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RELATIVE EFFECTIVENESS OF BRAINSTORMING AND THINK-PAIR-SHARE STRATEGIES ON STUDENTS' ACADEMIC ACHIEVEMENT AND RETENTION IN BIOLOGY

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Abstract
The need for higher success in academic achievement of students in biology has always been the concern of science teachers, educational assessors and evaluator. It is necessary to experiment more student-centre methods of teaching. This study, therefore, ascertain the effects of brainstorming and think-pair-share teaching strategies when compared with the usual conventional teaching method. Two research questions were answered and two corresponding hypotheses were tested. The quasi-experimental research design was employed. One hundred and thirty-nine senior secondary school students were sampled. The biology achievement test (BAT) with multiple choice questions was used as the instrument for data collection. The BAT was subjected to face and content validity, while Kuder-Richardson method was used for the reliability, which yielded a coefficient of 0.71. data were collected as pre-test, post-test, and delayed post-test. Mean, standard deviation, and analysis of covariance were used as statistic tools. Findings revealed that students showed higher academic achievement scores with the think-pair-share and brainstorming strategies than the conventional method. Nevertheless, no significant difference was found between the students taught biology with brainstorming and think-pair-share strategies. The implication is that students will report higher academic achievement when student-centre methods are employed in teaching biology in secondary school.
Keywords. Academic achievement, biology, brainstorming, retention, secondary school, think-pair-share.

Introduction

The massive growth in technology and scientific outburst is posing great pressure on the education system. The advancement of any nation depends to a large extent on the rate of her scientific and technological development especially in developing countries like Nigeria. The future of every society will be determined by citizens who are able to understand and help shape the complex influence of science and technology in the world (Ungar, 2010). Science is seen as a body of knowledge, a way of investigation and thinking in pursuit of an understanding of nature. (Author & Omosewo, 2006). Science education to which physics, chemistry and biology form the bases focus not only on producing excellent scientists but also, to produce citizens who use their knowledge to advance the society. As a result, students are being encouraged to take up science-related courses within the content of science education, Biology has been identified as a very important subject and as a core subject taught at the senior secondary school in Nigeria.

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Biology is the study of living things which includes plants and animals (Amaefuna, 2013). It deals with living organisms including their structure, function, evolution, distribution and inter-relationships. Biology curriculum is designed to continue students' investigation into natural phenomena, deepening students' understanding, interest and retention in biological science and to encourage students' ability to apply scientific knowledge to everyday life. (Federal Ministry of Education, 2009). A lot of reasons are borne in mind while studying biology. These include understanding oneself and environment, appreciation of nature as well as pollution control (Kalra, 2008). Predominantly, the teaching of Biology in secondary schools has been done using conventional method. Due to role dominance of teachers in conventional method which is a traditional teaching method, the students are not engaged in critical thinking and this leads to rote learning with little transfer of knowledge. The traditional/conventional teaching method often used by teachers in teaching Biology includes; lecture/expository method, demonstration and direct instruction. These methods of teaching stresses more on the transmission of knowledge in a manner that emphasizes memorization hence they have been characterized by some educators (Okoro,2011) as a poor method of teaching Biology and other science subjects. The conventional/traditional teaching methods involves unidirectional flow of knowledge from teacher to students and do not encourage process skill acquisition needed for proper understanding of biological principles, concepts and facts. Chidebe (2013) refers to these traditional teaching methods as teacher-centered approach to learning in the sense that the teachers are considered as the custodian of knowledge to be transferred to the students. And as such decides how the transfer takes place. The unidirectional flow of information in traditional teaching method makes students passive and unable to construct meaningful knowledge in the teaching and learning of Biology. Knowing fully well that students are not empty bottles that need to be filled by their teachers, they still have little knowledge that can be clarified and built upon. Okoro (2011) stated that poor academic achievement in schools suggested poor methodology of instruction and therefore called for an in dept investigation. It is therefore logical to say that the teacher is one custodian of knowledge and students are able to generate ideas from problem statement and do not develop problem solving scheme in conventional method.

