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Abstract

The study of heredity, or genetics, encompasses various biological ideas and is often seen as a challenging subject to teach and learn. Considering the, this study decided to employ mind maps to facilitate effective teaching of genetics in selected secondary schools in Ibadan, Nigeria. students were introduced to the practice and principles of using mind maps to help them envision and make connections between various concepts relating to a topic. This is done to facilitate easy recall of facts offered in a topic and meaningful learning. Using a pretest, posttest, and non-randomized control group, this study used a quasi-experimental approach. Two whole classrooms with a total of 126 senior school three pupils comprised the study sample. The Genetic Achievement Test (GAT) and the modified Visual Auditory and Kinesthetic (VAK) Questionnaire were used to gather the data. Descriptive and inferential statistics were used to analyze the data, and ANCOVA was used to test hypotheses at the 0.05 level of significance. The study's conclusions showed that pupils who were taught using mind maps performed better academically than those who were taught using a traditional approach. The research findings also showed that there was no statistically significant variation in the accomplishment levels taught between genders or based on the learning styles of the pupils. Thus, it was suggested that educators employ mind maps to help students understand genetics and other biological concepts that they may find challenging.

Introduction

Biology is the science that studies living organisms. Understanding biology is crucial for individuals to get knowledge about the environment and their own systems. Teaching biology is essential as it provides knowledge that can address various societal issues such as health, poverty, food scarcity, agriculture, and environmental protection, ultimately enhancing the quality of life.

Despite the significance of knowledge gained from Biology and its numerous advantages, pupils' academic performance is unsatisfactory. Various elements are known to impact students' academic performance in Biology. Teachers' factors were identified by researchers including Daworiye et al (2015). Errors in the Biology curriculum was identified by Sanders and Makotsa (2016). Unsuitable teaching methods and students' perception of certain areas of biology as difficult were discussed by various researchers (Cimer, 2012; Agboghoroma & Oyovwi, 2015; Etobro & Fabinu, 2017; Chukwemeka & Dorgu, 2019; Choden & Kijkuakul, 2020; Adelana, Akinsulure, Ajose & Ishola, 2023).

The researchers identified Genetics as one of the subjects viewed as difficult by students in Biology. Genetics is a branch of Biology that focuses on the study of heredity and variation. The field examines the behavior of genes, including their expression and transmission between generations (Ramalingham, 2015). Klug, Cummings, and Spencer (2018) defined genetics as the study of heredity and variation. Heredity refers to the transmission of traits from one generation to the next, leading to similarities, while variation pertains to the differences among individuals. Genetics elucidates the mechanism behind two fundamental aspects present in the universe: similarities and differences. Klug et al. (2018) stated that genetics is essential for comprehending various fields like molecular biology, cell biology, evolution, physiology, ecology, systematics, and behavior. Genetics is utilized in several fields such as genetic engineering, agriculture, biotechnology, transgenic organisms, gene therapy, crop and animal breeding, and medicine, contributing to human welfare. Genetics has been essential in addressing societal issues including infertility and determining paternity in disputed cases. Genetics, an aspect of biology explores the role and characteristics of genes, impacting several elements of our everyday lives such as food production, crime solving, sickness treatment, and more. Advancements in genetics in agriculture have allowed scientists to modify the structure and output of plants or animals to enhance their utility. The study of genetics is fundamental for the scientific and technical growth of society, as demonstrated by the points discussed above. Genetics principles and their applications seem to be more challenging compared to other topics in biology.

Coden and Kijkuakul (2020) identified misunderstandings held by teachers and students in the domains of genetics, including heredity, genetic engineering, cloning, and evolution, as a major factor contributing to challenges in teaching and learning genetics. Many students avoided genetics-related questions in exams, and those who attempted them often failed to provide the

necessary explanations for their answers, as reported by the Chief Examiners in WAEC reports from 2010, 2011, 2012, and 2015. The Chief Examiners' Report from WAEC in 2018 cited a lack of understanding of genetics as a contributing factor to pupils' poor performance in Biology. The challenge in teaching and learning genetics may be due to students struggling to grasp the connection between genes, chromosomes, and genetic information, hindering their ability to link chromosome doubling in cell division with the transmission of genetic material across generations, as highlighted in the study by William, Debarger, Montgomery, Zhou, and Tate (2011).

