Asian Journal of Assessment in Teaching and Learning
Vol 11, Issue 2, 2021 (77-92) eISSN 2821-2916

Partial Least Square Modeling of Personality Traits and Academic Achievement in Physics

Amusa Jamiu Oluwadamilare[1], Ayanwale Musa Adekunle[2*]
[1]Department of Science Education, National Open University of Nigeria.
[2]Department of Science and Technology Education, University of Johannesburg, South Africa.
ayanwalea@uj.ac.za[2]

Received: 14 June 2021; **Accepted:** 25 November 2021; **Published:** 16 December 2021

To cite this article (APA): Oluwadamilare, A. J., & Ayanwale, M. A. (2021). Partial Least Square Modeling of Personality Traits and Academic Achievement in Physics. *Asian Journal of Assessment in Teaching and Learning, 11*(2), 77-92. https://doi.org/10.37134/ajatel.vol11.2.8.2021

To link to this article: https://doi.org/10.37134/ajatel.vol11.2.8.2021

Abstract

Within the purview of educational settings, students possess some unique traits which make them react in an unexpected manner to the learning environment. Students are not only unique in terms of personality characteristics, family background, age and gender, they also showed diverse states of mind and enthusiastic reactions to the environment. Therefore, this study modelled the Big Five personality traits and academic achievement of students in Lagos State, Nigeria. A non-experimental design of scale development research type was adopted. A sample of 480 senior secondary school III students selected through multi-stage sampling procedure across the education districts 2 of Lagos State. Student's Personality Traits Scale (SPTS) and Physics Achievement Test (PAT) were deployed to capture the needed data after subjecting them to exploratory factor analysis using the psych package implemented in R programming language and item calibration of Item Response Theory. Data were analysed using Partial Least Square (PLS) path modelling to test the proposed model. Findings showed, there was significant direct positive relationship between the five personality traits and academic achievement in physics with (β= 0.23, t = 1.99, $p < 0.05$). Also, there was significant negative causal linkage of gender on physics achievement with (β = -0.10, t = 2.02, $p < 0.05$), although, its moderating effect was insignificant between the two constructs with (β = 0.02, t = 0.75, $p > 0.05$). Among other recommendations, physics teachers were enjoined to pay due attention to the development of positive traits among their students.

Keywords: Partial Least Square Modelling, Personality Traits, Physics Achievements, Psych Package, R Programming Language

INTRODUCTION

The discussions that surround the poor academic achievement of students in physics in Nigeria will continue to gain prominence among science educators until, perhaps, the country becomes sufficiently independent in the area of science, technology and innovation (STI). This is primarily because the relevance of physics and physics education towards the nation's autonomy in STI is no longer in doubt. At present, this what dominates conversation among world leaders in the movement into the 4th industrial revolution and globalization (WEF, 2019). The 4th industrial revolution is driven by STI, which is in turn propelled by the sufficient gains in the field of physics (Cirera & Maloney 2017). This assertion is further amplified by Adebayo and Adigun (2018) remarked that successful nations are assessed by their level of technological attainment. Technological attainment, according to Nwona and Madu (2018), is a function of the successes recorded in the country's physics education. Amusa (2020) argued that physics is a pivotal subject in the

development of science and technology in Nigeria. Physics as the most basic of the sciences, and its concept and techniques underpin the progress of all other branches of science. The ideas of Physics are fundamental to the more complicated sciences and were therefore classified as the most basic of all the sciences (Usman, et al., 2019). Understanding science and technology begins with an understanding of physics. Amadalo et al. (2012) noted that Physics plays important and dominant roles in spearheading technological advancement, promoting national wealth, improving health care and accelerating industrialization. Despite this significant relevance, students' poor achievement in physics has remained unresolved (Bello & Akinfesola, 2015).

In their quest to provide explanations to this challenge, Owolabi and Oginni (2013) identified inappropriate teaching method while Adeyemo (2010) observed that the inability of physics instructors in making use of a variety of non-verbal teaching aids have partly culminated into low achievement in physics and possibility of general phobia for mathematics as a subject integrated into the study of physics. While Ogunleye and Anyaegbuna (2018) alluded to the fact that teaching in the science classroom is geared around memorization of basic concepts and their reproduction in the examinations and many students consider physics as difficult, abstract and theoretical. Studies on poor academic achievement in physics are as old as the study of physics in Nigeria. Yet, the problem has consistently remained without hope of insight. Several attempts to unravel the challenges of poor academic achievement in schools, numerous researches have examined the roles of external factors such as type of school, teaching methodologies, school location, teachers' experience, qualities of instructional materials (Erinosho, 2013) while some educational psychologists have also examined varying factors such as intelligence, self-concept, gender, study habit, maturation, family background and personality traits in relation to academic achievement (Herrera et al., 2020; Islam, 2021). In other clime, the research literature is inundated with studies on the nexus between students' personality traits and academic achievement in other subjects using first generation statistical tools. However, much has not been done in determining the personality traits of physics students at the senior secondary school level, with specific reference to Nigeria. Hence, it becomes imperative to examine the causal modeling of the big-five personality traits (such as extroversion, openness, agreeableness, neuroticism and conscientiousness) and the students' academic achievement in physics at the senior secondary school (Laidra et al., 2007).

Concept of Personality Traits

Personality is described as the summation of varying characteristics that differentiate one individual from another (Daminabo, 2008). This can also be related to that property of an individual which have a consistent layout of feelings, considerations and conduct. Traits, on the other hand, can be portrayed as persevering or continuous dimensions of characteristics which separate one individual from another. Meanwhile, Daminabo (2008) posited that "trait is a continuous dimension on which person contrasts may be arranged quantitatively in terms of the number of characteristics the person has". On the whole, personality traits allude to the overall steady characteristics of an individual over distinctive time and circumstances which make him or her one of a kind or distinct from others (Ikpi et al., 2014). In educational settings, students have particular identity traits which make them react in an unexpected way to the learning environment. Learners are not only distinctive in term of personality characteristics, family foundation, age and gender, they also display diverse states of mind and enthusiastic reactions to the environment (Hakimi et al., 2011). The personality traits that have gained prominence among researchers in educational psychologists in the past few decades are called the Big-Five personality traits. They include openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (Rimfeld et al., 2016). Jensen (2015) remarked that educational researchers have successfully correlated the personality traits with abilities, behaviour, methods, strategies and academic achievement. It was further posited that the big-five traits are so stable over a long period and easily distinguishable from each other. These traits and their corresponding facets are presented in a tabular representation with their description and corresponding antonyms (See Table 1).

