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Relationship between Nature of Science Tenets and High School Students' Acceptance of Evolutionary Theory in Cameroon

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Abstract

Purpose: Low levels of evolution acceptance have been reported among students in several articles using the Measure of Acceptance of the Theory of Evolution (MATE) instruments. Amongst possible causes listed in literature are students'' religious, sociocultural background and educational approach used in teaching. Some studies have revealed that students who have a better understanding of the nature of science (NOS) are more likely to accept evolution, but the relationship between NOS and MATE has not been scientifically established. This article seeks to establish the relationship between NOS and MATE.

Materials and Methods: A cross sectional survey was done using Structural Equation Modelling (SEM) techniques to investigate the extent to which NOS tenets enhance biology students' acceptance of evolution using 482 purposeful and convenient sample size. The validity and reliability of the NOS and MATE instruments were investigated and standardised using Exploratory and Confirmatory Factor Analysis. Thereafter, a hypothesised SEM model was conceptualised and tested.

Findings: The model provided a reasonable good overall fit. Only understanding of three NOS tenets namely: The empirical nature of science; use of observation and inferences in science; and the nature of scientific laws and theories has a strong positive statistically significant direct effect on acceptance of evolution. The tentativeness, subjectivity and objectivity of science, and the use of creativity and imagination in science did not significantly enhance acceptance of evolution.

Implications to Theory, Practice and Policy: This can serve as a candidate theory for further investigation. It could have implication in the development of didactic strategies to overcome misconceptions in evolution.

Keywords: *Evolution, Science Nature, Structural Equation Modelling, Conception, Cameroon*

1.0 INTRODUCTION

Studies suggest that students who have a better understanding of the nature of science (NOS) are more likely to accept evolution (Carter & Wiles, 2014; Dunk et al., 2017; Rutledge & waden, 2000). To Dagher & Boujaoude, (2005) and Aroua et al. (2005), the non-mastery of the process of validation of the science of evolution by teachers and consequently students is because they perceive the experimental approach as the only valid scientific method. This is a misconception about the nature of science (NOS) as empirical evidence and argumentation are also valid scientific methods for historical sciences like evolution. Also, Nchia et al. (2024) found out that biology in-service and pre-service teachers in Cameroon had a non-coherent uniformed views about the nature of science, with major inconsistency and misconception about hierarchical relationship between hypothesis, theories and laws, and cumulative nature of scientific knowledge. This didactic obstacle from the didactic transposition process could influence students' acceptance of evolution.

Buaraphan, (2010); Lederman, (2007) amongst others have agreed on the following six tenets on NOS on which our six research hypotheses are based:

a. There is no universal step-by-step scientific method (Kuhn, 1970). From this tenet we belief that acceptance of evolution often hinges on the understanding that it is supported by a vast amount of empirical evidence from various scientific disciplines, including biology, geology, and genetics. Thus we hypothesised that *"Students who appreciate the importance of empirical evidence in science are more likely to accept the theory of Evolution"*

b. Scientific knowledge development involves a combination of both observations and inferences (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2000). From this tenet we belief understanding the role of inference in science can help students grasp how evolutionary theory is developed from observational data and scientific reasoning. Thus we hypothesised that *"Students who can distinguish between observation and inference in scientific practices are more likely to accept the theory of evolution".*

c. Scientific theories and laws are functionally different types of scientific knowledge (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2000. From this tenet we belief recognizing that theories explain laws and that both are critical components of scientific knowledge can help students see the explanatory power and validity of evolutionary theory. Thus we hypothesised that *"Students who understand the distinction between scientific laws and theories are more likely to accept the theory of evolution"*

d. Scientific knowledge is durable, yet tentative and subject to change (AAAS, 1990; Popper, 1998 & National Science Teachers Association, 2000). From this tenet we belief recognizing that scientific theories can change with new evidence may help students appreciate the robustness of the theory of evolution as a well - supported scientific theory, despite its ongoing development and refinement. Thus we hypothesised that: "*Students who understand the tentative nature of scientific knowledge are more likely to accept the theory of Evolution*"

e. Scientific knowledge is socially and culturally embedded (Akerson, Abd-El-Khalick, & Lederman, 2000). From this tenet we belief recognizing that science strives for objectivity but is conducted by humans who bring subjective perspectives can help students critically evaluate the evidence for evolution without dismissing it due to perceived biases. Thus we hypothesised that *"Students who understand the balance of subjectivity and objectivity in science are more likely to accept the theory of evolution"*

f. Scientific knowledge is the product of human creativity and imagination (Aikenhead & Ryan, 1992; Akerson, Abd-El-Khalick, & Lederman, 2000). From this tenet we belief understanding that scientific theories like evolution involve creative thinking and problem-solving may help students view evolution as a dynamic and innovative explanation of biological biodiversity. Thus we hypothesised that *"Students who appreciate the role of creativity in scientific research are more likely to accept the theory of evolution".*