Ausubel (1968) described specific techniques that help bridge the gaps between a learner's existing knowledge and new knowledge at any point in their educational journey. One such tool is a mental map. A mind map is a visual and creative tool used to organize thoughts, knowledge, and foster logical creativity. Mind mapping is a visual tool that helps learners organize and analyze information, leading to improved understanding and retention of ideas (Brandner, 2020). Mind mapping is a learning method created by Tony Buzan in the 1970s (Buzan, 2005). It allows users to create documents or maps in a visual format that helps them clearly grasp the relationships between ideas and facts. This technique originated from the notebooks of Leonardo da Vinci. Da Vinci's notes were not organized in a linear manner like most learners. Instead, he utilized drawings and text to demonstrate ideas and often linked several concepts together on the same page in an elliptical fashion. Although Leonardo da Vinci's method of notetaking, which involved writing backwards, was first perplexing to read, it provided him with a chance to combine thoughts, enabling him to efficiently engage both hemispheres of his cerebrum in problem-solving. Teachers can utilize a mind map to present information in a creative manner.

Mind maps are efficient to create and simpler to recall and examine due to their visual nature. The non-linear structure of mind maps facilitates the connection and correlation of various parts inside the map. Utilizing mind maps instead of conventional approaches allows students to perceive connections between non-linear concepts, fostering creativity and facilitating meaningful learning. Color is frequently utilized in mind maps to distinguish various ideas, hence increasing their usefulness and significance for learners who create them (Mona & Khalick, 2008). Mind maps are visual representations of pupils' thinking, which enhance the ability to remember knowledge. Utilizing mind maps allows teachers to diversify their teaching approaches, potentially reaching a broader range of learners (Nesbit & Adesope, 2006). Ginting (2017) conducted a study to assess the impact of the mind mapping learning approach on academic performance in Biology. The study

utilized a quasi-experimental research design with a pretest-post-test format. The researcher adopted research instruments such as tests exploring the cognitive domain of the students for data collection. The acquired data were analyzed using a t-test. The study included two complete courses. One class, the experimental group, was taught using the mind mapping learning model, while the other class, the control group, was taught using the expository learning model. The study discovered that the group using the mind mapping learning model achieved superior learning outcomes in biology compared to the group using the expository learning model. Teachers were advised to develop a learning model that focuses on students' actions and assess the success of the model.

Katcha, Orji, Ubele, Abubakar, and Mohammed (2018) conducted a study to investigate how using mind mapping as an educational strategy impacts the academic performance of senior school students in the subject of evolution. They implemented a pretest, post-test, control group design. The study was a quasi-experimental inquiry. The study included two research questions and two research hypotheses that were generated and tested. 105 pupils were randomly chosen from two secondary schools. The researchers devised a biology achievement test for evolution as the tool for data collecting. Students instructed with the mind mapping approach outperformed those taught through the usual lecture method. Anenye and Osuafor (2023) studied how using mind mapping as a teaching approach impacted the academic performance of high school students in Biology in Akwa South Local Government Area. The study utilized a quasi-experimental research approach known as the non-randomized control group design. The Biology Achievement Test was utilized for data gathering. The acquired data were analyzed via ANCOVA. The study's findings showed that students who were instructed utilizing the mind mapping strategy achieved superior results compared to those taught through the usual lecture method. Researchers proposed that biology professors use mind maps and mind mapping methodologies into their subject teaching.

Students' learning styles have been recognized as a significant element influencing their academic performance in an educational environment. Learning style is a trait that indicates how students prefer to learn and absorb information. Kayes (2007) defines it as an individual's inherent and innate way of growing and processing information within an educational environment. Understanding learning styles could improve students' academic performance (Ubah, 2012). Students' learning methods and critical thinking skills may impact their capacity to remember

information (Tsai & Thomas, 2011). Various techniques are employed to categorize students based on their learning styles.

The study utilized the VAK learning style model to determine the learning styles of pupils. The VAK learning styles model is a straightforward method to explore different learning preferences. The VAK learning style is based on three primary sensory receptors: Visual, Auditory, and Kinesthetic, which help identify an individual's preferred learning style (Siregar, 2018). Many people favor many learning styles. The individual's most prevalent learning style determines their overall learning styles. Certain individuals possess many learning styles. An individual exhibits a harmonious blend of all learning styles. Visual learners acquire knowledge using visual stimuli such as pictures, charts, and diagrams, enhancing their retention of information. Auditory learners acquire knowledge through hearing and speaking, retaining spoken information effectively. Kinesthetic learners learn through physical interaction and hands-on experience.