Table 1. Facets of Personality Traits

S/N	PERSONALITY TRAITS & FACETS	OPPOSITE TRAITS & FACETS
1	**OPENNESS / OPEN TO NEW EXPERIENCES** Imagination, creativity, originality, prefer variety, curiosity, liberal	**TRADITIONALIST** Down to Earth, uncreative, conventional, uncurious, prefer routines, conservative
2	**CONSCIENTIOUSNESS** Conscientious, hard-working, ambitious, well organized, persevering, punctual	**CARELESS** Quitting, negligent, lazy, disorganized, aimless, late and indifference.
3	**EXTRAVERSION** Talkative, a joiner, physically active, affectionate, passionate, fun-loving	**INTROVERSION** Reserved, seeking solitude (a loner), physically passive, quiet, sober, unfeeling
4	**AGREEABLENESS** Softhearted, trusting, generous, acquiescent, lenient, good-natured	**SELF-CENTERED** Suspicious, ruthless, stingy, antagonistic, critical, irritable
5	**NEUROTICISM** Worrying, temperamental, self-pitying, self-conscious, emotional, vulnerable	**EMOTIONALLY STABLE** Calm, even-tempered, self-satisfied, comfortable, unemotional, hardy

Source: Adapted from Jensen (2015)

Openness has been described as an individual's state of broad-mindedness, depth of attitude, and penetrable awareness, openness to novelty, creativity and originality. An open-minded individual is always ready to know and learn new things. Conscientiousness in the description of Troncone et al. (2014), stood for an individual's measure of accountability, accuracy, precision, academic persistence and perseverance. Students with this trait always work very hard with pleasure and strong determination to see the end of all their engagement (Bratko et al., 2006). While describing extroversion, Hakimi et al. (2014) identified an individual with a high level of socialization, loquacity, dynamism, activity, assertiveness and relating very well with the environment. Students with these traits are generally sociable, warm and seek connection with the environment. According to Ikpi et al. (2014), Agreeableness simply referred to interpersonal relationships. It is associated with traits such as sympathy, altruism, acceptance of others, honesty, sense of cooperation and hospitality. Neuroticism as the last on the list portrayed the emotional stability of an individual. It identified the level of mood stability and the ability to control one's emotional reaction like anger and irritations (Anita et al., 2020; Rodríguez-Ramos et al., 2021). The five-factor model of the personality traits can also be described on a continuum scale from the extreme positive "pole" to the extreme negative "pole" or on a Cartesian plane as depicted on the number line (See Figure 1).

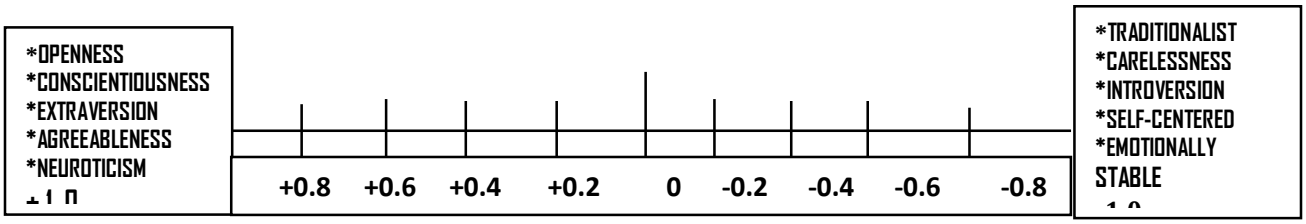

Figure 1: Extreme Positive and Negative Pole of Personality Traits. Source: (Authors, 2020)

Figure 1 depicts any of the traits can be read on the improvised scale towards assigning a ratio or coefficient in the range of +1.0 to -1.0. A physics student with a high extroversion rating may be assigned a ratio of +0.8 on the rating scale while the value of -0.6 on conscientiousness measure is tending towards carelessness.

A perusal of literature revealed that academic performance is positively associated with openness to experience, conscientiousness, agreeableness and extroversion. It is however negatively associated with neuroticism (Rimfeld et al., 2016). Wagerman and Funder (2007) argued that of all personality components,

conscientiousness is the foremost strong predictor of academic achievement across education, with an average correlation of 0.20. Subsequently, conscientious students are continuously known to achieve high academic achievement (Bratko et al., 2006).

Studies have also remarked that of all the big-five traits, extroversion shows the foremost interesting relationship with academic achievement as students' advance the educational ladder. It should be noted that Melissa et al. (2007) established a negative relationship between academic achievement and extroversion whereas Chomoro and Furnham (2003a) detailed the reverse. After a broad review on academic achievement and personality traits, Hakimi et al. (2014) submitted that higher levels of extroversion relate to higher academic achievement among basic school students but, to lower academic achievement at the higher educational level. This finding reflects a move from the informal, interactional and class-oriented environment at elementary schools to a more academic, study-oriented and knowledge-based environment at high schools and college settings. In other words, highly extroverted students are more likely to spend their time on social and extra-curricular activities in comparison to less extroverted students (Furnham et al., 2006).

Even though most studies have pointed to the negative relationship between neuroticism and academic achievement (Vidya & Ramyashilpa, 2014), there are in any case a few studies that have established a positive relationship between neuroticism and academic achievement although exceedingly neurotic individuals endure variations from the norm and disorders which obstructs their compelling performance (Chomoro & Furnham, 2003b). Neuroticism has been related to non-attendance from the classroom, ailment, etc. and consequently influences performance contrarily. Hakimi et al. (2014) commented that agreeable individuals are profoundly cooperative, strong and willing to work viably with others. Subsequently, positive relationships between agreeableness and academic achievement are not distant from expectation. In line with the direction of Furnham et al. (2006) submitted that more agreeable students tended to have higher scores and thus higher academic achievement. Hakimi et al. (2014) concluded that, without question, the Big Five personality factors are related to academic achievement, but the pattern of relationships among the traits are not consistent and seems to partly depend on other variables such as level of education (elementary, secondary or tertiary), the instrument used to measure performance, gender etc.

Batool and Aziz (2018) discovered that there was no gender wise difference in the total personality traits of the students. Similarly, Shah (2018) noted that there is no significant difference in openness to experience between male and female students. Due to the social nature and boldness of male students, the researcher further remarked that the male students have greater extroversion and conscientiousness than their female counterpart. The differences observed in the personality traits along the gender line is premised on the psychological adaptation of the students (Lounsbury et al., 2003b). The researcher also posited that the observed differences may be due to cultural universal gender differences while others may be due to socio-ecological context, environmental dynamics, institutional conditions, religious, and gender roles. In the study of personality of some physicists, Wilson and Jackson (1994) opined that physicist are always careful (conscientiousness), controlled, inhibited and unsociable (introversion) irrespective of their gender. Since a physicist was one time a physics student, it can be inferred that conscientiousness and introversion are possible traits of physics students. Thus, this study employed PLS path modelling to model student's personality traits with their achievement in Physics and also to examine the moderating effect of gender between the two constructs.

