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EFFECT OF COGNITIVE STYLES ON SENIOR SECONDARY STUDENTS' COGNITIVE LOAD AND ACHIEVEMENT IN BIOLOGY IN BENUE STATE, NIGERIA

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ABSTRACT

The study investigated the effect of cognitive styles on senior secondary students' cognitive load and achievement in Biology in Benue State, Nigeria. The study was guided by 2 research questions and 2 hypotheses. The research design for the study was ex-post-facto. The total population of the study was 66, 586 Senior Secondary Two (SSII) students (36052 males and 30534 females) from 301 co-educational schools in Benue State. The sample for the study was 398 SSII students (181 males and 217 females). Three instruments were used for the collection of data. The instruments are: Group Embedded Figures Test (GEFT), Cognitive Load Rating Scale (CLRS), and Biology Achievement Test (BAT). Data collected was analyzed using mean and standard deviation to answer research questions while hypotheses were tested using t-test at 0.05 level of significance. The decision rule for the acceptance or rejection of the hypotheses was based on the P – value. A hypothesis of no significant difference was rejected for any item whose P- value was less than 0.05 while it was not rejected for any item whose P- value was greater than or equal to 0.05. The findings revealed no significant difference in mean cognitive load rating of field dependent and field independent students in Biology. It also revealed a significant difference in mean achievement of field dependent and field independent students in Biology. However, there was no significant difference in mean achievement of field dependent and field independent cognitive styles of male and female students' in Biology. The study recommended the need for seminars and workshops to be organized for teachers so as to adequately equip them with the needed skills to create an environment where students with different cognitive styles can experience meaningful learning of Biology. Also, teachers should try as much as possible to

identify students' cognitive styles so as to carry them along during teaching and learning process.

KEYWORDS: Cognitive styles, Cognitive load and Achievement

INTRODUCTION

Science is the systematic pursuit of knowledge involving observation, experimentation, and critical analysis to understand natural phenomena and the laws governing them. It is a continuously evolving field driven by inquiry, evidence, and skepticism aimed at constructing reliable and objective explanations of the universe. At the secondary school level, science is most commonly broken down into three fields of Chemistry, Physics, and Biology. The field of Biology deals with living things, their relationship with one another and with the natural environment, among others (Abdullah, 2022).

Biology studies the origin of diseases and plagues such as infections, pathologies of animals and damage to plants. This field encompasses the study of the functions of living beings, enhancement of useful species, factors that cause illnesses, discovery and production of medicines, and sustainable use of natural resources. Through biotechnology, biologists find efficient ways to produce food and other supplies for people. They investigate the processes involved in producing various nutritional substances.

Biology is introduced to students at senior secondary school level as a preparatory ground for human development, where career abilities are groomed, potentials and talents are discovered and energized. The quality and quantity of science education received by secondary school students are geared toward developing future scientists, technologists, engineers, and related professionals (Kareem in Gunguma, 2023). Biology as a secondary school subject serves as a fundamental and indispensable component of the science curriculum, offering students with a comprehensive understanding of the living world. The subject provides a unique gateway for students to understand the intricate mechanisms governing life, from the molecular and cellular levels to the broader ecosystems as well as compulsory subject requirement for studying medicine and allied courses (Isma'il & Lukman, 2022; Oyovwi, 2021; Edeh & Martha, 2020; Chukwuemeka & Dorgu, 2019; Badmus & Omosewo, 2018). The objective of teaching Biology at the secondary school level is to prepare students to acquire adequate laboratory and field skills in the subject, meaningful and relevant knowledge, as well as the ability to apply scientific knowledge to everyday life in matters of personal and community

health and agriculture, researchable and functional scientific attitudes (National Educational Research and Development Council (NERDC), 2009).

As a field of science, Biology helps in the understanding of the living world and the way its many species (including humans) function, evolve, and interact. A knowledge of the subject has helped many to understand their body system and how it functions even without further pursue of science related disciplines. It is important that much attention be given to the study of Biology since it holds much importance in our daily lives. This is because it is a very crucial aspect of science, education, and life as a whole. Therefore, every nation must give high level of priority to the subject and its study.

The teaching and learning of Biology can be effective if students are allowed to contribute in the process. According to Eze *et al*. (2020), the learner or student is a central factor in determining whether meaningful learning will take place or not. This may include his background, interest, motivation, age, sex or gender, personality and so on (Andrews et al., 2023). In a similar view, Iji *et al*. (2017) listed factors responsible for the low achievement of students in sciences to include use of inappropriate teaching methods, lack of instructional materials, inadequate number of qualified teachers and inability to identify the cognitive styles of learners. Eriba *et al*. (2021) also argued that students' achievement may be low when the teaching method is inappropriate to students' cognitive styles. Knowledge of students' cognitive styles could be used to predict what kind of instructional strategies or methods would be most effective for a given individual and learning task. The study undertook a discourse about cognitive style, cognitive load and students' achievement in Biology.