However, studies have shown that this conventional method has not given the desired outcome in terms of students' achievement and learning processes when compared with innovative teaching methods. (Amaefuna, 2013, Okeke, 2016, Okoro 2011, Osuafor & Ogbaga, 2016). Having established the fact that conventional teaching methods like lecture method is not very appropriate, it is necessary to consider innovative approaches to learning like problem-solving approach, co-operative learning approach, brainstorming and Think-Pair-Share(TPS) amongst others.

Consequently, Nigeria's educational policies and goals are directed towards sciences and technology which are the pivot on which so many professional career courses revolves (Chidebe, 2013). Thus, the educational system needs to develop scientifically literate individuals that possess high competence for rational thought and actions especially amongst the young Nigerians and particularly the adolescents who need to transcend from secondary education to university education or labour market. If the adolescent students possess good skills like the ability to generate ideas (brainstorming), through thinking when posed with problems and possibly working in team (pairing up ideas and sharing of thoughts) especially in areas of creativity right from secondary school, the issues of unemployment on the part of both educated and uneducated ones will be halfway solved. This is because a lot of them would have been employers of labour rather than waiting for government or someone to employ them,

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notwithstanding their level of education (Ainley & Fleming, 2004). That is why Olehi (2005) stated that acquiring the highest level of education is not the only solution to the problem of survival but also the ability to create something out of nothing. Olehi (2005) further stated that creating something out of nothing does not occur as a result of one having only a great intelligence but is achieved mostly when individuals at training stage of their career could form group and tries to generate ideas. The idea behind Olehi's statement is referred to as brainstorming.

Brainstorming is a group or individual members' creativity technique by which efforts are made to find solution to a specific problem by gathering a list of ideas spontaneously contributed by its members (Osuafor & Ogbaga, 2016). The term brainstorming was popularized by Alex Faickney Osborn in his 1953 book of "Applied imagination" Osborn claims that brainstorming was more effective than individual working alone in generating ideas. Brainstorming involves thinking freely without restriction hence guided by the following rules according to Dehghan (2013): Withhold criticism within the session, Focus on the number of ideas generated by its group or individual members, Documentation of ideas generated. Combine and improve ideas.

Having stated the rules guiding the brainstorming session, the following stages are used; introducing the brainstorming rules by writing the list of rules on the board to guide the students through the route, stating the subject or problem- the teacher who acts as facilitator picks the topic and gives a little thought-provoking information about the topic to prompt their interest, expressing ideas in a revolving way, exhibiting ideas for combination and improvement and evaluating ideas which result in creative problem solving (Dehghan, 2013). Brainstorming involves critical thinking amongst group members without any form of discouragement. Ajiboye and Ajitoni (2008) observe that children learn best by being interested fully in their own work by seeing, doing, puzzling, verifying their suppositions, experimenting and drawing conclusions themselves on the strength of evidence which they have collected themselves. They can always make mistakes which they then, should rectify by themselves in the light of new information and evidence that is uncovered by them. One may also talk about other related innovative teaching methods that also connote collaborative strategies like co-operative learning, jigsaw model, peer to peer tutoring and Think-pair-share (TPS) amongst others. These pedagogic concepts should be participatory through social interaction, togetherness, and action-oriented communication.

Think-pair-share (TPS) strategy is one of the group discussion strategies and diverse method of learning collaboratively. This strategy was developed by Frank Lyman in 1981. Andrew and Alexandra, (2015) defined think-pair-share as a cooperative learning strategy that encourages students to work together to solve problems or answer questions on an assigned topic. TPS is used to keep all students actively involved in class discussion and provides an opportunity for everyone to share their idea and answer to every question posed by the teacher. As the teacher works to choose appropriate content, it gives the whole lesson preparation and formulation of good cognitive objectives. Think-pair-share strategy is one of the co-operative learning approaches which help learners to solve problems by giving them time to think. Being more willing and less apprehensive about sharing with a larger group gives them the opportunity to change their response if needed and reduce the fear of giving the wrong answer, thereby encouraging them to participate co-operatively and mutually learn between the individuals. This ensures that the contribution of each student works (Bamiro, 2015). Think-pair-share (TPS) strategy includes three components namely; Time for thinking, time for pairing with partner and time for sharing among the larger groups. The use of brainstorming and TPS strategy amongst other collaborative learning approaches unites the cognitive and social aspects of learning, promotes the development of thinking, construction of knowledge, building of learning team

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within a larger group during the sharing of ideas thereby encouraging active participation and interaction. One can therefore emphatically state that by virtue of the importance of biology as a school subject, there is need for its effective teaching and learning to bring about good academic achievement.