Structural Equation Modeling (SEM) is a second-generation multivariate data analysis method that is often used in marketing research because it can test theoretically supported linear and additive causal models (Chin, 1998). In SEM, a variable is either exogenous or endogenous. An exogenous variable has path arrows pointing outwards and none leading to it. Meanwhile, an endogenous variable has at least one path leading to it and represents the effects of other variables (s). Several techniques are available to structural equation modelling (SEM). These include Covariance-based (CB-SEM), Partial Least Square (PLS-SEM/PLS path modelling) or Variance-based SEM. In this study, PLS-SEM was emphasized. The following research questions and hypotheses were advanced: (a) Do the scales valid and reliable? (b) What is the predictive accuracy of the endogenous construct? (c) There is no significant relationship between

gender and achievement in Physics (d) There is no significant relationship between Students Personality Traits and Achievement in Physics. (e) There is no significant moderating effect of gender on Personality Traits and Achievement in Physics.

METHODS

Design, Participants and Sample

This study adopted a non-experimental design of scale development research type, with senior secondary school three (SSS III) physics students in Lagos State as the target population. Schools in Lagos State were stratified into six educational districts. This study used education district two. In this district, 24 secondary schools drawn randomly participated in the study, and 20 students were selected through systematic sampling procedure. A total of 480 SSS III physics students involved in the study. Their ages ranged between 17 and 21 years with 311 (64.8%) males and 169 (35.2%) females respectively.

Measured Instrument

Two instruments were used in this study. First, a self-developed questionnaire titled Student's Personality Traits Scale (SPTS) was used to generate data. Items contained in the SPTS were 35 items after initial revision by the experts in the field of psychology. These items were written in a clear, simple and devoid of ambiguity based on the suggestions of the experts with content validity index of 0.84. To get the responses for each item of the scale, a four-point Likert scale was used, where 1 denotes "Inaccurate" and 4 denotes "Very accurate". More so, Likert scales was employed to enable respondents to express their views and opinions in varying degrees. These items were subjected to exploratory factor analysis using psych package implemented in R programming language. The results suggested eight factors underlying the scale but only five factors (that is Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism**)** were interpretable with substantial items loading of 0.32 and at least 3 items under each component as suggested by (Tabachnik & Fidel, 2007). However, validity and reliability of the instrument was established using convergent validity, discriminant validity, internal consistency, indicator reliability and composite reliability as reported in the results.

Secondly, physics achievement test (PAT) was developed using senior secondary school curriculum comprises of six themes such as interaction of matter, space and time, conservation principles, waves, field at rest and in motion, energy quantisation and duality of matter and physics in technology respectively. The draft PAT consisted of 65 items, which was reduced to 40 valid good items after subjecting it to preliminary item analysis via Item Response Theory (that is item calibration). Items meeting the criteria proposed by De Mars (2010) that item difficulty values ranging between -2 to +2 and item discrimination values higher than 0.2 respectively should be retained. Based on this premise, 40 PAT items were considered substantial for this study and scored as either right (1) or wrong (0).

Data Analysis

The collected data were analysed using Partial Least Square (PLS) path modelling to test the proposed model. Partial least squares-structural equation modelling (PLS-SEM) is a multivariate statistical technique and its usage in various disciplines is increasing every day. Meanwhile, the rationale for using PLS path modelling was to predict accuracy and explain the variance of the endogenous construct. It was therefore, regarded PLS path modelling to be the most suitable analytical approach using SmartPLS software version 3.3.2 developed by (Ringle et al., 2014) for this study.

RESULTS AND DISCUSSION

Do the scales valid and reliable?

To answer this question, a PLS-SEM assessment was conducted in two phases; Phase one explains the measurement model or outer model while phase two stresses on the structural model or inner model. Furthermore, phase one can be evaluated using reflective and formative model techniques, which literature had depicted in recent time for assessing the validity and reliability of an instrument. The reflective measures are connoted by arrows directing from the construct to the indicators are estimated in PLS-SEM by the outer loadings. While the formative measures, which are indicated by arrows pointing from the indicator to the construct are estimated by their outer weights. Meanwhile, all indicators in this analysis were measured reflectively. The assessment of reflective models in this analysis was examined through: indicator reliability, construct reliability (Composite and Cronbach Reliability) and construct validity (convergent and discriminant validity). Figure 2 presents the proposed measurement model which has an exogenous construct known as Students Personality Traits with sub-constructs such as openness, conscientiousness, extraversion, agreeableness, and neuroticism measuring it. The endogenous construct includes Physics Achievement with themes such as Matter, Space and Time, Conservation Principles, Waves, Field at Rest and in Motion, Energy Quantisation and Duality of Matter and Physics in Technology students' satisfaction respectively.

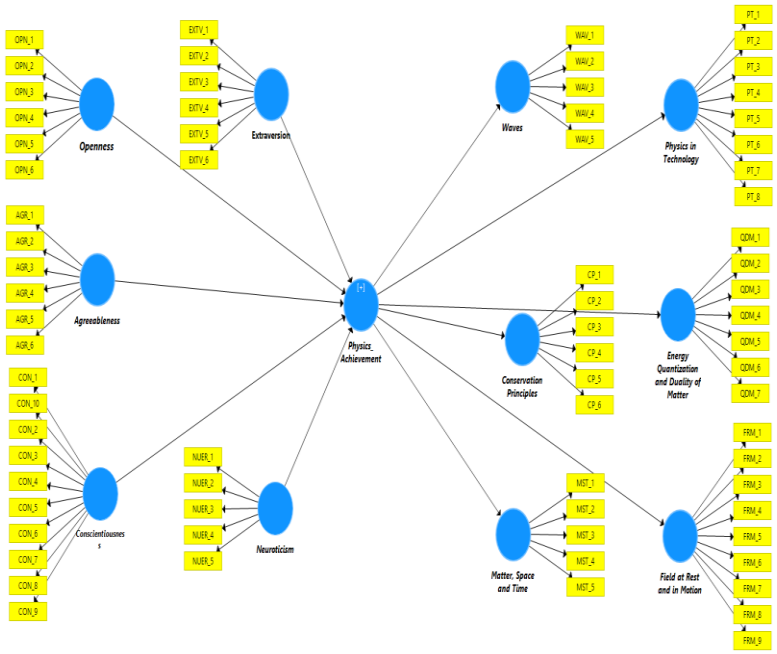

Figure 2: Proposed Measurement Model

However, due to the nature of the latent variable in the model, the second-order PLS-SEM model was developed and to develop the model, the two-stage approach to PLS-SEM was established (Hair, et al., 2016). In the two-stage approaches, the sub-factors of the latent variables (SPTS) were the first model as if they are constructs and their construct reliability and validity were assessed. On meeting the criterion of both, the second stage which uses the latent scores from the sub-factors is used as indicators for the parent construct (SPTS). Figure 3 presents the measurement model loadings.

