

## **BAYESIAN STRUCTURAL EQUATION MODELING OF PHYSICS- CLASSROOM-SITUATIONAL-INTEREST MEDIATED BY PERSONALITY TRAITS ON ACHIEVEMENT IN PHYSICS**

**Fidelis Obi Nnadi (Ph.D)**

*Department of Science Education, Enugu State University of Science and Technology, Enugu*

[obi.nnadi@esut.edu.ng](mailto:obi.nnadi@esut.edu.ng)

<https://orcid.org/0000-0002-7173-4517>

**Rose Chigoziri Anamezie (Ph.D)**

*Department of Science Education, Enugu State University of Science and Technology, Enugu*

[rose.anamezie@esut.edu.ng](mailto:rose.anamezie@esut.edu.ng)

<https://orcid.org/0000-0002-6316-7428>

**Abstract:** *Under-achievement in Physics by students in Upper-Basic schools in Nigeria was the problem which necessitated the study. Psychological variables including Physics-classroom-situational-interest (PCSI) and personality traits were implicated as strong non-cognitive variables that influenced Physics achievement. Structural equation model of PCSI as exogenous variable, personality traits as mediator and Physics achievement as major dependent variable was specified. The need to use a better estimation procedure capable to minimize standard errors of estimation of latent variables warranted the use of Bayesian parameter estimator. The result of data analysis indicated that none of the single traits of personality was a meaningful mediator in the model. However, the combined personality traits showed statistically meaningful mediation in the model. By boosting students' classroom situation interest in learning Physics through personality traits, achievement in Physics was increased. It was recommended that Physics students' personality traits should be developed by the government to enhance students' achievement profile.*

**Keywords and phrases:** *Bayesian inference, structural equation modeling, situation interest, personality, mediation and Physics achievement*

### **How To Cite**

Nnadi, F. O., & Anamezie, R. C. (2022). Bayesian Structural Equation Modeling Of Physics-Classroom-Situational-Interest Mediated By Personality Traits On Achievement In Physics. *Journal Of Research In Science And Vocational Education (Jrsve)*, 2(1). Retrieved From <https://jrsve.com/index.php/jrsve/article/view/17>

### **Introduction**

Science Education is an indispensable field of study that is concerned with imparting the knowledge of ever-dynamic science and technology to generations of people who do not possess such knowledge domains. It is the obligation of Science Education field to ensure that contemporary science and technology contents are brought to the learners

in contexts that would ensure their proper assimilations. The level of knowledge and practice of science and technology are indispensable weapons for any nation's industrial, economic cum political growth and stability. The United States of America for example has attained its apogee in political circles by policing troubled spots around the globe because of the height it has attained in

knowledge and practice of innovative science and technology. In realization of the clarion call for science and technological literacy for all it has been observed that the answers to global challenges including but not limited to globalization, energy and security are dependent on increasing technological innovations and the sound scientific advice brokered by decision makers (Aebischer, n.d). As one of the federating states of United Nations Educational Scientific and Cultural Organization (UNESCO), the Federal Government of Nigeria aligned with UNESCO declaration of science for all. Physics is one of the branches of Science studied in upper basic schools. It is regrettable to note that students' percentage achievement in Physics especially in external examinations has been reported to be low over the years (WAEC, 2016). For decades, researchers have been making efforts to solve the consistent problem of poor academic achievement in Physics. Psychological variables including poor level of Physics classroom situational interest in learning Physics content and personality traits of the students have been linked to poor academic achievement in Physics (Yu et al., 2011; Agbaje & Alake, 2014). In the context of this study, structural equation modeling, SEM typifies the linear relationship between Physics classroom situational interest, personality traits and achievement in Physics. Teo et al., (2013) indicated that structural model specified relationships among latent variables. The linear measure between the confirmatory factor analysis models of the constructs indicates the linear relationships between the latent constructs. This study is unique in the sense that it sought to determine the relationship between Physics classroom situational interest and Physics achievement through personality trait. Thus, personality trait acts as the mediator. In a mediation model, the product of the slope factor between Physics classroom situation interest and personality trait is multiplied with the slope factor of personality trait and achievement in Physics to determine the strength of mediation. SEM approach is utilized in this study because it can be used to study the linear relationships between latent or unobserved factors like Physics-classroom-situational-interest, personality trait and Physics achievement. Enhancing interest in science learning and pursuit of science careers are necessary aspects of education policy and policy implementation (European Union, 2016). Situational interest within the Physics classroom context stands for the

