continuous or remain the same throughout life. At the heart of constructivist philosophy is the belief that knowledge is not given but gained through real experiences that have purpose and meaning to the learner, and the exchange of perspectives about the experience with others (Piaget & Inhelder, 1969; Vygotsky,1978). An emphasis is now being placed on the ability to understand and use information, not just merely to possess it, but to improve their achievements, attitude and practices towards environmental education (Igboko & Ibeneme, 2006). Almost unanimously, educators believe the development of critical thinking ability should be a primary goal of education (Pithers & Soden, 2000).

Cognitive Constructivism according to Fosnot (1996), is the concept that learners actively construct their own knowledge and meaning from their experiences. Knowledge is deemed fluid and in a constant state of change, therefore, students' ability to construct viable knowledge, adapt and be flexible is highly paramount. The implication of cognitive constructivism, according to Kato and Kamii (2001), is that the child becomes very autonomous and independent, refusing to be governed by reward and punishment.

Research Instrument

Basic Science Students' Achievement Test (BSSAT) is the only instrument used for the study. This instrument, developed and validated by expert, and the researcher in collaboration with the supervisor tested the JSS II students' intellectual achievement in living things, changes in matter, changes in living things and changes in non-living things. The test contains twenty five multiple choice objectives test items. It has two sections with Section (A) containing demographic information such as Name of School, Students Name, Class, Gender, Age, Local Government Area and Highest Qualification of Parents, while section B contains the test items constructed as presented in Table 1. The options for the questions range from A to D. One mark was awarded for each correct option and zero for wrong option. This means that the total marks obtainable is 25. The test items were generated to cover cognitive domains of knowledge, Understanding and thinking, in accordance with Okpala, Onocha and Oyedeji (1998). The table of specification is contained in Table 1

Table 1: Table of Specification for Basic Science Students' Achievement Test (BSSAT)

Topic	Knowledge	Understanding	Thinking	Total
Living things	(2) 1,5	(1) 4	(3) 2,3,10	6
Changes in living things	(3) 6,8,12	(3) 7,9,13	(2) 11,14	8
Changes in non-living things	(2) 15,18	(2) 16,21	(3) 17,19,20	7
Changes in matter	(1)24	(2)25,23	(1) 22	4
Total	**8**	**8**	**9**	**25**

Validity and Reliability of Basic Science Students' Achievement Test

The validity and reliability coefficient of the (BSSAT) were determined using coefficient of the initial draft of forty multiple choice items and were given to some lecturers in the Science Unit of the Department of Teacher Education, Faculty of Education, University of Ibadan, Ibadan; some Ph.D students in the field of Basic Science and two lecturers who are experts in the field of Science Education. This was done to ascertain the face, content and construct validity of the instrument. The forty (40) multiple choice items were reduced to thirty (30) items while twenty five (25) items survived final scrutiny. It was later trial-tested in a representative secondary school that was not selected for the main study in which the items fell within the discriminating indices of 0.4 to 0.6. It consists thirty (30) multiple choice items, the discriminating indices range from 0.4 to 0.6 and using Kuder-Richardson formula 20 (KR20), the reliability coefficient was 0.81 and an average item difficulty index of 0.49 was obtained.

Procedure for Data Analysis

The data was analyzed using descriptive statistics (Mean and Standard Deviation) and inferential statistics such as Analysis of covariance (ANCOVA), using pretest scores as covariates. Also, the Estimated Marginal Mean (EMM) aspect of the ANCOVA was employed to determine the magnitude of the performance of the various groups. In the case of significant main effects, the Duncan analysis was used to determine the sources of such significant differences. The hypothesis was tested at 0.05 level of significance.

Result

Descriptive statistics associated with Treatment.

Table 2: Summary of Descriptive Statistics Associated with Treatment

	Achievement Scores		
	CAS	**CES**	**CS**
No of cases	90	90	90
Pre-test mean	12.68	12.58	7.11
Pre-test S.D	0.65	0.65	0.59
Posttest mean	13.35	13.23	7.40
Posttest S.D	0.34	0.35	0.40
Mean Gain	0.67	0.65	0.29

. CAS- Cognitive Apprenticeship Strategy

. CES- Critical Exploration Strategy

.CS- Conventional Strategy
.S.D- Standard Deviation

Table 2 displays the descriptive Statistics of the students' achievement scores. The Posttest scores improved for Cognitive apprenticeship in achievement scores 0.67. Critical exploration Posttest scores showed improvement with 0.65. In case of Conventional strategy, the Posttest scores do not improve in achievement.