Utilizing the VAK model in teaching assists teachers in the initial phase of instruction by enabling them to include classroom activities that promote effective learning for all types of learners in their lesson plan. Anggrawan, Ibrahim, Muslim, and Satria (2019) conducted a study on the correlation between learning style and gender in a mixed learning environment consisting of 40% face-to-face learning and 60% online learning. 50 students from Bumigora University in Indonesia were chosen at random for the study. The study collected data by surveying each student's learning style and assessing their learning results using quizzes, mid-semester, and final semester scores. Three kinds of students' learning styles were included: Visual, Auditory, and Kinesthetic. The study data was analyzed using 2-way ANOVA, t-test, and SCHEFFER. The study showed variations in students' learning outcomes based on their learning styles, with visual learners scoring higher. Male students outperformed female students, and there was a correlation between students' gender and learning styles in relation to their academic performance.

Nja, Umali, Asuquo, and Orim (2019) studied how learning styles affect the academic performance of scientific education undergraduates at the University of Calabar, Nigeria. The study included the entire population of scientific education students at the institution, with a random sample of 200 students selected for the research. The study utilized the Learning Style Questionnaire and the students' raw scores from their second semester. The data was evaluated using independent t-test and one-way analysis of variance. The study showed that pupils exhibit varying learning styles,

with visual learners demonstrating superior academic performance compared to other learning style groups. A positive association was found between students' learning styles and their academic accomplishment.

Literature exists on the utilization of mind maps to assess students' responsiveness in the learning process, particularly in the field of Biology (Ginting, 2017; Katcha, Orji, Ubele, Abubakar, and Mohammed, 2018; Siregar, 2018; Nja, Umali, Asuquo, and Orim, 2019; Anenye and Osuafor, 2023). However, few studies have explored the efficacy of utilizing mind maps to teach Genetics, a concept often considered challenging by students in secondary school biology classes. This study examines how using mind maps impacts the academic performance of high school students studying Genetics in Ibadan, Nigeria.

Research Questions

1. Was there any difference in the achievement of students that were taught genetics with mind maps and those taught with the conventional method?
2. Would there be any difference in the achievement of students taught genetics with mind maps based on their learning styles?

Research Hypotheses

H_{01}: Using mind map has no significant influence on students' achievement in genetics.

H_{02}: There is significant difference in academic achievement of students taught genetics with mind maps based on their learning styles.

Research Method

Research Design

The study utilized a quasi-experimental design, namely a non-randomized, non-equivalent, Pretest, Post-test, Experimental Control group (2 x 3) Design. The first two groups in the design are the experimental group, taught with mind maps, and the control group, taught with conventional methods. The next three groups reflect the three degrees of learning style: Auditory, Visual, and Kinesthetic. The independent variables were the instructional approaches: mind map and conventional methods. The dependent variable was Students' Achievement. The moderator variable was learning styles. The pupils' learning styles were assessed based on their answers to

the VAK questionnaire. The survey included 9880 senior secondary school students studying biology in Ibadan Metropolis according to the Ministry of Education, Science and Technology, Statistics Department in 2018. The target audience consisted of 9880 senior school three biology students in public secondary schools in Ibadan Metropolis. The selection of three senior school students was deemed suitable due to the expectation that the study's topic scope will be addressed at this level, as outlined in the biology curriculum.

Sampling Technique: The researcher employed purposive sampling to select two science-based co-educational schools with similar mean scores in biology from public schools in Oyo State for the study. The schools were then randomly assigned to either the experimental or control group. An complete class was chosen from each of the selected schools for the study. The sample sizes were 75 for the experimental group and 55 for the control group. The Genetics Achievement Test (GAT) and the VAK questionnaire were utilized for data collection. Genetics Achievement Test (GAT).

The Genetics Achievement Test questions were taken from the West African Senior School Certificate Examination (WASSCE; 2010-2018). The General Aptitude Test (GAT) was utilized for the pretest, posttest, and post-posttest. The GAT items consisted of 50 multiple choice questions, each with four options. The test items comprehensively addressed all the genetic concepts given to the pupils. The updated version of Bloom's Taxonomy of Educational Objectives by Krathwohl (2002) was utilized to create the test template. The researcher did this to guarantee that the items encompass the various levels of the cognitive domain. The VAK questionnaire was modified for online use from the website http://www.educationplanner.org.The VAK questionnaire was utilized to identify the learning styles of the students that took part. The assessment consisted of 20 tasks designed to evaluate the pupils' information processing abilities. Each question in the survey was accompanied by three choices. Option A caters to visual learners, Option B to auditory learners, and Option C to kinesthetic learners. The students' learning style was defined by the frequency of each choice chosen. The choice with the greatest number of selections indicated the students' learning style.