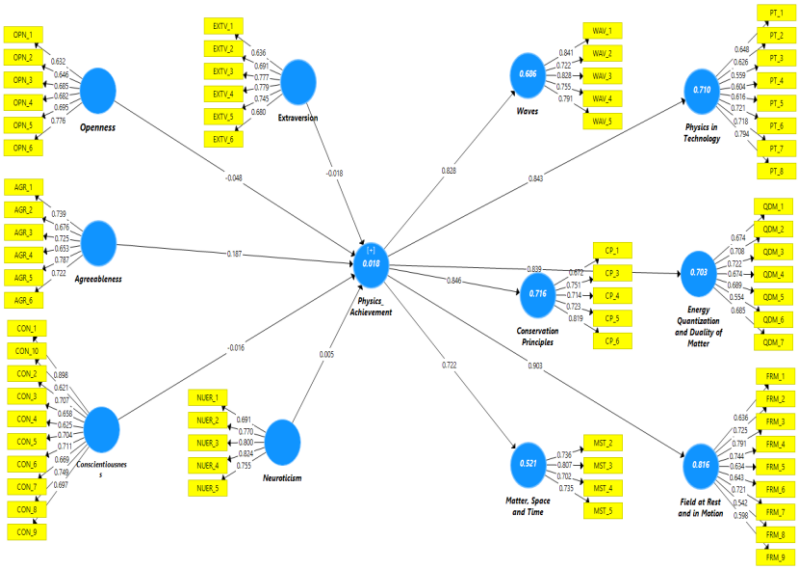

Figure 3: Measurement Model Factor Loadings

The results revealed that some of the indicators needed to be expunged, namely, MST1 and CP2. Once these indicators were removed, the parsimonious model showed an adequate specification for the proposed measurement model (See figure 3). Table 2 showed estimations for the indicator reliability, Cronbach's alpha (CA) and composite reliability (CR) of each construct and the average variance extracted. Hair et al (2010), remarked that indicator reliability is assessed by their respective factor loading on the underlying construct. He also argued that an item is considered reliable if its factor loading is greater than 0.70 is the standard but loading of 0.40 is acceptable as well (See Table 2). Furthermore, a construct is said to be reliable, if it meets reliability criteria, including Cronbach's alpha (CA) and composite reliability (CR), which must be higher than 0.70, as suggested by (Bagozzi, 1988); (Nunnally & Bernstein, 1994). The final criterion of convergent validity, average variance extracted (AVE), is a measure that indicates the amount of variance in an item that is explained by the underlying construct (Fornell & Larcker,1981). More so, Hair et al (2017b) suggested minimum value of 0.40 for estimated average variance extracted (AVE) to be considered ideal although 0.50 is the standard (See Table 2).

Table 2. Reliability and convergent validity of the measurement instrument

Indicators	Outer Loadings		T-Statistics	Cronbach Alpha (CA)	Composite Reliability (CR)	Average Variance Extracted (AVE)
Agreeableness						
AGR.1	0.74	**	9.12			
AGR.2	0.68	**	6.81			
AGR.3	0.73	**	8.56	0.82	0.86	0.52
AGR.4	0.65	**	5.57			
AGR.5	0.79	**	12.75			
AGR.6	0.72	**	9.39			
Conscientiousness						
CON.1	0.90	**	4.18			
CON.10	0.62	**	2.48			
CON.2	0.71	**	2.42			
CON.3	0.66	**	2.93	0.90	0.91	0.50
CON.4	0.63	**	2.46			
CON.5	0.70	**	3.20			

CON.6	0.71	**	3.67			
CON.7	0.67	**	3.37			
CON.8	0.75	**	4.07			
CON.9	0.70	**	2.47			
Conservation Principles						
CP.1	0.67	**	24.46			
CP.3	0.75	**	27.93			
CP.4	0.71	**	23.89	0.79	0.86	0.54
CP.5	0.72	**	27.77			
CP.6	0.82	**	42.32			
Extraversion						
EXTV.1	0.64	**	2.74			
EXTV.2	0.69	**	2.69			
EXTV.3	0.78	**	3.56	0.82	0.87	0.52
EXTV.4	0.78	**	4.32			
EXTV.5	0.75	**	3.51			
EXTV.6	0.68	**	3.01			
Field at Rest and in Motion						
FRM.1	0.64	**	20.50			
FRM.2	0.73	**	26.73			
FRM.3	0.79	**	38.58			
FRM.4	0.74	**	28.56	0.85	0.88	0.46
FRM.5	0.63	**	17.36			
FRM.6	0.64	**	21.95			
FRM.7	0.72	**	30.83			
FRM.8	0.54	**	17.37			
FRM.9	0.60	**	17.82			
Interaction of Matter, Space and Time						
MST.2	0.74	**	26.24			
MST.3	0.81	**	40.04	0.74	0.83	0.56
MST.4	0.70	**	25.71			
MST.5	0.74	**	25.66			
Neuroticism						
NUER.1	0.69	**	3.08			
NUER.2	0.77	**	4.62	0.83	0.88	0.59
NUER.3	0.80	**	3.68			
NUER.4	0.82	**	4.86			
NUER.5	0.76	**	3.46			
Openness						
OPN.1	0.63	**	2.54			
OPN.2	0.65	**	2.88			
OPN.3	0.69	**	2.74	0.78	0.84	0.47
OPN.4	0.68	**	2.78			
OPN.5	0.70	**	3.00			
OPN.6	0.78	**	3.77			
Physics in Technology						
PT.1	0.65	**	22.62			
PT.2	0.63	**	20.06			
PT.3	0.56	**	18.70			
PT.4	0.60	**	18.43	0.82	0.86	0.44