The mean gain in descending order is: Cognitive apprenticeship had higher mean gain than Critical exploration, while Critical exploration had higher mean gain than Conventional strategy. Figure 1 displayed the bar chart showing the magnitude of descriptive statistics of the students' achievement scores associated with treatment as presented earlier in Table 2.

This is further represented in Figure 1.

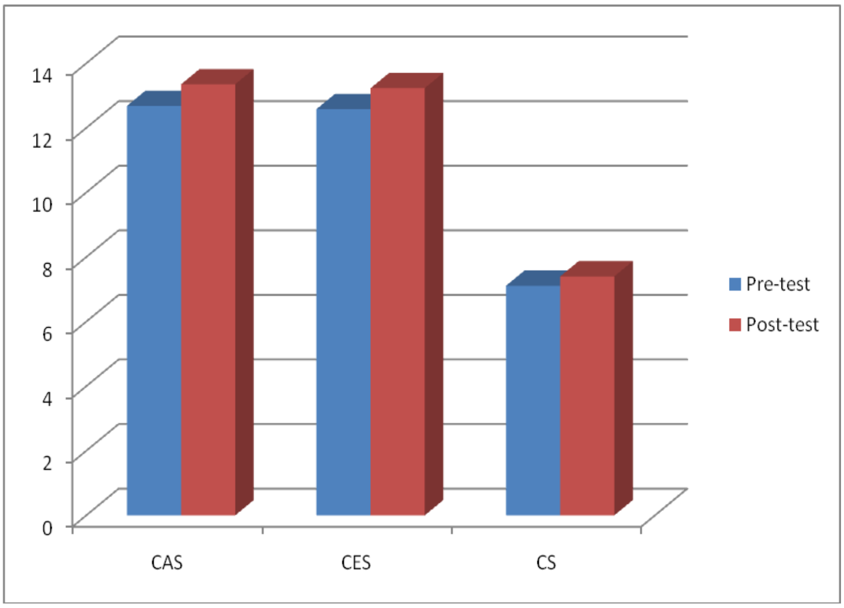

Figure 1: Bar chart showing descriptive statistics associated with treatment on achievement mean scores.

. CAS- Cognitive apprenticeship strategy

. CES-Critical exploration strategy
. CS-Conventional strategy

Figure 1 revealed the bar chart showing descriptive statistics associated with treatment on achievement mean scores. The posttest scores improved for Cognitive apprenticeship in achievement scores by 0.67 (pretest mean= 12.68, posttest mean= 13.35), Critical exploration strategy scores show improvement with 0.68 (pretest mean=12.58, posttest mean=13.23). In the case of Conventional strategy, the posttest scores do not improve in achievement (Pretest mean=7.11, Posttest scores=7.40).

The mean gain in descending order was; Cognitive apprenticeship had higher mean gain than Critical exploration strategy, while Critical exploration strategy had higher mean gain than Conventional strategy.

Testing of Hypothesis

There is no significant main effect of treatment on students' achievement in Basic Science. Table 3 represents the summary of ANCOVA results on participants' posttest achievement scores

Table 3: 3 x 2x 2 ANCOVA showing the Summary of post-test Achievement in Basic Science among Students by Treatment, Gender and Parental supportiveness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2243.596[a]	12	186.966	30.453	.000	.587
Intercept	1818.503	1	1818.503	296.194	.000	.535
Pre-test	270.049	1	270.049	43.985	.000	.146
Treatment	817.266	2	408.633	66.557	.000	.341
Gender	15.214	1	15.214	2.478	.117	.010
Parental support	.139	1	.139	.023	.881	.000
treatment * gender	.689	2	.345	.056	.945	.000
treatment* parentalsup	5.127	2	2.563	.418	.659	.003
gender * parentasupp	.024	1	.024	.004	.950	.000

treatment*gender* paretalsupp	16.221	2	8.111	1.321	.269	.010
Error	1577.870	257	6.140			
Total	39460.000	270				
Corrected Total	3821.467	269				

R. Squared=.587 (Adjusted R. Squared=)*Significant at p<.05

Table 3 shows a significant main effect of treatment on achievement in Basic Science among the students (F $(_{2,257})$ = 66.557; P<0.05, $\tilde{\eta}^2$ = 0.341). The effect size of 34.1%.was recorded. Hence, Ho1a was rejected statistically. To determine the actual source of the observed significant differences, Estimated Marginal Means (EMM) analysis was carried out on the mean scores of the groups. This is presented in Table 4.