The Concept of Cognitive Style

Cognitive style refers to an individual's preferred way of thinking. According to Imam and Ahmed (2020), it deals with how an individual processes information and it reflects the manner or mode of cognition of an individual, that is, the way an individual filters information, process stimuli, and conceptually organize his environment. Khandagale (2016) described cognitive style as the way an individual filters information, process stimuli and conceptually organize the environment so that the environment takes on a psychological meaning. It describes the way of constructing knowledge of an individual and personality dimensions. Cognitive styles are thought to be relatively stable strategies, preferences, and attitudes which determine an individual's typical modes of perceiving, remembering and problem-solving (Abubakar, in Eriba *et al*., 2021). Armstrong and Peterson in Eriba *et al*.

(2021) posit that cognitive style is the individual differences in people's preferred way of processing (perceiving, organizing, and analyzing) information using cognitive brain-based mechanisms and structures. Understanding cognitive styles of students would help to improve learning and creativity among them and account for individual differences in how students approach task.

Cognitive researchers have identified a number of cognitive styles. For instance, Witkin (1962) identified two cognitive styles to include 'field dependence and field independence', Paivio (1971) mentioned two cognitive styles to include 'verbalizer and visualizer' while Kagan (1964) identified two cognitive styles as 'impulsivity and reflexivity'. Field dependence and field independence are probably the most well-known styles since literature abounds them.

In cognitive style, the field dependent learners are those who are most affected by their environment. They are inclined to overall field learning and are less able to view things separate from the overall environment whereas the field independent learners conduct an analytical procedure and are more likely to break a model into different sections and details and tend to depend on their inner knowledge and analyze problems all by themselves without reference to the environment (Onyekuru, 2015).

From the foregoing, if cognitive styles of learners are taken into consideration in the delivery of lessons, it seems meaningful learning could be enhanced. Ifelunni *et al*. (2022) stated clearly that if the educational subjects and materials conform to students' cognitive styles, it will lead to a better performance. They maintained that field dependent people were better at learning materials with high human contents than the field independent ones. A study conducted by Chen (2018) yielded the result that field dependent individuals were better at recalling social information such as conversation and relationships. Garrison *et al* in Eriba *et al*. (2021) reported that field dependent individuals were more strongly influenced by the immediate social context and more inclined to attend to and learn about social aspects of their environments and that field dependent individuals show greater incidental learning for social materials than field independent individuals. Ifelunni *et al*. (2022) affirmed that field dependent learners are more socially oriented than field independent ones. They pay more attention to social cues, they like to be with others and they seek learning and vocational experiences that put them in contact with people. The field independent learners on the other

hand are good in task that requires critical thinking, analytical solutions, and preferred working individually on their task.

Biology being a subject that enables man to know much about himself as well as his environment, ought to be made interesting to students so as to boost their achievement in the subject. According to Ezeonwumelu (2020), students' poor achievement in sciences is due to the voluminous content of science subjects which leads to high cognitive load on the part of the students in order to cover the content in readiness for assessment.

The Concept of Cognitive Load

Cognitive load is the amount of information the human memory can process at a given time. It is usually discussed in line with the cognitive load theory which is concerned with the manner in which instruction should be presented and the activities in which learners should engage to maximize performance (Sweller *et al*., 2019). According to the authors, the basic idea of cognitive load theory is that cognitive capacity in working memory is limited, so that if a learning task requires too much capacity, learning will be hampered. The recommended remedy is to design instructional systems that optimize the use of working memory capacity and avoid cognitive overload.

The Concept of Achievement

It is the interest that students show in the subject of Biology that determines their achievement in it. Achievement refers to the accomplishment or successful performance of knowledge attained. According to Abakpa in Okwara and Upu (2017), it is the measure of accomplishment in a specific field of study. Academic achievement is an important education variable that expresses the success and failure of a teaching and learning process, and the extent educational goals are attained. However, students' academic achievement in sciences particularly Biology has been low. Many factors have been shown to have significant effect on students' interest, cognitive load, and achievement in Biology. Research report from Lambert and Etim (2022) found that students' achievement in Biology at the secondary school certificate examination is low. While this has been attributed to shallow knowledge of the subject, Atamonokhai (2017) stated that in spite of the attempts made by researchers to improve on the teaching and learning of science subjects, particularly Biology, the achievement of students still remain low. The United Nations Educational Scientific and Cultural Organization (UNESCO) in Bassey *et al* (2017) pointed out that the low and achievement of students in Biology may be influenced by gender (males and females)

imbalance leading to the problem which now constitutes a major research focus across the globe.

