

Improving the Academic Achievement and Critical Thinking Dispositions of Biology Students Using the Four Mode Application Technique (4MAT) Teaching Method

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Abstract

This study examined the use of four mode application technique (4MAT) in improving the achievement and critical thinking dispositions in Biology among students in Owerri education zone I of Imo state. A quasi-experimental research design (intact classes with pre-test, treatment and post-test procedure) was the study's design. Two research questions and two hypotheses guided the study. Two intact classes of 77 SS2 students served as the sample. An Achievement Test for Biology (ATFB) and a Biology critical thinking disposition rating scale (BCTDRS) were the study's data collection instruments. Kuder-Richardson (K-R20) was used to test the ATFB for reliability and Cronbach Alpha statistics for the BCTDRS which yielded internal consistency coefficients of 0.77 and 0.75 respectively. To answer the research questions, mean and standard deviations were used while ANCOVA F-test was employed to test the hypotheses at .05 significance level. Findings showed that Biology students exposed to 4MAT performed better in their academic achievement than those exposed to Lecture method ($p < .05$); the students exposed to 4MAT scored significantly higher mean critical thinking disposition scores compared with their counterparts exposed to Lecture method. Recommendation among others is the adoption of 4MAT by Biology instructors in Biology teaching for improved achievement and critical thinking dispositions.

Keywords: Academic Achievement, Biology, Critical thinking disposition, Four mode application technique (4MAT)

Introduction

Biology, a subject for majorly senior school students in Nigeria, takes a central position in the nation's scientific and technological development. In all aspects of human life, Biology plays a projecting role. As a result of Biology's indispensability, a lot of emphasis has been laid on its instruction in schools (Ezere, 2021). Good academic standards in the subject Biology through the years have been hampered by teaching approaches or strategies used to deliver Biology lessons (Ezere & Ndirika, 2022). The inability of students to be proactive in learning settings and also think critically disposes them to constant rote learning and examination misconduct leading to the observed poor academic achievement in the subject at external examinations which is a pertinent problem. Also, Students have various modes or styles of learning and this influences the extent to which they perform in any given subject. This brings to light the need to teach Biology using methods which not only cater for the various learning

styles of learners but also encourage critical thinking tendencies and dispositions among learners.

Lots of innovative teaching methods/approaches are currently in used to refine students' achievement and dispositions to critical thinking in Biology. An example of these teaching methods is the four mode application technique widely known as the 4MAT method. The Four Mode Application technique (4MAT) instructional approach is a learner-focused strategy that organizes learning in accordance with each learner's particular needs (Alanazi, 2020). This instructional approach was developed by Bernice McCarthy in 1970. This teaching approach transforms ideas about learning styles into teaching strategies. It is an eight-step teaching strategy that takes advantage of the four different primary learning preferences and brain dominance patterns of individuals. The four primary learning styles/preferences as popularised by Bernice McCarthy include: imaginative learners; analytical learners; common sense learners and dynamic

learners. These four primary learning styles are normally represented in a circle divided into four quadrats. Each quadrat has two steps (representing individuals with one learning preference) which sum up the 8-step strategy for teaching and learning using the 4MAT approach.

To check how 4MAT method affects Chemistry students' achievement, retention and attitude in Jalingo, Taraba State, Jack and Haladu (2022) carried out an experiment and recorded a remarkable increase in the after treatment scores of students who learned Chemistry with 4MAT method in contrast with students exposed to demonstration method. Also, Alanazi (2020) examined the impacts of applying 4MAT instructional approach on electricity conceptions (Physics) among seventh-grade students of Saudi Arabia and found out that the achievement of the respondents exposed to 4MAT and the control group differed significantly, with those taught with 4MAT performing better. These researchers examined students' achievement in Physics and Chemistry using 4MAT and also in different localities (Delta state and Saudi Arabia). Also Jack and Haladu (2022) compared the performance of students exposed to 4MAT with those taught with demonstration method. However, the researcher sought to check how 4MAT can be used to improve the achievement of Biology students and compare this achievement with that of those exposed to Lecture method of teaching in Owerri Education zone of Imo State.