The Measurement of Acceptance of the Theory of Evolution (MATE) instrument is a tool used to assess individual's acceptance of evolution theory. It was developed to quantify the extent to which people accept evolution as a scientifically valid explanation for the diversity of life on earth. The construct validity of MATE instrument showed a single factor in Rutledge & Warden (1999), bi-dimensional in Metzger et al., 2018 and multidimensional factors in studies carried out by Wagler & Wagler (2013), and Romine et al. (2016, 2018). We thus intended to carry out this study in our Cameroonian context to be able to take a position with respect to these studies, and to have an insight into the effectiveness of educational interventions used to teach this scientific theory.

By exploring these hypotheses, the study aims to identify which aspects of NOS understanding most significantly influence students' acceptance of evolution. This can inform educational strategies to enhance NOS education and, consequently, acceptance of scientific theories like evolution. From the literature reviewed above we develop the following conceptual framework below to guide our research.

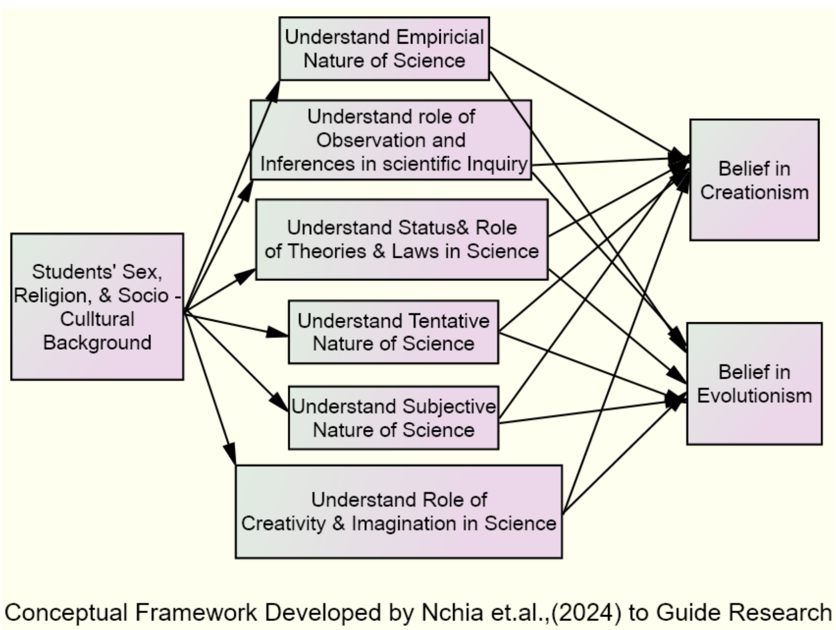

Figure 1: Conceptual Framework

The following research question we developed from our conceptual framework:

- *RQ 1. What are the underlying patterns or constructs that determine students' acceptance of evolution using the MATE and to what extent is the instrument valid and reliable in the Cameroonian context?*
- *RQ 2. What are the underlying patterns or constructs that determine students' conception of NOS and to what extent is the NOS instrument valid and reliable in the Cameroonian context?*
- *RQ 3. Is there any Correlation between Students Understanding of NOS and their acceptance of the theory of Evolution? (Path Analysis and SEM)*

This research will provide answers to specific research gaps related to: MATE & NOS instrument reliability and validity in Cameroon context; the aspects amongst the six NOS construct that significantly influence the acceptance of Evolution theory; and the extent to which these tenets influence acceptance of evolution. This will be beneficial to biology teachers in developing their lessons to teach evolution theory using Nos as a tools teaching and learning evolution concepts.

2.0 MATERIALS AND METHODS

This study used a cross-sectional survey design to collect data from a purposeful and convenient sample comprised of 482 high school Biology students from both the English and French speaking subsystems of Education in Cameroon. They represent a diversified range of socio-economic backgrounds, religious affiliations, and educational settings. NOS/SUSSI & MATE questionnaires were administered to students in their classrooms to ensure maximum returns.