liking for a Physics content that a student has during the period of instructional delivery. Situational interest can be a function of the context in which science content is presented to the learners. Situational interest is aroused based on how interesting a topic or activity may be or how useful study of the topic might be perceived in future science study or career (Hasni et al., 2016). The context in which science ideas are taught rather than the ideas themselves has influence on situational interest. Lavonen et al., (2021) indicated that interest in science studies and careers promoted situational interest in Physics during teaching and learning. Though, situational interest is short-lived, it can lead to individual interest on the long-run. Kolovie et al., (2014) and Rotgans et al., (2018) in support of the need for the cultivation of situational interest in classrooms indicated that it was a very powerful affective tool to learning.

The other psychological variable reported to affect Physics achievement in upper basic schools was poor personality level of the students. Personality traits represented stable patterns of thought processes, feelings and behavior (Borghana et al., 2008). Individuals with certain personality traits have a higher propensity to exhibit that particular trait compared to others (Nandi & Nicoletti, 2009). There is the possibility that an individual with a certain trait can change it over time. The big five bi-polar personality traits have received a general consensus among psychologists as personality indices (John & Srivastava, 1999). Nandi and Nicoletti (2009) identified the big-five personality traits as: openness to experience (versus closed to experience), conscientiousness (versus lack of direction), extraversion (versus introversion), agreeableness (versus antagonism) and neuroticism (versus emotional stability). Openness to experience is a general appreciation for emotion, curiosity, adventure and variety of experience. People who are open to experience are intellectually curious and open to emotions. They are always eager to try new things and are sensitive to beauty. They are aware of their feelings and tend to be creative. According to Toegel and Barsoux (2012), those who have high openness can be perceived as unpredictable and they lack focus.

Conscientiousness trait is associated with flexibility and spontaneity. A conscientious student has direction in his/her endeavor. Such a student has a tendency to display self-discipline, act dutifully and strive for achievement.

Extraversion trait is characterized by breath of activities. It is marked by pronounced involvement with external world. An extravert delights in interacting with people. Students with this trait tend to be action-oriented and enthusiastic in classroom learning activities. Agreeableness personality trait shows concern for social harmony. Those who possess the trait are generally generous, optimistic, co-operative, kind, considerate and trustworthy. Neuroticism is referred to as emotional instability. A neurotic individual exhibits nervous character.

Moreover, from the empirical studies reviewed, it was observed that some authors who studied the relationship between personality traits and academic achievement reported that some personality traits: conscientious, openness and agreeableness had strong positive relationship with academic achievement. Conscientiousness was reported to be the highest predictor of academic achievement (Edward & Kwabena, 2016; Irina & Alexandra, 2017). But, Safdar et al., (2015) reported that academic achievement showed no significant relationship with students' personality traits. There appears to be dearth of studies investigating the relationship between Physics classroom situational interest on achievement in Physics when mediated by the big five personality traits. Secondly, the method of estimation of the values of direct relationship between personality traits and academic achievement in reviewed studies was based on null hypotheses significance testing (NHST). Only data were collected and analyzed under the null hypothesis significance testing. Prior regression coefficients obtained from similar study within the population was not integrated with the data in the analysis. Thus, only the data collected were analyzed in the conventional significance testing of null hypotheses, ignoring either earlier parameter values of similar studies or the probability distribution of the data collected prior to the main study. According to Ortega and Navarrete (2017):

*Bayesian analysis allows us to move from dichotomous (reject/fail to reject) way of inference to a less artificial view that interprets results in terms of (the level of) evidence. Bayesian approach tests the plausibility of both null to alternative hypothesis which the current NHST paradigm does not encourage. When a researcher does not reach a required p*

*(probability) value, often times it is falsely assumed that the effect does not exist. Under NHST, an accepted null hypothesis can be rejected when the sample size increases (p.236)*