The lecture teaching method is a popular teaching method which is characterised by one-way communication and structured format and most favourable for large group settings. This method of teaching lays explicit emphasis on the teaching. This method is mostly used by many teachers since it is the best method used to cover a large expanse of syllabus such as Biology. Being the popularly used mode of instruction, the researcher sought to check whether there would be a noticeable disparity in the performance and critical thinking dispositions of students exposed to this method (Lecture method) and those exposed to 4MAT method in Biology.

Critical thinking is an aspect of thinking which may be about any subject or content and in which one carefully analyses, evaluates, and rearranges one's thinking to improve the type and precision of thought. Critical thinking dispositions refer to mental habits possessed by students which help them to properly use critical thinking skills (Paul & Elder, 2019). In other words, the focus of critical thinking dispositions is the habits of the individuals in question which point to critical thinking ability (Brookhart & Nitko, 2019). Critical thinking

disposition refers to the habits, attitude or an inclination towards engaging in critical thinking. In other words, it entails the willingness to engage in critical thinking. The ability of students to engage in critical thinking impacts on their academic achievement.

To determine the change in critical thinking skills of pupils, Sabry, El-Baaly and Abu-Risk (2021) investigated how effective 4MAT would be in developing pupils' science creativity skills and found a statistically significant difference between the critical thinking scores of pupils taught using 4MAT model and those exposed to conventional teaching, with the 4MAT group pupils having a more increased critical thinking disposition mean score. This reviewed study was undertaken among pupils while the focus of the present study is on secondary school students taking Biology. Perhaps, the 4MAT method may have a different effect on secondary school students' achievement and critical thinking dispositions. The previous studies reviewed created a gap in knowledge (differences in location, class of pupils, subject area and methods being compared with 4MAT) which the researcher sought to fill, hence the need to explore the effects of 4MAT on the academic achievement and critical thinking dispositions of Biology students in Owerri Education zone I of Imo State.

The following questions were posed:

1. What are the mean achievement scores of students taught Biology using 4MAT method and lecture teaching method at pre-test and post-test?
2. What are the mean critical thinking disposition scores of students taught Biology using 4MAT teaching method and lecture teaching method at pre-test and post-test?

Hypotheses

H₀₁: The mean achievement scores of students taught Biology using 4MAT method and those exposed to lecture method do not differ significantly.

H₀₂: There is no significant difference between the mean critical thinking disposition scores of students taught Biology using 4MAT method and those taught with lecture method.

Method

The study is delimited to SS2 students taking Biology in two secondary schools in Owerri education zone I. A quasi-experimental research design (two intact groups, with pre-test, treatment and post-test procedure) was the study's design. The

study instruments were Achievement Test for Biology (ATFB) made by the researcher and Biology Critical Thinking Disposition Rating Scale (BCTDRS) adapted from Irani et al (2007). The BAT is made up of 50 multiple choice item questions (with 5 options per question) where each correct question is awarded one point and wrong answer awarded no (zero) point. Hence the maximum score obtainable for the test is 50 points while minimum score is zero (0). The BCTDRS is a 16 item rating scale answered in a 4-point likert format of Strongly agree (4points), Agree (3 points), Disagree (2 points) and Strongly disagree (1 point). Hence the maximum score for the rating scale is given as 64 points while minimum score is 16 points. Content and face validation of the instruments were done by five specialists. Three specialists from Educational Measurement and Evaluation and two specialists from Education Biology. A table of specification was also used to determine coverage of the questions in the ATFB with Bloom's taxonomy of educational objectives. Reliability coefficients of 0.77 and 0.75 were obtained for the ATFB and BCTDRS respectively using Kuder Richardson 20 (KR-20) for the ATFB and Cronbach Alpha statistics for the BCTDRS. The sample size is made up of 77 SS2 Biology students. The sampling technique adopted for the study included purposive and random sampling techniques. Two Local Government areas in Owerri Education zone I of Imo State were randomly selected for the study. One coeducational school in each of the selected local government area was purposively selected for the study. From which SS2 class was purposively picked from each of the schools. The various clusters of SS 2 classes in each of the selected schools were identified (i.e SS2A, SS2B, SS2C etc) and one SS2 class from each of the identified clusters