Achievement is an important academic factor which according to Pierre, (2010), is the outcome of instruction and students' mastery of particular learning contents. Academic achievement is the outcome of education, the extent to which students, teachers or institution have attained their educational goals. It has been identified to be influenced by teaching methods, in all levels of education, students in co-operative situations achieved greater in academics, social and psychological benefits (Okoro, 2011). Specially, collaborative learning has been reported by several researchers to have improve students' academic achievement (Osuafor, Nwanze, Pius & Emerhioma 2018; Osuafor &Ogbaga,2016). Hence co-operative (collaborative) learning has been proven to have positive effects on achievement in learning process. Students' achievement is measured through examinations and continuous assessment. Achievement tests are used to assess a person's performance in a course of study which one has undergone. There are so many strategies in collaborative teaching and learning methods. Since brainstorming and TPS strategies are aspects of collaborative learning and teaching strategies, one would want to determine the effects of both strategies on the achievement of students. It is also important to know that knowledge gained or achieved can become worthless if it is not retained so as to be useful in the future. Thus the need to consider retention

Retention is the ability to store what has been laid out and recall what has been stored in the memory. According to Bichi (2002), retention is the ability to retain (store) and later remember information or knowledge gained after learning. To ensure life-long learning, students have to be actively involved in their educational journey so as to ensure that learning is desired rather than forced, and the subject matter retained for future application. According to Ibrahim, (2002), Biology teachers strive to establish the fact that understanding of the content comes before the memorization. However, due to the fact that Biology is such a content-rich subject, students often move straight into memorization which in the end results in zero retention of knowledge. There are some contents of biology that may require peer interaction, consistent brainstorming, and sharing of ideas between the peer or even teachers to internalize the learning of such contents or topics as the case may be (for example Transport system). Therefore Fuller (2004) advises that when students cannot learn the way we teach them, we should learn to teach them the way they learn which is the student-centered approach. Since Brainstorming and TPS are types of student-centered approaches to learning, one would want to determine the effects of both Brainstorming and TPS strategies on students' retention in biology.

The importance of effective teaching and learning of Biology notwithstanding appears that students learning outcome in it over the years is still not encouraging (Okeke, 2016). According to Chief examiner's report, the percentage of students who obtain credit pass in Biology at West African Senior School Certificate Examination (WASSCE) in Nigeria has been low and their performance is poor. Ahmed and Abimbola (2011) assert that an ineffective teaching method adopted by teachers at senior secondary school level in Nigeria have been identified as one of the major factors contributing to the poor performance of students in Biology. Amaefuna (2013) and Ogunleye (2006) attribute the high failure rate in Biology to a number of factors such as inadequate learning facilities, overpopulated classrooms, overloaded curriculum, poor mastery of concepts and inappropriate use of good teaching methods. Innovative teaching strategies in teaching and learning of biology could improve both achievement and retention irrespective of gender.

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Gender is defined as the state of being male or female (Suzane, 2010). Some researches have shown contradictory evidence on students' academic achievement in science due to influence of gender. Different methods of teaching are either gender sensitive or gender bias. Aninweze (2014) identifies sex-role stereotyping and masculine image of science as the origin of the difference between male and females' achievement in science education. While Olson (2002) reports that females performed better than male students when taught mathematics using cooperative learning. Attah (2014) found gender differences in favour of male students. Hence these mixed findings deem it fit to determine the influence of gender on biology students' achievement and retention when brainstorming and think-pair-share are used as teaching strategies. The study of the interaction effect of gender in both brainstorming and TPS strategies on students' achievement and retention will also be necessary to equip the biology teachers on how best to plan their lesson using brainstorming and TPS.