Bayesian analysis is an elevated NHST. The posterior values in Bayesian estimation are not sample-dependent. It adopts Markov Chain Monte Carlo, MCMC sampling procedure in determining posterior parameter values. The posterior values are determined through computer simulation. It provides the strength of evidence availability, provided that the nature of the data distribution is not multi-modal. It makes use of Bayes-factor in its inference system. Bayes-factor is a density ratio. It is opposed to a tail or asymptotic probability space (Lopes & Polson, 2018). As a density ratio, it targets the highest or modal region of concentration of posterior parameter values for sampling. Watzels and Wagenmakers (2012) indicated that Bayes-factor,  $BF_{10}$  was a weighted average likelihood ratio that indicated the plausibility of data under two competing hypotheses: null and alternative. The authors noted that when  $BF_{10}$  was greater than 1.00, it indicated that the result was more likely to occur under the alternative hypothesis than under the null hypothesis and vice versa. For details of  $BF_{10}$  classification based on the weight of evidence as suggested by Jefferys (1961), please consult Ortega and Navarrete (2017). Conventionally, small sample size was thought to be representative of the population from the NHST angle. Under the Bayesian framework, the values of parameters change with increased MCMC sample size, large enough to represent the population, using the method of simulated modal sampling. MCMC sampling is halted when stable values of parameters are reached. Secondly, the standard error of parameter values is reduced dramatically in Bayesian estimation, as a result of infusing prior parameter values to the data collected (Yuan & Mackinnon, 2009). Prior or starting values of parameters can be represented by the nature of the probability distribution of initially sampled data. In the NHST approach, prior values of parameters are usually thrown away or at least controlled while conducting the analysis. The standard error in NHST estimation is usually higher than Bayesian estimation standard error. By subtracting the standard error from the estimated value of a parameter, the true value of estimate is determined. So, higher standard errors affect the true

parameter values. So, Bayesian estimation is efficient in small samples for determining the true values of parameter estimates. The goal of the researchers is not to argue against the NHST approach to estimation of parameter values but to apply an alternative to NHST in the determination of values of unknown parameters. There is a dearth of studies that utilized Bayesian inference to study the relationship between the independent, dependent and mediating variables proposed in the study. Therefore, the problem of the study is to determine if the problem in Physics achievement at secondary school level can be solved by boosting Physics students' personality trait.

### **Purpose of the Study**

The study was designed to:

- determine the posterior values of mediation effects of Physics classroom situational interest and achievement in Physics mediated by each personality trait.
- determine the posterior value of mediation effect of Physics classroom situational interest and achievement in Physics mediated by combined personality traits.
- determine the Bayes-factor significance of mediation effect of Physics classroom situational interest and achievement in Physics mediated by each personality trait
- determine the Bayes-factor significance of mediation effect of Physics classroom situational interest and achievement in Physics mediated by combined personality traits

### **Research Questions**

The following research questions were formulated to guide the study:

- What are the posterior values of mediation effects of Physics classroom situational interest and achievement in Physics mediated by each personality trait?
- What are the posterior values of mediation effect of Physics classroom situational interest and achievement in Physics mediated by combined personality traits?

### **Hypotheses**

The study was anchored on the following Bayes-factor significance testing at 95% confidence interval:

BF<sub>10</sub>: There is no significant ratio between the alternative and null hypothesis mean posterior values of

mediated path of Physics classroom situational interest and achievement in Physics mediated by each personality trait.

BF<sub>20</sub>: There is no significant ratio between the alternative and null hypothesis mean posterior values of mediated path of Physics classroom situational interest and achievement in Physics mediated by combined personality traits.