Table 4: Estimated Marginal Means (EMM) analysis According to Treatment and control Group

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Conventional Strategy	7.900[a]	.401	7.110	8.690
Cognitive Apprenticeship Strategy	13.350[a]	.343	12.675	14.024
Critical Exploration Strategy	13.225[a]	.346	12.545	13.906

Table 4. shows that the mean score of participants exposed to cognitive apprenticeship strategy is higher than those of the critical exploration strategy and the conventional strategy group. Also, the mean score of participants exposed to critical exploration strategy is higher than that of the conventional strategy group. This is shown in Figure 2.

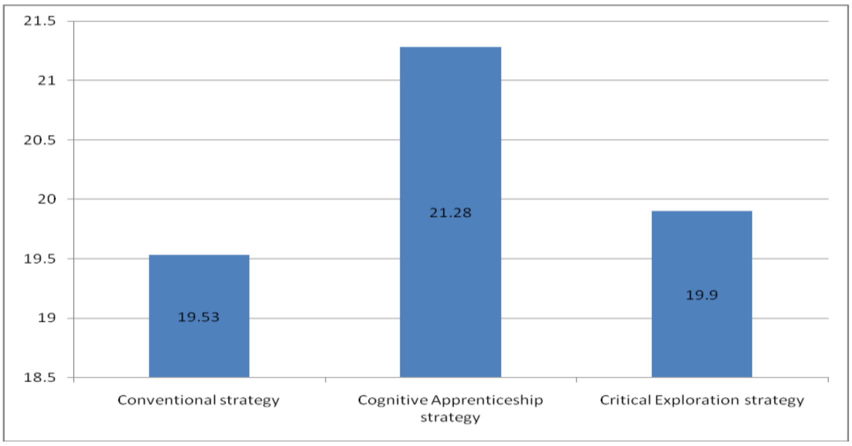

Figure 2: Bar Chart showing Estimated Marginal Mean according to Treatment and control.

Figure 2 shows that the mean score of participants exposed to cognitive apprenticeship strategy was 21.28, those of the critical exploration strategy was 19.90, and the conventional strategy group had the mean score of 19.53. Also, the mean score of participants exposed to cognitive apprenticeship strategy was higher than those of the critical exploration and conventional strategy groups. The Duncan post hoc analysis was conducted on the posttest mean and the result is presented in Table 5.

Table 5: Duncan Post Hoc Analysis According to Treatment Group

Treatment	**N**	**Mean**	**Treatment**		
			1. Cognitive Apprenticeship Strategy	2. Critical Exploration Strategy	3 Conventional Strategy
1. Cognitive Apprenticeship Strategy	90	13.350		*	*
2. Critical Exploration Strategy	90	13.225			*
3. Conventional Strategy	90	7.900	*	*	

*Pairs of group significantly different at P<.05.

The mean score of participants exposed to cognitive apprenticeship strategy is significantly higher than those of the critical exploration strategy and the conventional strategy groups. Also, the mean score of participants exposed to critical exploration strategy is significantly higher than that of the conventional strategy group. Therefore, the researcher concluded that cognitive apprenticeship strategy is the best among the three strategies used in enhancing achievement in Basic Science.

Discussion

This study has revealed that there was significant main effect of treatment on students' achievement in basic science. The students that used cognitive apprenticeship strategy performed better than those exposed to conventional strategy, and those in critical exploration strategy also performed better than those in conventional strategy. This clearly indicates that students learn better when they are consciously involved in the teaching and learning process rather than when the teacher is more active in the teaching and learning process than the students. The slogan which says: I forget what I hear, I remember what I see, but what I participate in or do becomes part of me. Young children often learn better when they construct their own thinking, interact with their peers and come out with their own interpretation of issues with a little guidance rather than being spoon fed. Vygotsky, (1978) believed that students should utilize the input of others to build or construct their own learning through collaborative experiences (Martins, 2009). Cornelius-White (2007) found that students using more learner-centred methods often performed at a higher level. The two interventions in this study have been found to be useful alternatives to conventional teaching method; therefore, utilizing them would increase students' achievement in all academic endeavours, especially in learning basic science.

Recommendations

Based on the findings of this study, the following recommendations are hereby made:

In order to improve students' performance in Basic Science, Cognitive apprenticeship and Critical exploration teaching strategies are recommended to secondary school Basic Science teachers for teaching the subject in Nigerian Secondary Schools. Teaching strategies, such as cognitive apprenticeship and critical exploration strategies that reduce anxiety in learning for both male and female students, should be adopted in all schools.

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