Many researches on the innovative pedagogical methods that will adequately develop students' potentials assess and improve their achievement and retention which include co-operative learning, Jigsaw method, constructivism models, brainstorming and think-pair-share strategies amongst others have been recorded. Some researchers (e. g., Walid, 2013) have carried out studies on Brainstorming as an innovative teaching method in education, and found out that it improves the performance of students in mathematics and computer science. Also, Ogunyebi (2018) finds think-pair-share effective in improving the performance of integrated science students. If brainstorming and TPS are effective and have been used in mathematics, computer science and integrated science, one may want to find out what their effects will be in biology. This study seeks to determine the effects of brainstorming and TPS strategy on Biology students' achievement and Retention.

Statement of the Problem

Biology is seen by science educators to be an important subject as it cuts across several disciplines. However, despite its importance and usefulness, the performance of biology students at senior secondary school level has been poor.

The evidence of poor results is shown by the WAEC chief examiner's report (2007-2018) summarized. Following the chief examiners WASSCE report, it is glaring therefore that a lot of works need to be done towards effective teaching and learning that will foster appropriate interaction between the students and learning material for proper functioning of the school system. Brainstorming and TPS instructional strategies have been found effective in improving students' achievement and retaining of learning materials in some subjects like Mathematics, Computer science and Integrated Science but no such study known to the researcher has been carried out in biology. The need therefore arose to determine the effects of brainstorming and TPS instructional strategies on students' achievement and retention in biology.

Research Questions

The following research questions were answered in this study.

1. What is the difference in the mean academic achievement scores between the students taught biology with brainstorming strategy, think-pair-share strategy and conventional method?
2. What is the difference in the mean retention scores between the students taught biology with brainstorming strategy, think-pair-share strategy and conventional method?

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Research Hypotheses

The following corresponding hypotheses were also tested at .05 level of significant

1. There is no significant difference in the mean academic achievement scores between the students taught biology with brainstorming strategy, think-pair-share strategy and conventional method.
2. There is no significant difference in the mean retention scores between the students taught biology with brainstorming strategy, think-pair-share strategy and conventional method.
3. There is no significant difference in the mean academic achievement scores between male and female students taught biology with think-pair-share strategy and conventional method.
4. There is no significant interactive effect of teaching strategies and gender on students' academic achievement in biology.

Methods

This study adopts the quasi-experimental research design, involving three groups – two groups are the experimental groups while one is the control group. The two experimental groups were exposed to brainstorming and think-pair-share strategies, while the control group was taught with the conventional method (lecture method). The choice of this method was born in mind because the researchers do not have the permission to randomize the participants. Hence, quasi-experimental design was considered appropriate for this study.

Using a purposive sampling technique, the sample for this study was 139 senior secondary school students offering biology. The sample was drawn from three intact classes in Awka education zone in Anambra State, Nigeria. The three schools selected for this study represented the three groups, such that students from one school were taught biology using brainstorming strategy (n = 448), another set of students from another school were taught biology using think-pair=share strategy (n = 46), and the students from the last school were taught biology using the conventional method (n = 45).

The instrument used for the study was the biology achievement test (BAT), which consist of 25 multiple choice objective questions (A to D) such that only one response is the correct answer. The items were selected from previous standardized questions from WAEC, NECO, and NABTEB. The BAT was used to collect data to measure the students' academic achievement and retention test. For the psychometric test, the instrument was further subjected to face and content validity. The face validity was carried out with three experts in Biology Education programmes, while the content validity was performed with table of specification. The reliability of the instrument was performed using Kuder-Richardson method. The instrument was administered to 20 biology students and their answers were scored and coded. Thus, a reliability coefficient of 0.71 was obtained

Research assistants were used for data collection. Data were, therefore, collected three different times to measure the students' achievement and retention scores using the BAT. The first data was the pre-test, which was collected two weeks before the experiment. The second data was the post-test, which was collected four days after the experiment. While the third data was the delayed post-test, which was collected four weeks after the post-test. Note that the BAT was used to collect the three data set, but the questions were reshuffled and different paper colours were used at post-test and delayed post-test. To analyse the data, the mean, standard deviation and analysis of covariance (ANCOVA) were employed. The mean and standard deviation were employed for the research questions, while ANCOVA was used to test the

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hypotheses at 0.05 level of significance. To ascertain the academic achievement scores, the pretest and post-test scores were used. Similarly, the retention scores of the students were determined from the post-test and delayed post test scores.