Treatment: The Teachers' Instructional Package on teaching using mind maps (TIPM) and lesson notes for the conventional approach were used as instructional tools. The packages contained the modules used to train the biology teachers in the study. The Genetics Achievement Test and the

VAK underwent a test-retest reliability procedure. The researcher distributed the tools to forty biology students from a school not included in the primary investigation. The instruments were given to the students twice, with a three-week break. The students' scores from the two tests were associated using the Pearson Product Moment Correlation Coefficient, resulting in calculated values of 0.83 and 0.79, respectively. The high correlations showed that the instruments were suitable for the investigation.

Research Ethics

To forestall any ethical breach, each student and their parents were provided with a comprehensive informed consent form, which included complete information about the research. The purpose of the form was to obtain parental consent and cooperation for their children's participation in the study. This is essential because the students were minors. The participants were guaranteed that any information submitted would be handled with the highest level of confidentiality. The participants were also provided with explicit information regarding several ethical concerns, including anonymity, confidentiality, dangers, advantages, and the rights to leave the study on their own volition without any consequence. Additionally, the researchers ensured the anonymity of the respondent as no identifying data was collected. The researcher also notified the participants that the courses would occur within their classrooms at the designated time specified on the school timetable. Therefore, no potential harm was anticipated over the duration of the study, since they were expected to gain greater advantages in terms of achieving high scores in Biology in the WASSCE and other public exams necessary for admittance into higher education institutions.

Data Analysis Technique

The data collected for this study were analyzed using both descriptive and inferential statistics. The descriptive statistics involved were mean and standard deviation while the inferential statistics were *t*-test and ANCOVA.

Results

Research Question 1

What is the difference in the achievement of students taught genetics with mind maps and those taught with the conventional method?

Table 1 shows the mean gain scores of students taught genetics with mind maps and students taught genetics with the conventional method. The mean score of students taught genetics with mind maps was 26.44 and the mean score of students taught genetics with the conventional method was 23.40. The mean difference between the students taught genetics with mind maps and students taught with the conventional method was 3. 04. This difference suggests that using mind maps to teach genetics could lead to the higher achievement of students in the concept and provided an answer to research question 1. Table 1

Descriptive Statistics of Students Taught with Mind Maps and Conventional Methods

Treatment Group	Sample N	Pre-test Mean	SD	Post-test Mean	Diff.	SD
Mind map	71	12.45	6.26	26.44	3.04	6.97
Control	55	13.09	3.29	23.40		3.94

H_{01}: There was no significant difference in the achievement of students taught genetics using mind maps and those taught with the conventional method.

The *t*-test result presented in Table 2 shows that there was a significant statistical difference in the achievement of students taught genetics with mind maps and those taught with the conventional method ($t_{(124)}$=-2.89; p<0.05), based on this, hypothesis 2 was therefore rejected since the *p*-value is less than 0.05 significant level. This implies that using mind maps to teach genetics could enhance the achievement of students significantly better than using the conventional method.

Table 2

The t-test Analysis for the Achievement of Students' Taught with Mind maps and the Conventional Method

Group	N	Mean	SD	Df	*t*	Sig.	Remark
Mind maps	**71**	**26.44**	**6.97**				
				124	**-2.89.**	**.00**	**S**
Control	**55**	**23.40**	**3.94**				

***p*<0.05**

Research Question 2: What was the difference in the achievement of students taught genetics with mind maps based on their learning styles?

The mean values of students taught genetics related topics with mind-maps based on their learning style are shown in Table 3. Visual has highest mean value of 27.13, followed by Auditory with 26.33 and Kinesthetic with 25.65.

Table 3

Mean Values of Students' Learning Style when Taught Genetics Related Topics with Mind-maps

Learning Style	N	Mean	SD.
Auditory	30	26.33	4.87
Kinesthetic	17	25.65	8.09
Visual	24	27.13	8.44

H_{02}: There was no significant difference in the achievement of students taught genetics with mind maps based on their learning styles.

The result of ANCOVA in Table 4 reveals that there was no significant difference in the learning style of students taught genetics related topics with mind-maps ($F_{(2,67)}$=0.83; p>0.05), this is because p-value .92 is greater than 0.05 significant level. Therefore, hypothesis 2 is not rejected.