NOS and MATE questionnaires were administered to all participants. Data were analysed after coding using SPSS version 23. Descriptive and inferential statistical methods such as: Pearson correlation; Exploratory Factor Analysis (EFA); Confirmatory Factor Analysis (CFA); and Structural Equation Modelling (SEM) analysis were used to test the relationships between NOS understanding and evolution acceptance, and the validity of these instruments. The questions items measuring the different constructs or NOS tenets were identified and each construct summed in other to transform individual Likert scale data into interval data to run correlation test. Coding and reverse coding of Likert scale items between 1 and 5 were done on the MATE questionnaire. We computed both average composite scores which reflect individual average scores.

In addition, this research study employed a two-step approach in the Structural Equation Modelling (SEM) analysis. In the first step, measurement model evaluation was conducted in order to examine the dimensionality, validity, and reliability of latent constructs using EFA & CFA. In the next step, the structural model procedure was employed in order to examine the hypothesized relationships between the latent constructs in the proposed research model. SEM analysis was employed to investigate how well the hypothesized model fits the data. Before performing SEM analysis, EFA and CFA were used respectively to validate the instruments in the Cameroon context.

The entire sample was randomly split into two separate samples. One sample was used in the EFA analysis, and another in the CFA analysis. After the instruments were adequately validated, SEM analysis was conducted to investigate the relationship between these construct. The computer program AMOS 21 was employed for the SEM analysis.

Underlying Construct and Validation of the MATE Instrument Using EFA & CFA (RQ 1)

Table 1: Results of Exploratory Factor Analysis (EFA) Showing Two Component for MATE Instrument

Rotated Component Matrix[a]		
	Components	
Retained Items on MATE Measurement Scales	**1**	**2**
E10. Evolution is not a scientifically valid theory.	.648	
E14. The theory of evolution cannot be correct since it disagrees with the Biblical account of creation.	.609	
E17. Much of the scientific community doubts if evolution occurs.	.601	
E19. With few exceptions, organisms on earth came into existence at about the same time.	.597	
E4. The theory of evolution is based on speculation and not valid scientific observation and testing.	.588	
E15. Humans exist today in essentially the same form in which they always have.	.574	
E7. The age of the earth is less than 20,000 years.	.543	
E2. The theory of evolution is incapable of being scientifically tested.	.543	
E9.Organisms exist today in essentially the same form in which they always have.	.501	
E6. The available data are ambiguous as to whether evolution actually occurs.		
E20.Evolution is a scientifically valid theory.		.553
E12. Current evolutionary theory is the result of sound scientific research and methodology.		.550
E5. Most scientists accept evolutionary theory to be a scientifically valid theory.		.544
E3. Modem humans are the product of evolutionary processes which have occurred over millions of years.		.524
E13. Evolutionary theory generates testable predictions with respect to the characteristics of life.		.513
E1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.		.509
E18. The theory of evolution brings meaning to the diverse characteristics and behaviours observed in living forms.		.471
E16. Evolutionary theory is supported by factual, historical, and laboratory data.		.460
E11. The age of the earth is at least 4 billion years.		.442
E8. There is a significant body of data which supports evolutionary theory.		
Extraction Method: Principal Component Analysis. *Rotation Method: Varimax with Kaiser Normalization.*		
a. Rotation converged in 3 iterations.		

Of the 20 items of the MATE questionnaire used for this PCA only 18 items were retained based on the EFA conditions. Items E6 and E8 were dropped because of low factor loading values.

PCA reveals TWO principal components which accounts for 29.44 % of the total variance. The first component accounts for 16.42 % of the variance and represents the latent construct

Creationism. The Second component accounts for 13.02 % of the variance and represents the latent construct Role of Evolutionism.

The most determinant indicator being in decreasing order of the values of their factor loading as shown on Table 1 above. CFA obtained from EFA is shown in Figure 2 below. The criteria for its validation based on literature are shown on Table 2 below.