PT.5	0.62	**	20.06			
PT.6	0.72	**	25.74			
PT.7	0.72	**	25.34			
PT.8	0.79	**	36.03			
Energy Quantization and Duality of Matter						
QDM.1	0.67	**	21.11			
QDM.2	0.71	**	18.03			
QDM.3	0.72	**	23.80			
QDM.4	0.67	**	23.50	0.80	0.85	0.45
QDM.5	0.69	**	21.99			
QDM.6	0.55	**	16.90			
QDM.7	0.69	**	22.89			
Waves						
WAV.1	0.84	**	52.79			
WAV.2	0.72	**	27.23			
WAV.3	0.83	**	43.22	0.85	0.89	0.62
WAV.4	0.76	**	30.13			
WAV.5	0.79	**	38.79			

Table 2 showed sub-constructs of the latent variables and their items/measures were reliable (all loading was ≥ 0.40; all constructs had Cronbach alpha and composite reliability ≥ 0.70). This result implies that the scale was valid and reliable. More so, discriminant validity is measured using the Fornell-Larcker criterion which states that the square root of AVE must be greater than the correlation of the reflective construct with all other constructs; this criterion does not apply to formative measurement models and single-item constructs. Checking cross-loadings, all the indicators should load the highest on their associated constructs. Consequently, the square root of AVE was higher than the relationships among the latent factors (See Table 3). This shows satisfactory discriminant validity of all the constructs within the model. Long ago, the HeteroTrait-MonoTrait ratio of correlations (HTMT) has ended up the essential basis for assessing discriminant validity since it offers predominant performance compared with the Fornell-Larcker criterion and the appraisal of cross-loadings (Henseler et al., 2015). This was computed for reflective measurement models against the threshold value of 0.90 (that is, for discriminant validity to be established, the HTMT values ought to not exceed 0.90; Henseler et al., 2015). In this way, the study found an HTMT ratio underneath these values (See Table 4), so the model's discriminant validity was established.

Table 3. Fornell-Larcker Discriminate validity

Variables	**AGR**	**CON**	**CP**	**QDM**	**EXTV**	**FRM**	**MST**	**NEUR**	**OPN**	**PT**	**WAV**
AGR	**0.72**										
CON	0.14	**0.71**									
CP	0.02	-0.02	**0.74**								
QDM	0.22	0.22	0.55	**0.67**							
EXTV	0.67	0.66	-0.02	0.17	**0.72**						
FRM	0.18	0.13	0.72	0.29	0.13	**0.67**					
MST	-0.02	-0.05	0.64	0.49	-0.04	0.54	**0.75**				
NEUR	0.05	0.68	-0.01	0.17	0.55	0.12	-0.04	**0.77**			
OPN	0.54	0.09	-0.03	0.17	0.48	0.13	-0.06	0.66	**0.69**		
PT	0.18	0.16	0.64	0.43	0.13	0.28	0.53	0.13	0.12	**0.67**	
WAV	-0.04	-0.07	0.36	0.60	-0.05	0.09	0.63	-0.05	-0.06	0.53	**0.79**

Table 4. Hetero Trait-Mono Trait Ratio of Correlations (HTMT)

Variables	AGR	CON	CP	QDM	EXTV	FRM	MST	NEUR	OPN	PT	WAV
AGR											
CON	0.51										
CP	0.05	0.07									
QDM	0.27	0.24	0.67								
EXTV	0.62	0.22	0.07	0.23							
FRM	0.23	0.16	0.66	0.75	0.18						
MST	0.08	0.08	0.83	0.63	0.09	0.65					
NEUR	0.69	0.78	0.06	0.21	0.32	0.16	0.09				
OPN	0.48	0.54	0.06	0.22	0.28	0.18	0.10	0.81			
PT	0.25	0.23	0.78	0.11	0.22	0.83	0.63	0.19	0.19		
WAV	0.06	0.11	0.79	0.72	0.08	0.79	0.80	0.07	0.08	0.59	

Structural Model Assessment

Since the measurement of outer model evaluation validates the estimated constructs in the study, next is the assessment of the structural or inner model. Structural model evaluation is an effort to find evidence supporting the theoretical model that is the hypothesised relationships between exogenous constructs and the endogenous construct. This can be expressed mathematically as suggested by (Tenenhaus et al., 2005).

$$\varepsilon_{j\ =\ \beta_{jo}} + \sum_i \beta_{ji}\ \varepsilon_i + v_j \quad \ldots\ldots\ldots\ldots \text{Equation 1}$$

where ξ_j is the endogenous construct and ξ_i represents the exogenous constructs, while β_{jo} is the constant term in this (multiple) regression model, β_{ji} are the regression coefficients, and v_j is the error term; the predictor specification condition applies. Furthermore, in assessing the structural model using PLS-SEM, the size, sign, and significance of the path coefficient were checked. PLS-SEM does not assume normal data distribution, so the significance testing needs to apply resampling methods such as bootstrapping or jackknifing (Kock, 2018). To test the significance level of path coefficients in PLS-SEM, bias-corrected and accelerated (BCa) bootstrap confidence intervals and t-values were advanced (Ali et al., 2018). To achieve this feat as remarked by Hair et al. (2014); Henseler et al. (2009), the method used 500 bootstraps samples and 480 subjects to determine the significance of the path coefficients of both the direct and moderating effect. Consequently, Tables 5 to 6 and Figures 4 to 5 present detailed assessment of the structural model together with the statistics relating to a direct and moderating variable.