Gender has continued to be an issue of concern in science education research. Gender is a socio-cultural construct whereby a society ascribes different roles, values, and attitudes to males and females. It refers to males and females. Okeke (2016) defined gender as the socio-cultural constructed characteristics and roles which are ascribed to male and female by the society. It is a culturally determined trait associated with males and females. According to Nzewi in Aniaku and Nwankwo (2024), an individual grows and is socialized into the society to fit into certain roles prescribed by the society as masculine or feminine such as behaviour, belief, value, and roles.

Many researchers including Ifelunni (2019); Idika (2017) and Onyekuru (2015) have conducted researches on students' cognitive styles. These researches have not answered the question of effect of field dependent and field independent cognitive styles on interest and achievement in Biology. Therefore, there is need to ascertain if field dependent and field independent cognitive styles affect learners interest and achievement in Biology.

Statement of Problem

In science learning particularly Biology, students in secondary schools are expected to develop sustained interest and attain high academic achievement, given the subject's vital role in understanding life processes and its relevance to careers in pharmacy, nursing, biotechnology, and medicine among others. High achievement in public examinations indicates a mastery of content. When effectively taught, Biology helps to instill in learners the basic science process skills necessary for national development. However, the current reality in many public secondary schools in Benue State is worrisome. Students' achievement in Biology appears to be poor, with many perceiving the subject as abstract, difficult, and disconnected from real-life applications.

An observation made by the researcher indicates that the failure of teachers to identify students' cognitive styles and adopt suitable teaching strategies may have been the cause of low achievement in Biology. Thus, the major purpose of this study is to investigate the effect of cognitive styles on senior secondary students' cognitive load and achievement in Biology in Benue State, Nigeria.

Purpose of the Study

The general purpose of this study is to investigate the effect of cognitive styles on senior secondary students' interest and achievement in Biology in Benue State, Nigeria with the following specific objectives as 1. Ascertain the effect of field dependent and field independent students' cognitive load in Biology; 2. Find out the effect of field dependent and field independent male and female students cognitive load in Biology; 3. Ascertain the effect of field dependent and field independent students' achievement in Biology; 4. Find out the effect of field dependent and field independent male and female students achievement in Biology.

Research Questions

The study was guided by the following research questions:

i. What is the difference in cognitive load rating of field dependent and field independent students in Biology?

ii. What is the difference in cognitive load rating of field dependent and field independent male and female students in Biology?

iii. What is the difference in mean achievement of field dependent and field independent students in Biology?

iv. What is the difference in mean achievement of field dependent and field independent male and female students in Biology?

Hypotheses

The following hypotheses were formulated for the study and tested at 0.05 level of significance.

i. There is no significant difference in mean cognitive load rating of field dependent and field independent students in Biology.

ii. There is no significant difference in mean cognitive load rating of field dependent and field independent male and female students in Biology.

iii. There is no significant difference in mean achievement of field dependent and field independent students in Biology.

iv. There is no significant difference in mean achievement of field dependent and field independent male and female students in Biology.

METHODOLOGY

The research design for the study was ex-post-facto. According to Emaikwu (2021), it is a research design that is appropriate where it is not possible for the researcher to directly manipulate the independent variable. The total population of the study was 66, 586 Senior Secondary Two (SSII) students (36052 males and 30534 females) from 301 co-educational schools in Benue State. The sample for the study was 398 SSII students (181 males and 217 females). Three instruments were used for the collection of data. The instruments are: Group Embedded Figures Test (GEFT), Cognitive Load Rating Scale (CLRS), and Biology Achievement Test (BAT). Data collected was analyzed using mean and standard deviation to answer research questions while hypotheses were tested using t-test at 0.05 level of significance. The decision rule for the acceptance or rejection of the hypotheses was based on the P - value. A hypothesis of no significant difference was rejected for any item whose P-value was less than 0.05 while it was not rejected for any item whose P- value was greater than or equal to 0.05.

RESULTS

Research Question 1: What is the difference in cognitive load rating of field dependent and field independent students in Biology?

Table 1: Mean and Standard Deviation of Field Dependent and Field Independent Students Cognitive Load Rating in Biology.

	Groups	N	Mean	Std. Deviation
Cognitive load	Field Dependent	194	5.26	1.60
	Field Independent	204	5.54	1.72
Mean Diff.		**398**	**0.28**	

Table 1 shows the mean and standard deviation of field dependent and field independent students' cognitive load rating in Biology, which the mean of field dependent is 5.26 with standard deviation of 1.60 and the mean of field independent is 5.54 with standard deviation of 1.72. The mean difference of field dependent and independent students' cognitive load rating in Biology is 0.28. This implies that the mean cognitive load rating of field independent students is slightly higher than that of field dependent students, with a low standard deviation in field independent than in field dependent.