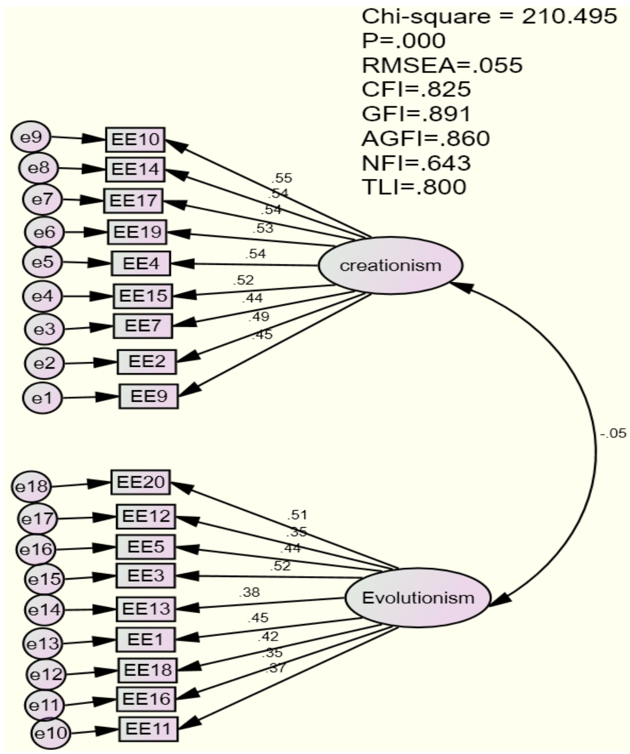

Figure 2: CFA Obtained from EFA on MATE Instrument

Table 2: Condition for Measuring Model to Suit the Data (Generated from Literature)

S/N	Fit Index	Cut of Value from Literature	References
	Absolute Fit Index		Byrne, 2010; Kline, 1998; Tabachnil and Fidell, 2007 Ullman, 2007 Hair et al., 2010
	Chi-square / df ($\chi 2$/df),	≤ 3	
	RMSEA	≤ .08	
2	Comparative Fit Index (CFI)	≥ .90	
3	Incremental Fit Index IFI	≥ .90	

Using the maximum likelihood method of estimation from AMOS 21 (Arbuckle, 2006), CFA was conducted in order to confirm the findings of the EFA. CFA shows how well the explored two-factor measurement model fits the data adequately**.**

Conclusion on Research Question 1

The underlying patterns or constructs that determine the acceptance of evolution using the MATE instrument are beliefs in creationism or Evolutionism. From the EFA and CFA studies, the MATE instrument is reliable to measure these construct. This result is different from that of Rutledge & Warden (1999) that revealed unidimensional; that of Wagler & Wagler (2013) and Romine et al.

(2016, 2018) that revealed multidimensional nature of MATE. It is similar to the bi-dimensional results obtained by Metzger et al., 2018.

Underlying Constructs and Validity of NOS Instrument (RQ 2)

EFA Results of NOS

Of the 28 items of the NOS questionnaire used for this PCA only 25 items were retained based on the EFA conditions as shown on table 3 below. They presented KMO = 0.750, all anti-image > 0.63, communality > 0.50, eigenvalue > 1, factor loading > 0.40, reveals six principal components which accounts for 49.67 % of the total variance. Three items were dropped because they showed cross loadings or loading values less than 0.40 not satisfying these conditions. Only 25 out of the 28 items were eventually retained to measure the NOS tenet constructs.

- The first component accounts for 18.69 % of the variance and represents the latent construct Empirical Nature of NOS (EMP) with the most determinant indicators being in decreasing order: EMP1 > EMP2 > EMP3 > EMP4 > EMP5.
- The Second component accounts for 9.52 % of the variance and represents the latent construct Role of Observation & Inferences in NOS (OBI) with the most determinant indicator being in decreasing order: OBI1 > OBI2 > OBI3 > OBI4.
- The third component accounts for 7.72 % of the variance and represents the latent construct Scientific Theories & Laws (STL) with the most determinant indicators being in decreasing order: STL11 > STL2 > STL3 > STL4
- The fourth component accounts for 5.98 % of the variance and represents the latent construct Tentative nature of NOS (TEN) with the most determinant indicators being in decreasing order: TEN1 > TEN2 > TEN3 > TEN4 > TEN5.
- The Fifth component accounts for 5.98 % of the variance and represents the latent construct Subjective nature of NOS (SUB) with the most determinant indicators being in decreasing order: SUB1 > SUB2 > SUB3 > SUB4.
- The Sixth component accounts for 5.98 % of the variance and represents the latent construct Creativity & Imagination in NOS (CRE) with the most determinant indicators being in decreasing order: CRE1 > CRE2 > CRE3.

The three most prominent conceptions of NOS are: its empirical nature (18.7%), followed by the role of observation and inference (9.2%), thence the status of scientific theories and laws (7.2%). The EFA result was then subjected to CFA testing for validity and reliability and the results presented in section 4.2.2 below.