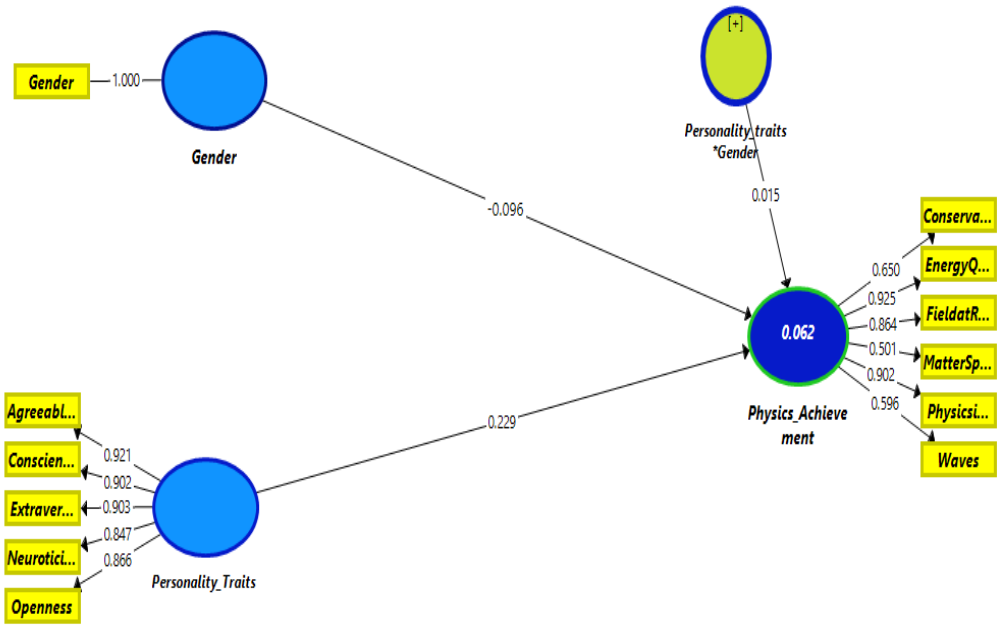

Figure 4: Proposed Structural Model

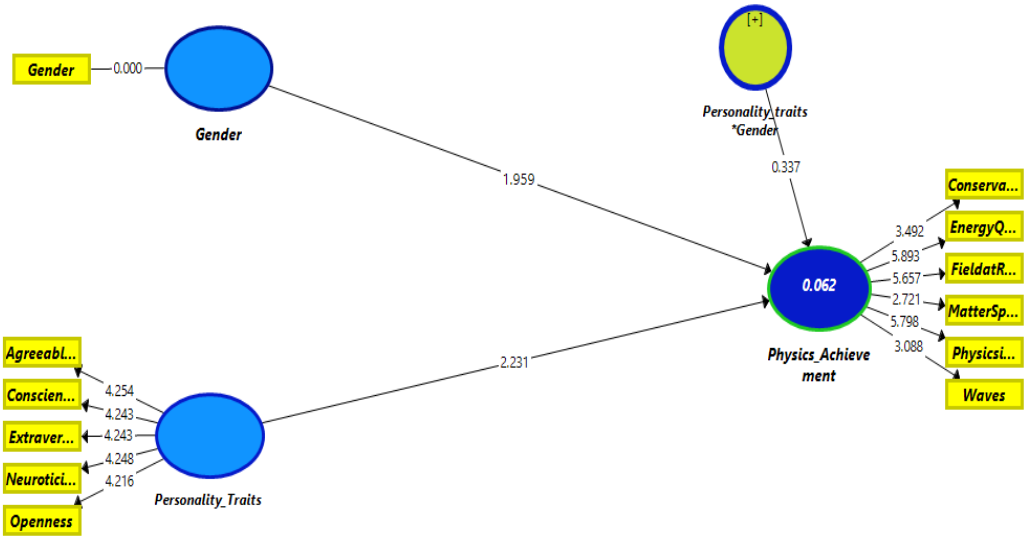

Figure 5: Structural model parameter estimate (Bootstrapped)

What is the predictive accuracy of the endogenous construct?

To answer this question, Hair et al. (2016) commented that the coefficient of determination (R^2) measurement shows to what extent the exogenous construct(s) are describing the endogenous construct. Supporting Hair et al. (2017b), suggested that R^2 values of 0.25, 0.50, and 0.75 symbolise weak, moderate, and large levels. Thus, in this study, the obtained R^2 value was 0.062 for physics achievement endogenous construct. This implies that the exogenous constructs explain 6.2% of the change in physics achievement.

Testing the Hypotheses

Table 5. Direct Causal Relationship Between Constructs in the Model

Hypothesis	Relationship	Original Sample (O.)	Sample Mean (M.)	Standard Deviation (STDEV.)	T- Statistics (|O/STDEV|)	P - Values	Remarks	Decision
Ho	Gender -> Physics Achievement	-0.10	-0.10	0.05	2.02	0.04	Sig.	Rejected
Ho	Personality Traits -> Physics Achievement	0.23	0.22	0.12	1.99	0.05	Sig.	Rejected

Ho: There is no significant relationship between gender and achievement in Physics.

Table 5 showed the degree and direction of the direct effect in the model. The analysis showed that the direct effect of gender on Physics Achievement was -0.10 ($p < 0.05$). This showed that there was a significant direct causal relationship between gender and Physics Achievement. This suggests that for every unit increase in gender decreases Physics Achievement by 0.10 units for every 0.05 standard deviation while controlling for other variables. Also, there was negative significant relationship between gender and Physics Achievement with ($\beta = -0.10$, $t = 2.02$, $p < 0.05$). Subsequently, the null hypothesis (Ho) was rejected. This finding is consistent with some of the earlier studies that showed a significant and direct relationship with gender. Shah (2018); Batool and Aziz (2018) also found out that female students have significantly higher academic achievement when compared to their male counterparts due to exercise of self-regulated approach.

Ho: There is no significant relationship between Students Personality Traits and Achievement in Physics.

As remarked in Table 5 that students' personality traits had a significant positive relationship with Physics Achievement with ($\beta = 0.23$, $t = 1.99$, $p < 0.05$). Consequently, there is no significant relationship between student's personality traits and Physics Achievement was rejected. More importantly, it can be inferred that 100% improvement in student's personality traits will account for about 23.0% enhancement in Physics Achievement. The implication is that the nature of personality traits possessed by the student can significantly influence their performance in physics subject. This finding aligns with the position of Rimfeld (2016) who posited that academic achievement has a positive relationship with openness to experience, conscientiousness, agreeableness, and extroversion. However, Melissa et al. (2007) expressed a different view on the issue of the relationship between Neuroticism and achievement. On the whole, the cumulative result of the five personality traits on academic achievement in physics signifies a positive significant relationship.

Table 6. Moderating Effect of Gender in the model

Hypothesis	Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T- Statistics (|O/STDEV|)	P - Values	Remarks	Decision
Ho	Personality traits*Gender -> Physics Achievement	0.02	0.01	0.05	0.32	0.75	Not Sig.	Not Rejected

Ho: There is no significant moderating effect of gender on Personality Traits and Achievement in Physics.

To evaluate the moderating effect in this study. The product indicator method of PLS-SEM suggested by Henseler and Chin (2010) was adopted for identifying and assessing the strength of the moderating effect of gender on the relationship between personality traits and achievement in physics. The guiding principles as remarked by Cohen (1988) for determining the moderating effects strictly adhered to. Consequently, model interaction in Table 6 showed that personality traits had no impact achievement in physics through the moderating effect of gender. That is the relationship was insignificant between the personality traits and achievement in physics which is moderated by gender with ($\beta = 0.02$, $t = 0.75$, $p > 0.05$). Hence, the null hypothesis was not rejected. Subsequently, concerning Aiken and West (1991) guiding principles, path coefficients information was utilised for plotting the moderating effect of gender on the relationship between personality traits and achievement in physics. Thus, the graph (Figure 6) further indicates the poor relationship between the moderating variable and the construct variables.