Table 4 ***ANCOVA Result of Students' Learning Style when Taught Genetics Related Topics with Mind-maps***

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1327.44[a]	3	442.48	14.34	.00
Intercept	4388.51	1	4388.51	142.18	.00
Pre-test	1305.15	1	1305.15	42.29	.00
Learning Style	5.10	2	2.55	.08	.92
Error	2068.02	67	30.87		
Total	53017.00	71			
Corrected Total	3395.47	70			

a. R Squared = .18 (Adjusted R Squared = .14)

Discussion of Findings

The study investigated the effect of mind maps on senior school students' achievement in genetics. The findings from the study revealed that students taught with mind maps had a higher achievement compared with the students taught with conventional method. This finding could be

as a result of the ability of mind maps to enable the students to visualize connections between concepts involved in genetics and lay a foundation for what they are yet to learn from what they have learnt. This makes them identify and note important information and ideas as well as comprehend the content of the instruction process. From the findings of this study, all these are not applicable to the control group. The findings of this research are in line with the Ginting (2017) who investigated the effect of mind-mapping teaching strategy on secondary school student's achievement in biology and reported that mind-mapping teaching strategy positively affects student's achievement in biology. In a similar study carried out by Anenye and Osuafor (2023) which examined the effect of mind mapping strategy on secondary school biology student's achievement, it was also reported that students achieve higher when mind mapping teaching strategy is employed to teach them.

The findings further showed that there was no significant difference in the achievement of students in genetics based on students' learning styles when taught with mind maps. This means that students' performance based on their learning styles was better generally when taught with mind maps and none of the learning styles was inferior as the result showed no significant difference. This could be because using mind maps to teach took care of three levels of learning styles and that led to improving performance in genetics. This agrees with the findings of Gappi (2013) who found no significant correlation between students' academic achievement and the learning style preferences. This is contrary to the study of Lengkana, Surbakti and Amala (2019) which reported that visual learners had higher achievement when students are taught respiratory system a concept in biology using mind mapping.

Conclusion

The study examined the effect of mind maps on senior school students' achievement in genetics. The study concluded that using mind maps to teach genetics led to higher achievement in genetics as such mind maps can be employed by teachers to teach genetics and other topics in biology. It was also concluded that students achieved significantly higher when taught with mind maps irrespective of their learning styles.

The main limitation of the study is that it adopted a quasi-experimental design as intact classes were involved; the data collected were absolutely quantitative data. Other researchers intending to do similar study may use both quantitative and qualitative approach for data collection. Another

limitation to the study was the involvement of only senior school three students in the study as the topic under study is only taught at the level. Future researchers can apply the use of mind maps to topics taught at other levels. Despite the stated limitations, the research is of significance as it revealed the importance and effectiveness of the use of mind maps in improving the teaching and learning of genetics. Similar studies can be replicated by other researchers on other topics in biology especially the perceived difficult concepts. Textbook authors can also incorporate mind maps in their textbooks.

Recommendation

1. Teachers should be encouraged to employ teaching strategies that suit students with varying ability and score levels. The use of mind maps promotes this.
2. Teachers should be encouraged to embed mind maps when preparing learning activities to provide the students with an opportunity to interact with the mind maps and arouse their interest.

References

Adelana, O. P., Akinsulure, A. O., Ajose, M. A., & Ishola, A. M. (2023). Perceptions of genetics difficulty among science students. Journal of Science and Mathematics Letters, 11(1), 51-58.

Agboghoroma, T. E., & Oyovwi, E. O. (2015).Evaluating effect of students' academic achievement on identified difficult concepts in senior secondary school biology in Delta State.Journal of Education and Practice, 6(30), 2-13.

Anenye, C. M. &Osuafor, A. M. (2023). Effect of mind-mapping teaching strategy on secondary school student's academic achievement in biology in Awka South Local Government Area. South Eastern Journal of Research and Sustainable Development,11 (1); 55-73.

Anggrawan, A., Ibrahim, N., Muslim, S. & Satria, C.(2019). Interaction between learning style and gender in mixed learning with 40% face-to-face learning and 60% online learning (IJACSA) International Journal of Advanced Computer Science and Applications, 10(5),407-413.

Ausubel, D. P. (1968). Educational Psychology: A Cognitive View. New York: Holt, Rinehart and Winston.