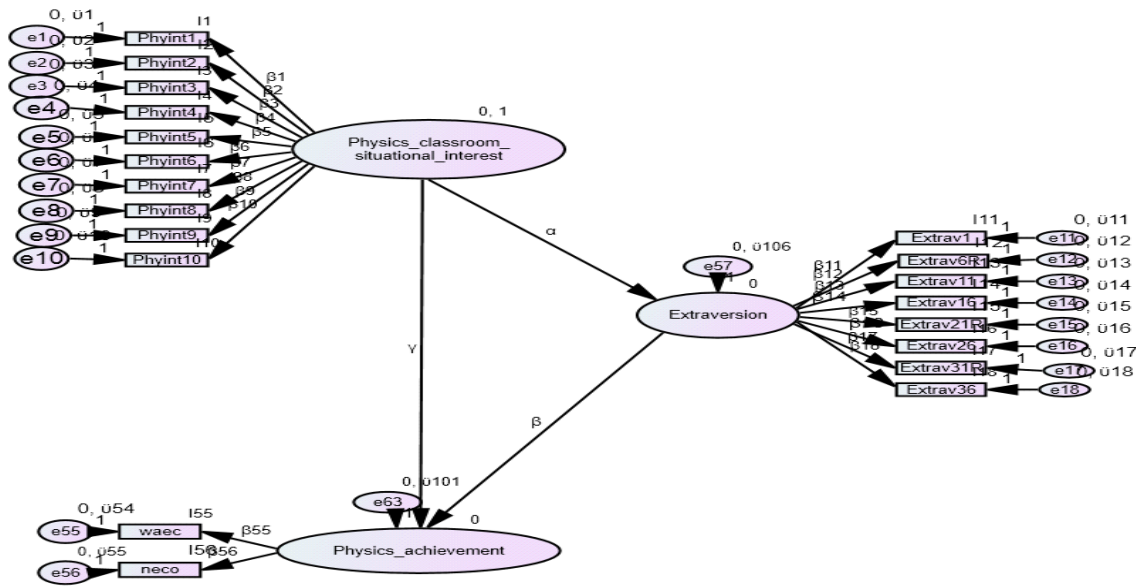
### **Research Method**

Descriptive survey research design was adopted in the study. Two hundred and sixty two senior secondary three (SS3) Physics students whose senior secondary school certificate examinations results were released and who completed the questionnaire consisting of one hundred and forty-four (144) male and one hundred and eighteen (118) female students nested within four schools in Enugu education zone of Enugu state, Nigeria constituted the study's sample. Balloting with replacement was used to sample four different schools one after the other after reshuffling of cards that contained the school names in the area. Balloting continued until the first two schools in urban and rural areas were sampled. The Enugu education zone was chosen as the population for the study out of a total of six education zones in Enugu state through tossing a fair dice. Using proportionate sampling, one hundred and fifty five (80 male & 75 female) were sampled from two schools in the urban. Also, one hundred and seven (64 male and 43 female) were sampled from two rural schools, using proportionate sampling. The instruments used to collect data included: (i) Physics classroom situational interest (PCSI) questionnaire. It was adapted from "section C" of Relevance of Science Education (ROSE) project (Schreiner & Sjoberg, 2004) ROSE project aims at shedding light on affective factors considered importance to the learning of science and technology. ROSE was developed by the University of Oslo, Norway. It was a four-point scale ranging from 1 (*Not Interested*) to 4 (*Very Interested*). It measured the extent of student's interest in learning about Physics concepts. The adaptation of ROSE was in terms of selecting 10 in 18 items for use in this study and changing the likert scale from four to five points as follows: 1 (*Not Interested*), 2 (*Moderately Interested*), 3 (*No Opinion*), 4 (*Moderately Interested*) and 5 (*Very Interested*). (ii) The Big-five-personality inventory (BFPI). The BFPI, developed by Goldberg (1993) and chart-recreated by John and Srivastava (1999) was adopted by

the researchers because it was not culture-specific. The instrument which consisted of forty-four items measuring five bi-polar personality sub-constructs: Extraversion Vs Introversion, Agreeableness Vs Antagonism, Conscientiousness Vs lack of direction, Neuroticism Vs Emotional stability and Openness to experience Vs 'Closedness' to experience had a five-point scale ranging from 1 (*Strongly Disagree*), 3 (*Neither Agree nor Disagree*) to 5 (*Strongly Agree*). It had some reverse coded items, marked with the letter "R". (iii) 2019 National Examination council's (NECO) prepared grades sheet and (iv) 2019 West African Senior School Certificate Examinations (WASSCE) prepared grades sheet. Both NECO and WASSCE prepared grades sheet had two parts: A and B. Part A sought information on examination centre name and number. Part B contained the student's examination number, gender and grade in Physics. Since NECO and WASSCE grades were inverse-stanine scores: A<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, C<sub>4</sub>, C<sub>5</sub>, C<sub>6</sub>, P<sub>7</sub>, P<sub>8</sub> and F<sub>9</sub>. The sub-script number of each grade represented its numerical strength. They were reverse-scored, regrouped and reweighted to be at par with the five-point personality scale as follows: A<sub>5</sub>, B<sub>4</sub>, C<sub>3</sub>, P<sub>2</sub> and F<sub>1</sub>. The Physics teachers in their respective schools administered the instruments to all the students in the SS3 stream of the schools used, under the supervision of the