Results

The results are presented in the order of the research questions and the corresponding hypothesis.

Research Question 1: What is the difference in the mean academic achievement scores between the students taught biology with brainstorming strategy, think-pair-share strategy and conventional method?

Table 1

Mean and Standard Deviation of the Mean Achievement Scores among the Group

		Pretest		Posttest		
Groups	N	Mean	SD	Mean	SD	Mean Gain
Brainstorming	48	47.08	10.48	61.33	11.03	14.25
Think-Pair-Share	46	44.00	9.03	63.30	11.94	19.30
Conventional	45	43.33	9.84	50.20	5.38	6.87

Table 1 reveals the pretest and posttest mean achievement scores of the students taught biology using think-pair share, brainstorming and conventional methods. The pretest mean scores for the groups in the brainstorming, think-pair share, and conventional method are 47.08, 44.00, and 43.33 respectively. The posttest mean scores are 61.33, 63.30, and 50.20 respectively. The mean gain for the three groups are 14.25, 19.30, and 6.87 respectively, which depicts that the students in the think-pair share strategy have the highest mean achievement score, followed by those in the brainstorming strategy; while the students in the convectional method have the lowest mean achievement score.

Hypothesis 1: There is no significant difference in the mean academic achievement scores between the students taught biology with brainstorming strategy, think-pair-share strategy and conventional method.

Table 2

The ANCOVA Results of Achievement Scores among the Groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4637.023[a]	3	1545.674	15.685	.000	.258
Intercept	18524.945	1	18524.945	187.982	.000	.582
Pretest	91.838	1	91.838	.932	.336	.007
Group	4402.099	2	2201.049	22.335	.000	.249
Error	13303.768	135	98.546			
Total	491705.000	139				
Corrected Total	17940.791	138				

R Squared = .258 (Adjusted R Squared = .242)

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Data presented in Table 2 reveals the ANCOVA results on the effect of brainstorming, think-pair share and lecture methods on students' academic achievement in biology. The results show a significant difference (F = 22.335, p = .000 < .05, η^2_p = .249) in pretest and posttest mean scores of the students taught biolo gy with the three method. The partial eta square of .249 also reveals that the effect is 24.9 percent. In all, the null hypothesis is rejected. The result shows that there is a significant difference in the effect of the three methods on the students' academic performance in biology. Thus, the multiple comparison tests determine the direction of the difference.

Table 3
The Multiple Comparison Test of Achievement Scores between the Groups

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Think-Pair-Share	Brainstorm	2.229	2.066	.282
	Conventional	13.049*	2.082	.000
Brainstorm	Think-Pair-Share	-2.229	2.066	.282
	Conventional	10.819*	2.085	.000
Conventional	Think-Pair-Share	-13.049*	2.082	.000
	Brainstorm	-10.819*	2.085	.000

Table 3 reveals the multiple comparison test of difference in the academic performance of the students. The table reveals no significant difference between think-pair-share and brainstorming (p = .282 > .05), but there are significant differences between think-pair-share strategy and the conventional method (p = .000 < .05) and brainstorming strategy and the conventional methods (p = .000 < .05). Thus, brainstorming and think-pair-share do not have any significant difference between them, but the two strategies are superior to the conventional method in fostering academic performance.

Research Question 2: What is the difference in the mean retention scores between male and female students taught biology with brainstorming strategy, think-pair-share strategy and conventional method?