Research Question 2: What is the difference in cognitive load rating of field dependent and field independent male and female students in Biology?

Table 2: Mean and Standard Deviation of Field Dependent and Field Independent Male and Female Students' Cognitive Load Rating in Biology.

GENDER	N	Group Embedded Figures Test				
		Field Dependent		Field Independent		
		Mean	Std. Deviation	Mean	Std. Deviation	
Male	181	5.25	1.60	5.45	2.50	
Female	217	5.33	1.69	5.54	1.67	
Mean Diff.		**- 0.08**		**- 0.09**		

Table 2 shows the mean and standard deviation of field dependent and field independent male and female students' cognitive load rating in Biology, which male has the mean of field dependent and independent of 5.25 and 5.45 with standard deviation of 1.60 and 2.50 respectively. The female has mean of field dependent and independent of 5.33 and 5.54 with standard deviation of 1.69 and 1.67 respectively. Both male and female mean result showed that field independent has the highest mean (male =5.45 and female =5.54), with a low standard deviation in female field independent than in male field independent. This implies that the mean cognitive load rating of gender in field independent is higher than that of field dependent.

Research Question 3: What is the difference in mean achievement of field dependent and field independent students in Biology?

Table 3: Mean and Standard Deviation of Field Dependent and Field Independent Students Achievement in Biology.

	Groups	N	Mean	Std. Deviation
Achievement	Field Dependent	194	21.27	.97
	Field Independent	204	22.38	.77
Mean Diff.		**398**	**1.11**	

Table 3 shows the mean and standard deviation of field dependent and field independent students achievement in Biology, which the mean of field dependent is 21.27 with standard deviation of .97 and the mean of field independent is 22.38 with standard deviation of .77. The mean difference of field dependent and field independent students' achievement is 1.11. This implies that the mean achievement of students in field independent is higher than that of field dependent students, with a low standard deviation in field independent than in field dependent.

Research Question 4: What is the difference in mean achievement of field dependent and field independent male and female students in Biology?

Table 6: Mean and Standard Deviation of Field Dependent and Field Independent Male and Female Students Achievement in Biology.

GENDER	N	Group Embedded Figures Test				
		Field Dependent		Field Independent		
		Mean	Std. Deviation	Mean	Std. Deviation	
Male	181	21.28	4.47	26.45	2.81	
Female	217	21.25	4.59	22.15	4.31	
Mean Diff.		**0.03**		**4.3**		

Table 6 shows the mean and standard deviation of field dependent and field independent male and female students' achievement in Biology, which male has the mean of field dependent and independent of 21.28 and 26.45 with standard deviation of 4.47 and 2.81 respectively. The female has mean of field dependent and independent of 21.25 and 22.15 with standard deviation of 4.59 and 4.31 respectively. Both male and female mean result showed that field independent has the highest mean (male =26.45 and female =22.15), with a low standard deviation in male field independent than in female filed independent. This implies that the mean achievement of gender in field independent is higher than that of field dependent.

DISCUSSION OF FINDINGS

The findings revealed no significant difference in mean cognitive load rating of field dependent and field independent students in Biology. This is an indication that cognitive styles of students have no effect on their cognitive load in Biology. The finding addresses the research objective which sought to find out the effect of field dependent and field independent students' cognitive load in Biology. It also provides an answer to the corresponding research question by establishing that there is no significant difference in students' cognitive load in Biology. The findings also revealed a significant difference in mean achievement of field dependent and field independent students in Biology. However, there was no significant difference in mean achievement of field dependent and field independent cognitive styles of male and female students in Biology. The finding directly addresses the research objective which sought to ascertain the effect of field dependent and field independent students' achievement in Biology. It also provides an answer to the corresponding research question by establishing the difference in students' achievement in Biology.

CONCLUSION

From the study, the cognitive styles of students indicate no significant effect on their cognitive load in Biology. However, it shows a significant effect on students' achievement in Biology though not gender wise. Therefore, it is important that in the teaching and learning of Biology, the cognitive styles of students be placed at the forefront of the instructional process. This will help to improve their achievement in Biology.

Recommendations

1. There is need for seminars and workshops to be organized for teachers so as to adequately equip them with the needed skills to create an environment where students with different cognitive styles can experience meaningful learning of Biology.
2. Teachers should try as much as possible to identify students' cognitive styles so as to carry them along during teaching and learning process.

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