Brandner, R. (2020). Why mind mapping? Scribbr. https://www.mindmeister.com/blog/why-mind-mapping

Buzan, T. (2005).Mindmap handbook. Great Britain: Thorsons

Choden, T.,& Kijkuakul, S. (2020). Blending problem based learning with scientific argumentation to enhance students' understanding of basic genetics. International Journal of Instruction, 13(1), 445-462.

Chukwuemeka, I. P. & Dorgu, T. E.(2019). Students' Perceptions of the Difficult Topics in Biology at Senior School Level in Delta State, Nigeria. J Adv Educ Philos., 3(2): 62-66

Cimer, A. (2012). What makes biology learning difficult and effective: Student's views.Education Research and Reviews, 7(3), 61-71.

Daworiye, P. S., Alagoa, K. J., Enaregha, E.,& Eremasi, Y. B. (2015).Factors affecting the teaching and learning of biology in Kolokuma/Opokuma Local Government Area, Bayelsa State, Nigeria. Int. J. Curr. Res. Biosci. Plant Biol., 2(4), 151-156.

Etobro, A. B.,& Fabinu, O. E. (2017).Students' perceptions of difficult concepts in biology in senior secondary schools in Lagos State. Global Journal of Educational Research, 16(1), 139–147.

Gappi, L. L. (2013). Relationships between learning style preferences and academic performance of students. International Journal of Educational Research and Technology (IJERT), 4(2), 7-13.

Ginting, S. N. (2017). The effectiveness on mind mapping learning model to improve the learning achievements of biology. Advances in Social Science, Education and Humanities Research, 104, 456-459.

Katcha, M. A., Orji, A. B., Ubele, F. U. Abubakar, Z.,& Mohammed, B. (2018). Effects of mind-mapping instructional approach on senior secondaryschool biology students' achievement in evolution in Minna, NigerState, Nigeria. Journalof Science, Technology, Mathematics and Education (JOSTMED),14(2), 146-154.

Kayes, D. C. (2007). Institutional barriers to experiential learning revisited. In M. Reynolds, & R. Vince, (Ed.), The handbook of experiential learning and management education. Oxford: Oxford University Press.

Klug, W. S., Cummings, M. R., & Spencer, C. A. (2018).Concept of genetics (12th Ed). Upper Saddle River, New Jersey: Pearson Prince Hall.

Krathwohl, D. (2002). A revision of Bloom's taxonomy: An overview.TIP, 41(1), 212–218.

Lengkana, D., Surbaki, A., & Amala, D. (2019). The effect of mind mapping and learning style on concepts mastery and students' representation skills. Advances in Social Science, Education and Humanities Research, 422, 110-117.

Mona, I.,& Khalick, F. (2008).The influence of mind mapping on eighth graders' science achievement.School Science and Mathematics.

Nesbit, J. C., & Adesope, O. (2006). Learning with concept and knowledge maps: A meta-analysis. Academic Journals Review of Educational Research, 76(3), 413-448.

Nja, C. O., Umali, C. B., Asuquo E. E.,& Orim, R. E. (2019).The influence of learning styles on academic performance among science education undergraduates at the University of Calabar. Educational Research and Reviews, 14(17), 618-624.

Ramalingam, S. T. (2015). Modern Biology for Senior Schools (6th Ed.). Onitsha: Africa First Publishers Ltd.

Sanders, M.,& Makotsa, D. (2016). The possible influence of curriculum statements and textbooks on misconceptions: The case of evolution. Edu. as Change, 20(1), 1-23.

Siregar, R. (2018). Teaching model of visualisation, auditory and kinesthetic (VAK) to improve the economic education achievement. International Journal of Humanities and Social Science Research, 4(1), 6–10.

Tsai, C. I.,& Thomas, M. (2011). When do feelings of fluency matter? How abstract and concrete construal influence fluency effects. Psychological Science, 22(3), 348–54.

Ubah, J. N. (2012). Learning styles among medical students: A case study of Ladoke Akintola University of Technology Medical School, Osogbo.Journal of Education and Practice, 3(5), 211-116.

West African Examinations Council (2010; 2011; 2012; 2013; 2016; 2017; 2018).Chief Examiners'Report.Yaba, Lagos: WAEC.

Williams, M., Debarger, A. B. Montgomery, B. L., Zhou, X., & Tate, E. (2011).Exploring middle school students' conceptions of the relationship between genetic inheritance and cell division.Wiley Online Library.