Using the maximum likelihood method of estimation from AMOS 21 (Arbuckle, 2006), CFA was conducted in order to confirm the findings of the EFA, using same criteria on Table 2 above. CFA was conducted for another sample to evaluate how well the explored six-factor structure fits the data. Some items such as TEN4; TEN3 AND CRE1, CRE2, CRE3, etc., were finally deleted because it had a very low factor loading less than 0.04. (Figure 3).

Successive CFA analysis were conducted on the remaining items until the goodness of fit indices which are shown in Table 3 below were obtained. We thus obtained a three-factor measurement model that fits the data adequately as shown on Figure 4 above.

Table 3: Results of Exploratory Factor Analysis Showing Six Component for NOS Instrument

Rotated Component Matrix[a]						
	Principal Component					
Retained Items on NOS Measurement Scales	**1**	**2**	**3**	**4**	**5**	**6**
1. EMP1 - After scientists have successfully developed a theory, the theory can be changed if new evidence is found and valid.	.756					
2. EMP2 - Experiments are not the only means used in the development of scientific knowledge	.737					
3. EMP3- Scientific explanations are based on empirical observations or experiments.	.599					
4. EMP4 - Scientific explanation contents must be able to be proven.	.461					
5. EMP5 - Scientific solutions cannot be based solely on personal opinions, beliefs, or judgments.	.452					
6. OBI1 - Science differs from other knowledge because science requires evidence, emphasizes the use of empirical standards, logical arguments, and doubts.		.748				
7. OBI2 - Scientists' observations of the same event may be different because the scientists' prior knowledge may affect their observations		.716				
8. OBI3 - Scientists' observations of the same event will be the same because observations are facts.		.643				
9. OBI4 - Scientists may make different interpretations based on the same observations		.565				
10. STL1 - If a theory continues to be tested and proven to be valid, the theory will turn into a law.			.706			
11. STL2 - Theories are laws that are immature or unproven.			.695			
12. STL3 - A scientific theory is not supported by as much scientific evidence as a law of science.			.637			
13. STL4- Scientific theories explain scientific laws			.562			
14. TEN1 - Disagreements between scientists are considered as weaknesses of science.				.646		
15. TEN2 - Science, because it is based on empirical evidence, is testable and deniable.				.617		
16. TEN3- Scientific theories may be changed because scientists reinterpret existing observations.				.554		
17. TEN4 - Something that has been extensively researched and "scientifically proven" can no longer change again.				.496		
18. TEN5 - Scientists always provide temporary answers to questions.				.451		
19. SUB1 - Scientific research can be influenced by race, gender, nationality, or the religion of the scientists.					.718	
20. SUB2 - Scientists work together in the formulation of new scientific knowledge and sometimes disagree with each other about their ideas and explanations.					.587	
21. SUB3 - Scientific theories change with new ways of looking at old evidence.					.554	
22. SUB4 - Bias occurs when scientists believe something will happen before they make an observation.					.409	
23. CRE1 - Human imagination cannot be involved in the creation of new scientific knowledge.						.658
24. CRE2 - Scientists must use creativity and art in developing new theories about the natural world.						.643
25. CRE3 - Scientists use their imagination and creativity when they collect, analyse and interpret data.						.488
Extraction Method: Principal Component Analysis. *Rotation Method: Varimax with Kaiser Normalization.*						
a. Rotation converged in 8 iterations.						

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CFA for the Validation of the NOS Measurement Model Revealed by EFA