researchers. Kuder-Richardson's formula-21 yielded an alpha value of .87, .71, .64, .82 and .77 for the personality traits: Extraversion, agreeableness, conscientiousness, neuroticism and openness respectively, while situational interest had coefficient of .75 using the main dataset. The main data collected with the prior distribution of earlier collected data from the sample as pretest were analyzed using Analysis of Moment Structures (AMOS) computer programme version 21. The following structural equation modeling steps: model specification, load data and evaluate the hypothesized theory, model identification and model re-evaluation were observed.

Model specification: From figure 1, Physics classroom situational interest is an exogenous latent variable with ten manifest variables: Phyint1 to Phyint10 whereas Physics achievement is endogenous. Physics achievement has two manifest variables: WAEC and NECO. The mediating latent variable used for purpose of illustration and to economize space was Extraversion. Extraversion had eight manifest variables: Extra1 to Extrav36. The direct effect of a single personality trait mediator is represented as  $\gamma$ , whereas the mediating effect is represented by  $\alpha\beta$ . The hypothesized theory which the model in fig1 represented was that  $\alpha\beta$  was greater than  $\gamma$  when each and every personality trait was the mediator.



*Figure 1: The hypothesized structural model of Physics classroom situational interest and Physics achievement mediated by a single personality trait: Extraversion*

Source: The researchers

From figure 2, it was hypothesized that when all the personality traits were connected in hierarchy, Physics classroom situational interest predicted Physic

achievement with a weak directional effect,  $\gamma_2$ . The mediation path  $\alpha_2\beta_2$  due to personality was hypothesized to be greater than  $\gamma_2$ .