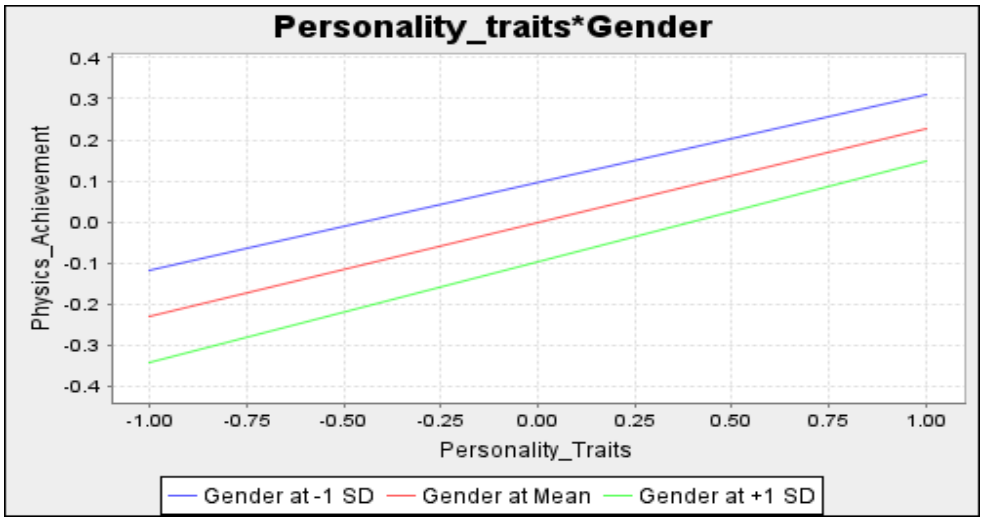

Figure 6: Interaction effect of gender on personality traits and achievement in physics

CONCLUSION AND RECOMMENDATIONS

It was established in this study that physics educators search for solutions to the long-standing problem of poor academic achievement in senior secondary physics should be extended to studies on students' personality traits with a specific focus on the Big Five factors-openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. It was discovered that students' personality traits have a significant positive causal relationship to the academic achievement of physics in a senior secondary school in Lagos State, Nigeria. Also, the authors concluded that gender played a significant role in determining the achievement, although its moderating effect between personality traits and achievement in physics was insignificant.

Therefore, the authors recommend that (a) Physics teachers should as a matter of necessity, focus on the development of positive traits such as openness to experience, conscientiousness, extraversion, and agreeableness among the senior secondary school physics students to enable them to attain achievement in physics. (b) School administrators at both public and private secondary school should have a comprehensive plan for a regular mentoring program for all physics students towards the inculcation of the academic-related traits**.** Emphasis should be placed on the study of educational psychology as a component of the

curriculum in science teacher's education. (c) Regular in-service training of physics teachers on the understanding of personality traits should also be encouraged.

REFERENCES

Adebayo, O. O., & Adigun, S. Q. (2018). Impact of Instructional Aids on Students' Academic Performance in Physics in Secondary Schools in Federal Capital Territory (FCT) Abuja. *Nigeria European Scientific Journal*. 14(4), 366-376.

Adeyemo, S. A. (2010). Teaching and Learning of Physics in Nigerian Secondary Schools: The Curriculum Transformation, Issues, Problems, and Prospects. *International Journal of Educational Research and Technology, 1*(1), 99-111.

Aiken, L. S. & West, S. G. (1991). *Multiple Regression: Testing and Interpreting Interactions*, Sage Publications, Newbury Park, CA.

Ali, F., Rasoolimanesh, S. M., Sarstedt, M., Ringle, C. M., & Ryu, K. (2018). An assessment of the use of partial least squares structural equation modelling (PLS-SEM) in hospitality research. *International Journal of Contemporary Hospitality Management*, *30*(1), 514-538.

Amadalo, M. M., Ocholla, A. A., & Memba, E. B. (2012). Effect of Practical Work in Physics on Girls' Performance, Attitude, and Skills acquisition in the two-form three Secondary Schools' transition in Kenya. *International Journal of Humanities and Social Science, 2*(23), 151-166.

Amusa, J. O. (2020). Appraisal of the physics education programme in the National Open University of Nigeria. *Technical University of Varna Annual Journal*, *4*(1), 1-12 https://doi.org/10.29114/ajtuv.vol4.iss1.158

Anita, P., Małgorzata D., Anna T., & Mateusz P. (2020). The Effects of the Big Five Personality Traits on Stress among Robot Programming Students. *Sustainability*, 12, 5196; doi:10.3390/su12125196 www.mdpi.com/journal/sustainability.

Bagozzi, R. Y. (1988). On the evaluation of structural equation models. J. Acad. Mark. Sci., 16, 74-94.

Batool, S., & Aziz, S. (2018). Effect of Parental Influence on Students' Personality and Academic Achievement at Secondary School Level. *International Journal of Innovation in Teaching and Learning*, 4(1), 1-15.

Bello, T. O., & Akinfesola O. E. (2015). Dissemination and utilization of physics education research findings towards enhanced teaching and learning of physics in secondary school. *Mediterranean Journal of Social Sciences*. *6*(6), 333-339.

Bratko, D., Chamoro, T., & Saks, Z. (2006). Personality and school performance: Incremental validity of self and peer-ratings over intelligence. *Personality and Individual Differences, 41*, 131-142.

Chin, W. W. (1998). "The partial least squares approach to structural equation modeling", in Marcoulides, G.A. (Ed.), Modern Methods for Business Research, Lawrence Erlbaum Associates Inc., Mahway, NJ, pp. 295-336.

Chin, W. W. (2010). How to write up and report PLS analyses. In V. E. Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), *Handbook of partial least squares: Concepts, methods, and applications: Vol. 2. Springer handbooks of computational statistics series* (pp. 655–690).

Cirera, X., & Maloney, W. (2017). The innovation paradox: Developing-country capabilities and the unrealized promise of technological catch-up. Washington, DC: World Bank. https://openknowledge.worldbank .org/bitstream/handle/10986/28341/211160ov.pdf

Chomoro-Premuzic, T., & Furnham, A. (2003a). Personality predicts academic performance: Evidence from two longitudinal university samples. *Journal of Research in Personality*, *37*(4), 319-338.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*, Lawrence Erlbaum Associates, Hillsdale, NJ.

Daminabo, W. H. (2008). The Relationship between Personality Traits and Academic Achievement of Secondary School students in Rivers State. Unpublished M.Ed. dissertation, University of Port-Harcourt.

De Mars, C. (2010). *Item Response Theory. Understanding statistics measurement*. NY: Oxford University Press.