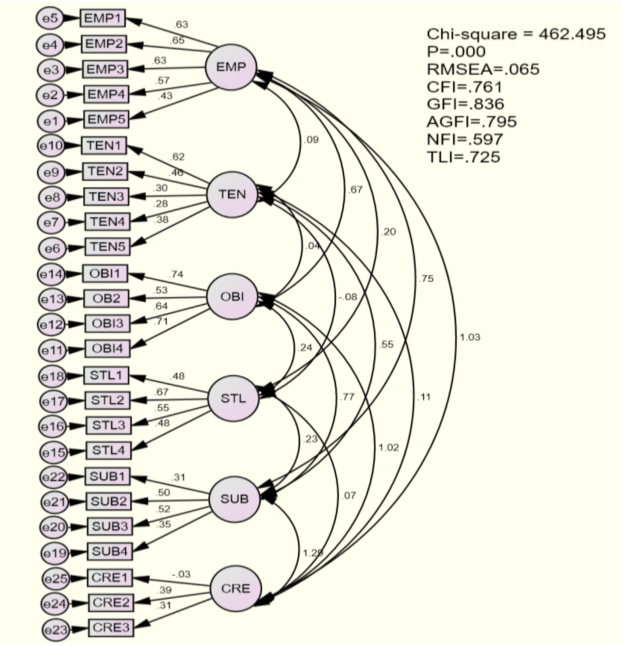

Figure 3: Invalidated NOS Measurement Model

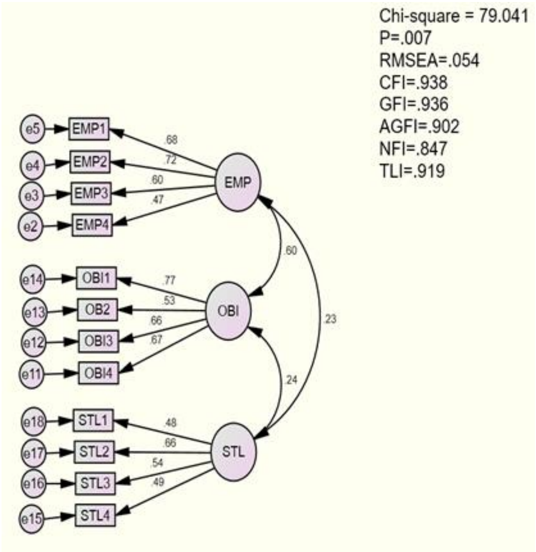

Figure 4: Validated NOS Measurement Model

Only three construct and 12 items were retained out of the initial six (6) constructs with 28 items. Some items and consequent construct were dropped because they did not meet the CFA condition of validity and reliability.

Table 4: Fit Indexes for High School Students' Views of NOS (Data Generated by Nchia)

	$\chi 2$	P Values	RMSEA	GFI	AGFI	CFI	TLI	NFI
Original Health View	402.49	0.000	0.065	0.836	0.795	0.761	0.725	0.597
Retained Health View	79.04	0.007	0.054	0.9836	0.902	0.938	0.919	0.847

Conclusion on Research Question 2

Six principal components were obtained from our exploratory factor analysis (EFA) but based on confirmatory factor analysis (CFA), only three constructs and 12 items of NOS instrument are reliable to measure these constructs (Figure 4). The reliable three constructs that discriminate our respondents are: the empirical nature of Science (EMP); Observations and inferences in Science (OBI) and Scientific Theories and Laws (STI).

Influence of NOS on MATE (RQ 3)

Structural Equation Model for the Hypothesized Structural Model

Confirmatory Factor Analysis (CFA) was conducted in order to confirm the hypothesised Structural Equation Model (SEM) shown on Figure 5 below, following the criteria on Table 2 above. It was found out that the structural model fits the Data.

The regression data obtained from the Structural Equation Model for the Hypothesized Structural Model is shown on Table 5 below. The Critical Ratio (CR) values greater than 2 indicate the corresponding pair of factors or constructs significantly covary, in other words, these factors are correlated. C.R. values below 2 indicate no correlation. The p values confirm the hypotheses.