Table 4
Mean and Standard Deviation of the Retention Scores among the Group

		Posttest		Delayed Posttest		
Groups	N	Mean	SD	Mean	SD	Mean Gain/Loss
Brainstorming	48	61.33	11.03	60.33	10.82	- 1.00
Think-Pair-Share	46	63.30	11.94	64.61	13.14	1.31
Conventional	45	50.20	5.38	46.38	10.92	- 3.82

The result presented in Table 4 reveals the mean retention scores of the students taught biology with brainstorming, think-pair-share, and conventional methods. The table reveals that the posttest mean scores are 61.33, 63.30, and 50.20 respectively. Similarly, the respective delayed posttest mean scores are 60.33, 64.61, and 46.38. While the think-pair-share strategy has a mean gain of 1.31, the mean loss for the brainstorming strategy and conventional method are

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1.00 and 3.82 respectively. This indicates that the students in the think-pair-share have higher mean retention score than those in the brainstorming strategy.

Hypothesis 2: There is no significant difference in the mean retention scores between male and female students taught biology with brainstorming strategy, think-pair-share strategy and conventional method.

Table 5
The ANCOVA Results of Mean Retention Scores among the Groups

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8383.214[a]	3	2794.405	20.494	.000	.313
Intercept	10236.922	1	10236.922	75.078	.000	.357
Posttest	116.782	1	116.782	.856	.356	.006
Group	5366.486	2	2683.243	19.679	.000	.226
Error	18407.419	135	136.351			
Total	482057.000	139				
Corrected Total	26790.633	138				

Table 5 shows the ANCOVA results on the effect of brainstorming, think-pair share and conventional methods on students' retention in biology. The results show a significant difference (F = 19.679, p = .000 < .05, η^2_p = .226) in the mean retention scores of the students taught biology with the three method. From the table, the partial eta square of .305 also reveals that the effect is 22.6 percent. Based on these, the null hypothesis is rejected. Hence, the result shows that there is a significant difference in the effect of the three methods on the students' mean retention scores in biology. Thus, the multiple comparison test determines the direction of the difference.

Table 6
The Multiple Comparison Test of Mean Retention Scores between the Groups

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Think-Pair-Share	Brainstorm	4.091	2.418	.093
	Conventional	17.007*	2.782	.000
Brainstorm	Think-Pair-Share	-4.091	2.418	.093
	Conventional	12.916*	2.671	.000
Conventional	Think-Pair-Share	-17.007*	2.782	.000
	Brainstorm	-12.916*	2.671	.000

Table 6 reveals the multiple comparison test of difference in the mean retention scores of the students. The table reveals no significant difference between think-pair shared and brainstorming (p = .093 > .05), but there are significant differences between think-pair-share and conventional methods (p = .000 < .05) and brainstorming and conventional methods (p = .000 < .05). Thus, brainstorming and think-pai-share do not significantly differ in enhancing students'

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retention, but the two strategies are superior to the conventional method in enhancing students retention ability.

Discussion of Findings

From the results used to answer research question 1, it was found that the academic achievement of the students in the three groups increased; although the think-pair-share strategy appears to have more effect. Thus, the findings have shown that the students taught Biology using brainstorming and think-pair-share strategies performed significantly better than those taught with conventional method. The difference may be as a result of the fact that both brainstorming and TPS provides an opportunity for students to take active role in building their own knowledge. This finding is in consonance with the research of Bilal-Adel (2012) who view brainstorming as a lateral thinking process by which students develop ideas or thoughts on solution to problems based on layout criteria. It may also be as a result of new useful ideas and creative thinking that the techniques bring to problems.

The data obtained shows that there is significant difference in the retention scores of Biology student taught using brainstorming and think-pair-share strategies than those taught using conventional method. The variation may not be surprising because there may likely exist an excitement on one's state when one makes contribution and gets motivated. This is in line with the study carried out by Imoka and Agwagah (2006) which stated that retention is a subjective feeling of concentration or persisting tendency to pay attention and enjoy some activity of content presentation of learning materials which learners are interested in to evoke spontaneous interest and motivate them to work for hours.

Conclusion

While it is important to improve the academic achievement of students in Biology, the appropriate teaching method or technique is a concern among science and technology educationists. This study, therefore, found that think-pair share and brainstorming are good teaching methods that can enhance students' academic achievement and retention in Biology. Hence, it is concluded that think-pair share and brainstorming teaching methods should argument the conventional methods for effective teaching and learning of Biology in secondary school.

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