Erinosho, S. Y. (2013). How do students perceive the difficulty of physics in secondary school? An exploratory study in Nigeria. *International Journal for Cross-Disciplinary Subjects in Education*, *3*(3), 1510-1515.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18* (1), 39-50.

Furnham, A., Zhang, J., & Chamoro, T. (2006). The relationship between psychometric and self-estimated intelligence, creativity, personality, and academic achievement. *Imagination, cognition and personality*, *25*(2), 119-145.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis (7th ed.)*. Englewood Cliffs: Prentice-Hall.

Hair Jr, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM). *European Business Review, 26*(2), 106-121.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017b). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). Thousand Oaks: Sage.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed, a silver bullet. *Journal of Marketing Theory and Practice, 19*(2), 139–151.

Hair, J.F., Hult, G. T. M., Ringle, C., & Sarstedt, M. A. (2016). Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), Sage Publications, Thousand Oaks, CA.

Hakimi, S., Hejazi, E., & Lavasani, M. G. (2011). The relationships between personality traits and students' academic achievement. *Procedia-Social and Behavioral Sciences*, *29*, 836-845.Retrieved from http://dx.doi.org/10.1016/j.sbspro.2011.11.312

Henseler, J., & Chin, W. W. (2010). "A comparison of approaches for the analysis of interaction effects between latent variables using partial least squares path modeling", Structural Equation Modeling: *A Multidisciplinary Journal*, Vol. 17 No. 1, pp. 82-109.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*, 115–135.

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. In R. R. Sinkovics & P. N. Ghauri (Eds.), *New challenges to international marketing: Advances in international marketing* (Vol. 20, pp. 277–319).

Herrera, L., Al-Lal, M., & Mohamed, L. (2020). Academic Achievement, Self-Concept, Personality and Emotional Intelligence in Primary Education. Analysis by Gender and Cultural Group. *Front. Psychol.* 10:3075. doi: 10.3389/fpsyg.2019.03075.

Islam, M. N. (2021). Study habits, self-esteem, and academic achievement among public and private secondary school students in Bangladesh, *International Journal of Psychology and Educational Studies*, 2021, 8(3), 39-50. https://dx.doi.org/10.52380/ijpes.2021.8.3.214

Ikpi, E. E., Enya, D. B., & Johnny, U. A. (2014). The Influence of Personality Trait on the Academic Performance of Secondary School Students in Cross River State, Nigeria. *Journal of Humanities and Social Science, 19*(3), 12-19.

Jensen, M. (2015). Personality Traits, Learning, and Academic Achievements, *Journal of Education and Learning*, *4*(4), 91 – 102.

Kock, N. (2018). "Should Bootstrapping Be Used in PLS-SEM? Toward Stable P-Value Calculation Methods", *Journal of Applied Structural Equation Modeling*, 1(2), 1-12

Laidra, K., Pullmann, H., & Allik, J. (2007). Personality and intelligence as predictors of academic achievement: A cross-sectional study from elementary to secondary school. *Personality and individual differences*, 1-11.

Lounsbury, J. W., Sundstrum, E., Gibson, L. W., & Loveland, J. L. (2003b). Broad versus narrow personality traits in predicting academic performance of adolescents. *Learning and individual differences, 14*(1), 65-75.

Melissa, C., Sampo, C., & Paunonen, V. (2007). Big five personality predictors of post-secondary academic performance. *Personality and Individual Differences, 43*, 437-448.

Nunnally, J., & Bernstein, I. (1994). Psychometric Theory, 3rd ed.; McGraw Hill: New York, NY, USA.

Nwona, H. A., & Madu, B. C. (2018). Assessment of Senior Secondary School Physics Teachers' Content Knowledge in Kogi Central Zone of Kogi State, Nigeria. *International Journal of Education and Evaluation* 4(5), 83 – 90.

Ogunleye, A., & Anyaegbuna, B. A. (2018). An assessment of physics laboratory teaching and learning resources in two Nigerian universities. *Cypriot Journal of Educational Science*. 8(1),1-14.

Owolabi, O. T., & Oginni, O. I. (2013). Assessing the relative effectiveness of three teaching methods in the measurement of students' performance in Physics. *International Journals of Material, Methods and Technologies*, 1(8), 116-125

Rimfeld, K., Kovas, Y., Dale, P. S., & Plomin, R. (2016). True Grit and Genetics: Predicting Academic Achievement from Personality. Journal of Personality and Social Psychology, 3(5), 780 –789.

Ringle, C., Wende, S., & Becker, J. (2014). SmartPLS 3; University of Hamburg: Hamburg, Germany.

Rodríguez-Ramos, Á., Moriana, J. A., García-Torres, F., & Ruiz-Rubio, M. (2021). Emotional stability is related to D:4D and social desirability in women: Possible implications on subjective well-being and psychopathology. *PLoS ONE* 16(3): e0248368. https://doi.org/10.1371/journal.pone.0248368.

Shah, A. (2018). Gender Disparity in Big Five Factors of Personality and Their Effect on Academic Achievement of Students. *Pakistan Journal of Physiology*.14(4):51-54.

Tabachnik, L. S., & Fidell, B. G. (2007). *Using Multivariate Statistics*. Boston: Pearson.

Tenenhaus, M., Vinzi, V. E., Chatelin, Y.M., & Lauro, C. (2005). PLS path modeling. *Computational Statistics & Data Analysis, 48*, 159–205.

Troncone, A., Drammis, M. L., & Labella, A. (2014). Personality Traits, Self-Esteem and Academic Achievement in Secondary School Students in Campania, Italy. Universal Journal of Educational Research 2(7), 512- 520. http://www.hrpub.org DOI: 10.13189/ujer.2014.020703.

Usman, I. S., Simyyap, W. L., & Fasanya, A. G. (2019). Challenges of Effective Implementation of NewSecondary School Physics Curriculum in Public and Private Schools in Nigeria. *Journal of Science Technology and Education* 7(3), 1 – 6.

Vidya, B., & Ramyashilpa, D. (2014). Neuroticism and Academic Performance of Medical Students.*International Journal of Humanities and Social Science Invention*. 3 (1) 51-55 www.ijhssi.org

Wagerman, S. A., & Funder, D. C. (2007). Acquaintance reports of personality and academic achievement: A case for conscientiousness. *Journal of Research in Personality*, *41*, 221-229.

Wilson, G. D., & Jackson, C. (1994). *The personality of physicists*. Person. Individ. Diff. 16(1), 187 189).

World Economic Forum (WEF). (2019). Globalization 4.0: Shaping a Global Architecture in the Age of the Fourth Industrial Revolution'.