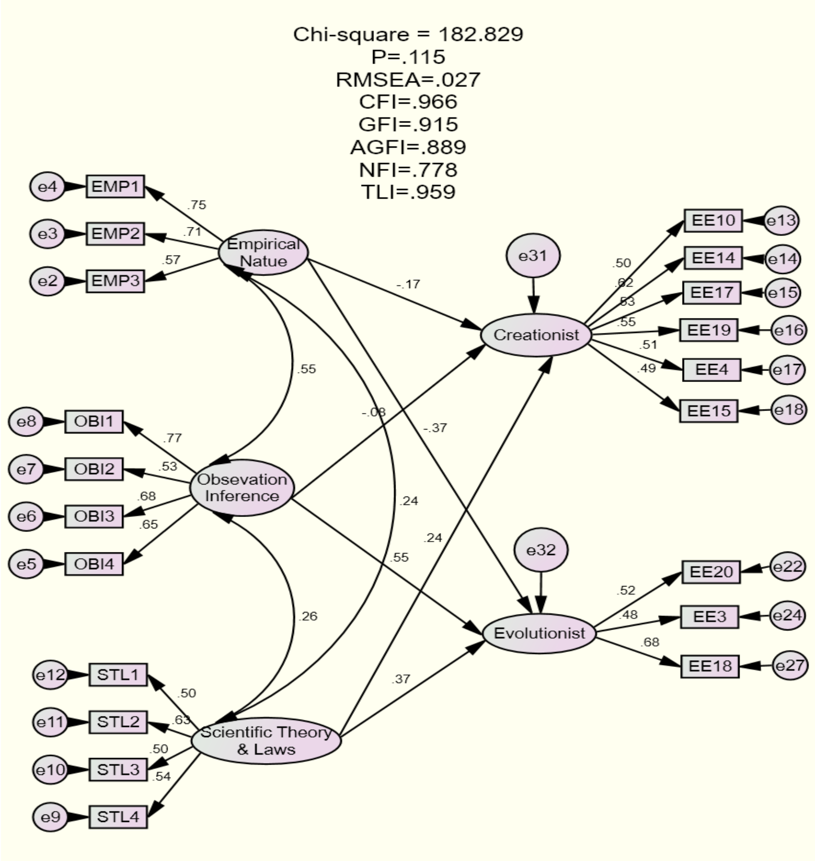

Figure 5: Standardised Path Coefficient and R Square Values for the Hypothesised Structural Model Proposed by Nchia 2024

The correlation results reveal that, understanding the three NOS tenets: Empirical nature of science; scientific theory and Laws; and observation and inferences have a statistically significant influence on accepting the Evolution concept and is not statistically significant for creationism.

- Understanding role of Observation and inferences in scientific inquiry has a statistically significant, strongly and positive predictor (ß=0.55) of evolution.
- Understanding status of Theories and Laws in science has a statistically significant, moderate and positive predictor (ß=0.37) of evolution.
- Understanding the Empirical nature of science has a statistically significant, moderate and negative predictor (ß= -0.37) of evolution.

Table 5: Regression Weights Data Obtained from the Structural Equation Model for the Hypothesized Structural Model

Hypothesized relationship outcome			Standardized Estimate (effect size)	Standard Error (S.E).	Critical value (C.R).	Probability value (P)	Inference or Conclusion
Creationist	←	Empirical Nature of Science	-.429	.346	-1.241	.215	Non sign. at 0.05
Creationist	←	Observation and Inference	-.141	.233	-.606	.545	Non sign. at 0.05
Creationist	←	Scientific Theory & Laws	.344	.179	1.925	.054	Non sign. at 0.05 . fail to reject null hypothesis
Evolutionist	←	Scientific Theory & Laws	.490	.200	2.445	.014	Statistically sig. at 0.05 level. Ho rejected. STL has a positive direct effect on Evolution at p=0.05
Evolutionist	←	Empirical Nature of Science	-.867	.380	-2.281	.023	Statistically sig. at 0.05 level
Evolutionist	←	Observation and Inference	.930	.289	3.214	.001	Statistically sig. at 0.05 level

Interpretation

Empirical Nature of Science in Evolution

The theory of evolution, like all scientific theories, is based on empirical evidence gathered through observation, experimentation, and data analysis. NOS emphasizes the importance of evidence in supporting scientific claims. Individuals with a strong grasp of NOS recognize the importance of empirical evidence in scientific inquiry. They are more likely to appreciate the vast array of evidence supporting evolution, including fossil records, genetic studies, and comparative anatomy. Thus, they are better equipped to understand and accept the theory of evolution as a well-supported scientific explanation for the diversity of life on earth. For example:

- The discovery of transitional fossils like Archaeopteryx provides direct evidence of evolutionary transitions between major groups (reptiles and birds).
- Empirical science involves forming hypotheses that can be tested through experiments and observations. Evolutionary hypotheses about ancestral relationships or adaptive traits can be tested using various methods. For Example: The hypothesis that certain traits increase

fitness can be tested through field studies and controlled experiments, as seen in the long-term study of Galápagos finches by Peter and Rosemary Grant, (2002). They have demonstrated how very rapid changes in body and beak size in response to changes in the food supply are driven by natural selection.

- Empirical science requires that results be reproducible by other scientists. Consistent findings across different studies and methods strengthen the validity of evolutionary theory. For Example: Genetic studies repeatedly showing similar phylogenetic trees for different species confirm common descent and evolutionary relationships.
- Based on empirical data, evolutionary theory makes predictions that can be observed and tested. These predictions range from the development of antibiotic resistance to the presence of specific traits in populations under certain conditions. For Example: Predicting the development of drug-resistant bacteria in response to the use of antibiotics highlights the practical implications of understanding evolution.