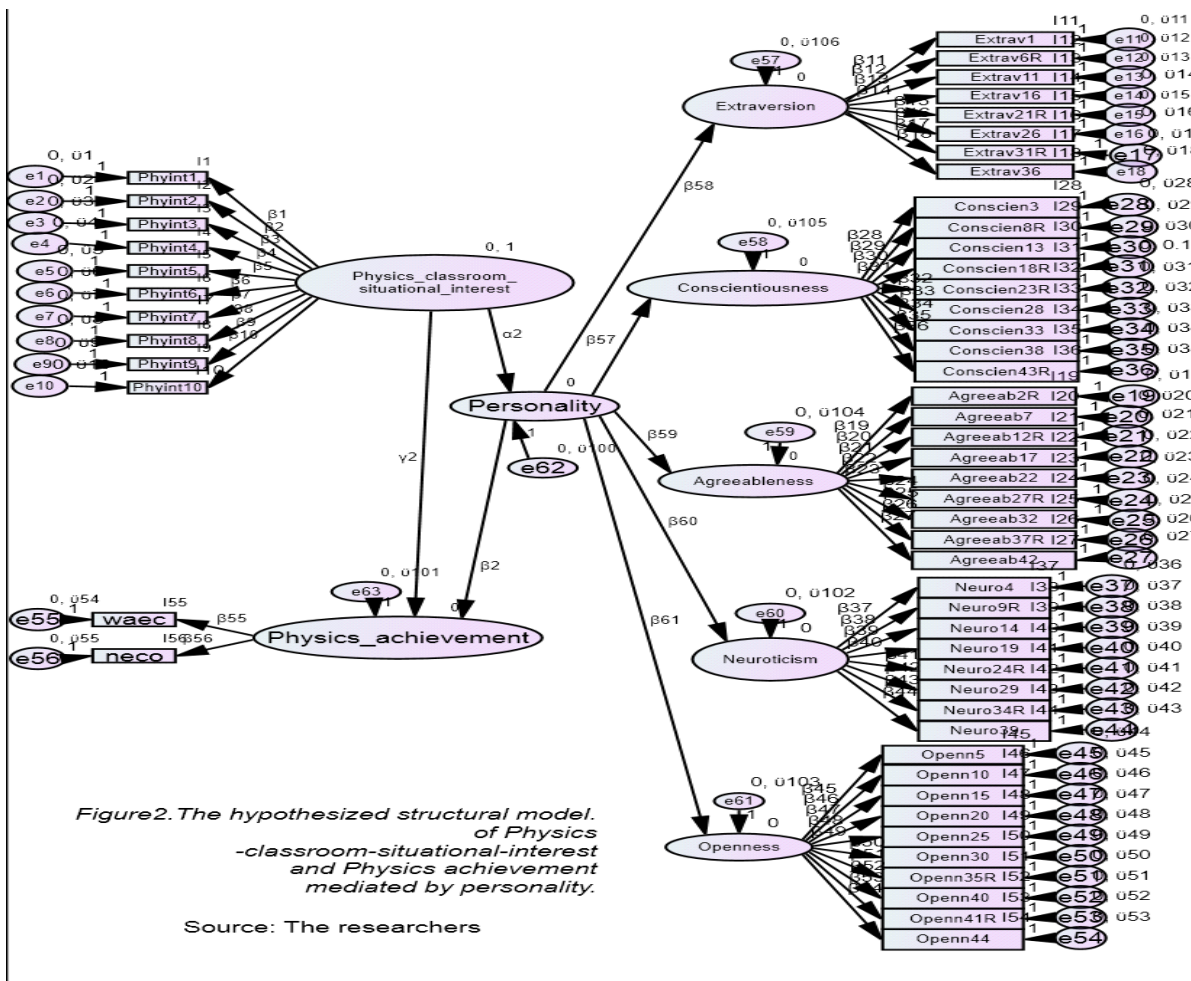


Figure 2. The hypothesized structural model of Physics-classroom-situational-interest and Physics achievement mediated by personality.

Source: The researchers

**Model Evaluation:** After loading the data, the model was first evaluated to determine the values of the unknown parameters:  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\alpha_2$ ,  $\beta_2$  and  $\gamma_2$  using maximum-likelihood parameter estimator to ensure that the model could converge before using Bayesian parameter estimator. There was no convergence.

**Model Identification:** One of the factor loadings of each latent variable indicator ( $\beta_1 = \beta_{11} = \beta_{55} = 1$ ) were set equal to 1.0 in the model containing extraversion as the mediator. For agreeableness, conscientiousness, neuroticism and openness personality traits, the following constraints were made:  $\beta_1 = \beta_{19} = \beta_{55} = 1$ ,  $\beta_1 = \beta_{28} = \beta_{55} = 1$ ,  $\beta_1 = \beta_{55} = \beta_{37} = 1$  and  $\beta_1 = \beta_{45} = \beta_{55} = 1$  respectively, because preliminary model screening of parameter values under maximum likelihood estimator showed that the paths

were unidentified. The models showed convergence. For the overall model, the following constraints were made:  $\beta_1 = \beta_{11} = \beta_{28} = \beta_{19} = \beta_{45} = \beta_{55} = \beta_{58} = 1$ . Also, the variance parameter value due to the 60<sup>th</sup> error term,  $\psi_{102}$  was fixed to .12 because it initially had a negative variance which made the path unidentified. Furthermore, the model's parameter values were evaluated using Bayesian estimator. There was no convergence. As a trick to Bayesian model identification, a two-manifest factor model which represented a simple model but different from the one used in this study was specified and estimated using Bayesian estimator, with the intent to open the Bayesian structural equation model (SEM) window. The simple model ran. With the Bayesian SEM window open, the admissibility, stability and Hamiltonian

sampler check-boxes were turned “on.” Hamiltonian sampler was chosen because of its effectiveness in analyzing a large model relative to “random-walk” sampler. Both the turning parameter and convergence criteria were set at their default values of .1875 and 1.02 respectively. The number of burn-in observation which should be exceeded before the Hamiltonian sampler could start to generate parameter values was fixed at 1000. The Bayesian SEM window was closed.

Model re-evaluation: The final model parameter values were re-evaluated using Bayesian estimator. The posterior values of the models’ parameters showed convergence. The overall model showed convergence at 20,000<sup>th</sup> computation cycle.

Research questions one and two were answered using the product of mean posterior values of regression slopes.

Hypotheses three and four were answered using Bayes-factor statistic as suggested by (Nuijten et al., 2014) at 95% confidence interval.

**Results**

The results are presented in consonance with the research questions and hypotheses formulated for the study.

**Research Question 1:** What are the posterior values of mediation effects of Physics classroom situational interest and achievement in Physics mediated by each personality trait?