was randomly chosen (making it two SS2 classes in all). The researcher randomly assigned the schools experimental group I (4MAT) consisting of 37 students and group II (Lecture) consisting of 40 students. Group I was taught excretion, nutrient cycling in nature and ecological management (Associations, Adaptation and Pollution) using 4MAT method, while group II was taught the same topics using the lecture method. These topics were chosen for the study because the past chief WAEC examiner's report recorded poor answers to questions bordering nutrient cycling, excretion and ecological management. A pre-test was administered to the SS2 students in the two schools using the ATFB and BCTDRS to establish their comparability before treatment and also was also used as a covariate for the statistical analysis. A one week revision period was allowed for the two groups. The students were given the ATFBT and BCTDRS (the instruments were reshuffled) as post-test after treatment. To avoid experimental/sensitization bias, the Biology teachers in the sampled schools handled the teaching. The participating SS2 Biology teachers were trained by the researcher using a guide for the 4MAT method and the Lecture teaching method. There was no prior notification of students about their participation in the research and the classes used were not randomised. This implies that the research did not target the best minds in the class nor target students that are below average. Also, ANCOVA was used in the analysis to partial out initial group differences. The researcher used mean and standard deviation to answer the research questions while the hypotheses were tested using ANCOVA F-test at 0.05 significance level where p-value of $<.05$ led to rejection of null hypothesis and vice versa.

Table 1: Achievement Scores of Students in Groups I and II

Test: Mean academic achievement	Pre-test		Post-test		Mean gain	
GROUP	N	\bar{X}	SD	\bar{X}	SD	
I	37	18.00	3.38	30.29	6.95	12.29
II	40	17.52	3.52	23.92	3.87	6.40

On table 1, the mean achievement scores of students taught Biology with 4MAT (I) and Lecture (II) teaching methods at pre-test and post-test are shown. The results reveal that students exposed to 4MAT had pre and post-test mean achievement scores of 18.00 and 30.29 (mean gain =12.29) respectively while students exposed to Lecture method had pre and post-test mean achievement

scores of 17.52 and 23.92 (mean gain= 6.40) respectively. The standard deviation scores are spread apart from the mean, which indicate score homogeneity in the distribution for all the groups. From the table, it is seen that students exposed to 4MAT (group I) performed higher (in achievement) than group II (Lecture method).

Table 2: ANCOVA F-test Analysis for the Test of significant difference between the achievement scores of biology students taught with 4MAT and Lecture methods
Tests of Between-Subjects Effects

Dependent Variable: Post-Test					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	790.312 ^a	2	395.156	12.633	.000
Intercept	1163.537	1	1163.537	37.198	.000
Pretest	9.830	1	9.830	.314	.577
Group	720.885	1	720.885	23.047	.000
Error	2314.675	74	31.279		
Total	59184.000	77			
Corrected Total	3104.987	76			

a. R Squared = .225 (Adjusted R Squared = .234) S= Significant

Table 2 shows the statistical difference between the achievement of Biology 4MAT group and Lecture method group students. It is indicated in the table that $F=23.047$; $P=.000$ ($p<.05$ significance

level). Thus, the null hypothesis is rejected and it is concluded that there is a significant difference in the mean achievement scores of students taught Biology using 4MAT and lecture methods.

Table 3: Mean critical thinking disposition of students in groups I and II

Test: critical thinking disposition	Pre-test		Post-test			
GROUP	N	\bar{X}	SD	\bar{X}	SD	Mean gain
I	37	40.05	8.27	56.18	7.16	16.13
II	40	39.77	8.75	44.52	6.07	4.75

Data on table 3 show the mean critical thinking disposition scores of Biology students exposed to 4MAT and lecture teaching methods at pre-test and post-test. From the table, it is revealed that Biology students exposed to 4MAT teaching method had pre-test and post-test mean critical thinking disposition score of 40.05 and 56.18 (mean

gain= 16.13) while that of Biology students exposed to lecture method had pre-test and post-test mean critical thinking disposition score of 39.77 and 44.52 (mean gain = 4.75) respectively. Invariably, this means that students who learned Biology using 4MAT method scored higher than those in the lecture method group.