Roles of Scientific Theories and Laws in Evolution

By understanding the roles of scientific theories and laws, students and the public can better grasp how evolution explains the natural world, predicts biological phenomena, and unifies various biological disciplines. This comprehension enhances appreciation for the scientific process and the robustness of evolutionary theory. For example:

- The evolution theory integrates various observations and experiments, offering a robust explanatory framework. It helps explain why and how species change over time through mechanisms such as natural selection, genetic drift, mutation, and gene flow. The theory of natural selection explains how advantageous traits become more common in a population over generations.
- Theories Predict Outcomes, thus the evolutionary theory can predict how populations will respond to environmental changes or selective pressures. For example: Predicting the development of antibiotic resistance in bacteria based on the principles of natural selection.
- Understanding evolutionary mechanisms explains the vast diversity of life. Different species have evolved unique adaptations to their environments through processes such as speciation. For Example: The diversification of Darwin's finches on the Galápagos Islands into species with different beak shapes adapted to different food sources.

Theories in biology provide broad explanations for complex biological phenomena and are considered the highest level of scientific understanding. Theories are comprehensive explanations that integrate multiple hypotheses, facts, concepts, and principles into a coherent framework. They are supported by a vast body of evidence and have withstood extensive testing and scrutiny. NOS highlights that scientific theories are developed through a process of hypothesis formation, testing, and refinement. Evolutionary theory has undergone continuous refinement since Darwin proposed it in the 19th century. New evidence, technological advancements, and interdisciplinary approaches have contributed to its development and refinement over time.

Laws describe phenomena that consistently occur under certain conditions. They often take the form of mathematical relationships. While there are no specific "laws of evolution" comparable to laws in physics, principles such as Mendel's laws of inheritance contribute to the broader understanding of genetic mechanisms within evolutionary theory.

Roles of Observation and Inferences in Evolution

Observation and inferences in the Nature of Science (NOS) are fundamental in enhancing the understanding of evolutionary theory. For example:

- Evolutionary theory is grounded in empirical evidence. Observations of the natural world, such as fossil records, anatomical similarities, genetic sequences, and biogeographical distributions, provide data that support the theory. Scientists infer evolutionary relationships and processes from these observations. For example, observing similarities in DNA sequences between species leads to the inference of common ancestry.
- Charles Darwin's observations of diverse species on the Galápagos Islands, including finches with varied beak shapes, were critical in formulating hypothesis that was tested to eventual become the theory of natural selection. Darwin inferred that these variations were adaptations to different environmental niches, leading to the broader theory of evolution by natural selection
- Scientists test evolutionary hypotheses by making predictions and observing if they hold true. For example, predicting the presence of transitional fossils and then discovering fossils like *Tiktaalik*. Consistent observations across different disciplines (paleontology, genetics, and ecology) reinforce the inference that evolution is a robust explanatory framework.
- Observing phenomena such as antibiotic resistance in bacteria or changes in the beak size of finches during droughts provides real-time examples of evolutionary mechanisms. These observations lead to inferences about the mechanisms of evolution, such as natural selection, genetic drift, and gene flow, providing a deeper understanding of how evolutionary changes occur.
- Much of evolutionary biology deals with historical science, where direct observation of events (e.g., the extinction of dinosaurs) is impossible. Scientists infer historical processes from current observations, such as using the distribution of traits among living organisms to reconstruct evolutionary histories and phylogenies.

Teaching the inferential processes in science clarifies that theories are well-supported explanations based on extensive evidence. By emphasizing the role of observation and inference in the NOS, educators and scientists can better communicate the evidential basis and explanatory power of evolutionary theory, fostering a deeper and more accurate understanding among students and the public

5.0 CONCLUSION AND RECOMMENDATIONS

The tenets of NOS provide a comprehensive framework that helps people understand the scientific process and the robustness of scientific knowledge. By relating these tenets to evolutionary theory, educators and students can enhance the acceptance of evolution, showing it as a well-supported, dynamic, and credible scientific explanation for the diversity of life on Earth. Thus NOS can be used as a teaching and learning tool of science.

Our research thus recommends teachers design lesson plans with activities to enhance students' appreciation of the importance of empirical evident in science, to enable them distinguish between observation and inference in scientific procedures and to distinguish between scientific laws and theories. This will enhance acceptance of the evolution theory as demonstrated in our hypothesised structural model, a candidate theory for further investigation. It could have implication in the development of didactic strategies to overcome misconceptions in evolution.

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