Table 4: ANCOVA F-test Analysis for the Test of significant difference between the mean critical thinking disposition scores of 4MAT and Lecture method groups.
Tests of Between-Subjects Effects

Dependent Variable: Post-Test critical thinking dispositions					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	891.979 ^a	2	445.990	10.956	.000
Intercept	5452.932	1	5452.932	133.955	.000
Pretest	275.318	1	275.318	6.763	.111
Groups	697.512	1	697.512	17.135	.000
Error	3012.333	74	40.707		
Total	222216.000	77			
Corrected Total	3904.312	76			

a. R Squared = .228 (Adjusted R Squared = .208)

Data on table 4 show the difference between the mean critical thinking disposition scores of

Biology students exposed to 4MAT and lecture methods. The F-calculated value is given as 17.135;

$p=.000$ ($p<.05$). The null hypothesis is therefore rejected, indicating that the mean critical thinking disposition scores of Biology students exposed to 4MAT and lecture teaching methods are significantly different at 0.05 significance level.

Discussion

Findings in research question one show that students who learned Biology using 4MAT performed better academically than those exposed to the lecture method. The difference in the students' scores (in 4MAT and lecture method groups) proved to be significant ($p<.05$). This by implication means that 4MAT method is a good instructional approach when compared with Lecture teaching method and that it is effective in improving students' achievement in Biology. The cause of this finding could be hinged on the fact that 4MAT method catered for the individual learning styles of the students unlike the lecture method. In affirmation to these findings, Murtala, Dogo, Toro and Nehemiah (2022) in their study on the use of 4MAT to improve the interest and achievement of Algebra students recorded a significant difference students' achievement and interest when exposed to 4MAT and lecture methods with 4MAT improving the students' achievement significantly. Also, Chukwuka and Ijeh (2022), studying how the four mode application technique (4MAT) affects students' retention of Biology concepts, recorded an increase in achievement of students in Biology after exposure to 4MAT. It can therefore be inferred that 4MAT method has a significant positive effect on the achievement of students in Biology.

From the findings in research question two, it is seen that that students who were taught Biology using 4MAT had a remarkable increase in their critical thinking disposition scores at post- test, unlike the students exposed to Lecture method who although an increase was noted in their critical thinking disposition scores, was not as high as that of those taught with 4MAT. The corresponding hypothesis for this finding reveals a statistically significant difference among the mean critical thinking disposition scores of the students in the two groups. The reason for this finding could be that the various steps in the 4MAT teaching method gave students opportunities to relate their lessons to their everyday environment and make vivid use of their imaginations in the learning process. Supporting this finding are the findings of Ilkorucu, Broutin and Boyaci (2022) who integrated critical thinking based teaching to 4MAT (CT-4MAT) instructional procedure to examine students' critical thinking dispositions. They recorded a significant difference favouring the experimental

(4MAT CT based) group students. Also supporting the findings above are the findings of Sabry, El-Baaly and Abu-Risk (2021) who checked how effective 4MAT would be in developing pupils' science creativity skills and reported significant differences between the mean critical thinking scores of pupils instructed with CT based 4MAT model and the control group, with the CT based 4MAT group pupils having a more pronounced critical thinking disposition mean score.

Conclusion

In the teaching of Biology, it is necessary to use 4MAT for impactful learning and increased improvement in academic achievement and critical thinking disposition skills in Biology. The use of 4MAT method accommodates the various learning styles of students and at the same time positively influences students' ability to think deeply and critically. Having established the importance of this teaching methods to students' academic achievement and critical thinking disposition in Biology, it is therefore pertinent for Biology teachers to use 4MAT method in Biology teaching as it is an effective approach to encourage active learning and understanding on the part of the students.

Recommendations

The researcher recommends the following:

1. Biology instructors should adopt the 4MAT teaching method in the teaching of the subject for improved academic achievement and critical thinking dispositions.
2. Workshops, symposia, and trainings should be occasionally organized for Biology instructors to update their knowledge of emerging teaching methods and to train them on these methods such as 4MAT method.

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