Data in Table 1A shows the posterior values of regression slopes between Physics classroom situational interest and achievement in Physics ( $\gamma$ -path coefficient) and the mediated effect of Physics classroom situational interest through “extraversion” (as a personality indicator) on achievement in Physics ( $\alpha\beta$ ).

**Table 1A: Extract of the posterior values of “Extraversion” mediated effect**

$\alpha$ -direct path coefficient	$\beta$ -path coefficient	$\gamma$ -path coefficient	Mediation evidence ( $\alpha\beta$ )	1- $\alpha\beta$	Bayes-factor(BF <sub>10</sub> ) mediation index = $\alpha\beta/1- \alpha\beta$	BF <sub>10</sub> (Critical value)
.99	.28	.66	.28	.72	.38	1.00

The regression slope of Physics classroom situational interest on Physics achievement ( $\gamma$ ) had a value of .66. The regression slope of Physics interest on “extraversion” ( $\alpha$ ) had a value of .99, while the regression slope of “extraversion” on Physics achievement ( $\beta$ ) had a value of .28. Therefore, the mediation effect due to “extraversion” ( $\alpha\beta$ ) in the model had a value of .28.

Data in Table 1B below shows the posterior values of direct effect between Physics classroom situational interest and achievement in Physics ( $\gamma$ ) and the mediated effect of Physics classroom situational interest through “agreeableness” on achievement in Physics ( $\alpha\beta$ ).

**Table 1B: Extract of the posterior values of “Agreeableness” mediated effect**

$\alpha$ -path coefficient	$\beta$ -path coefficient	$\gamma$ -path coefficient	Mediation evidence ( $\alpha\beta$ )	1- $\alpha\beta$	Bayes-factor(BF <sub>10</sub> ) mediation index = $\alpha\beta/1- \alpha\beta$	BF <sub>10</sub> (Critical value)
.32	.68	.70	.22	.78	.28	1.00

The regression slope of Physics classroom situational interest on Physics achievement ( $\gamma$ ) had a value of .70. The regression slope of Physics interest on “agreeableness” ( $\alpha$ ) had a value of .32, while the regression slope of “agreeableness” on Physics achievement ( $\beta$ ) had a value of .68. Therefore, the

mediation effect due to “agreeableness” ( $\alpha\beta$ ) in the model had a value of .22.

Data in Table 1C shows the posterior values of regression slopes between Physics classroom situational interest and achievement in Physics ( $\gamma$ ) and the mediated effect of Physics classroom situational interest through “conscientiousness” on achievement in Physics ( $\alpha\beta$ ).

**Table 1C: Extract of the posterior values of “Conscientiousness” mediated effect**

$\alpha$ -path coefficient	$\beta$ -path coefficient	$\gamma$ -path coefficient	Mediation evidence ( $\alpha\beta$ )	$1-\alpha\beta$	Bayes-factor( $BF_{10}$ ) mediation index = $\alpha\beta/1-\alpha\beta$	$BF_{10}$ (Critical value)
.34	.34	.83	.12	.88	.14	1.00

The regression slope of Physics classroom situational interest on Physics achievement ( $\gamma$ ) had a value of .83. The regression slope of Physics interest on “conscientiousness” ( $\alpha$ ) had a value of .34, while the direct effect of “conscientiousness” on Physics achievement ( $\beta$ ) had a value of .34. Therefore, the

mediation effect due to “conscientiousness” ( $\alpha\beta$ ) in the model had a value of .12.

Data in Table 1D shows the posterior values of regression slopes between Physics classroom situational interest and achievement in Physics ( $\gamma$ ) and the mediated effect of Physics classroom situational interest through “neuroticism” on achievement in Physics ( $\alpha\beta$ ).

**Table 1D: Extract of the posterior values of “Neuroticism” mediated effect**

$\alpha$ -path coefficient	$\beta$ -path coefficient	$\gamma$ -path coefficient	Mediation evidence ( $\alpha\beta$ )	$1-\alpha\beta$	Bayes-factor( $BF_{10}$ ) mediation index = $\alpha\beta/1-\alpha\beta$	$BF_{10}$ (Critical value)
1.00	.30	.64	.30	.70	.43	1.00

The regression slope of Physics classroom situational interest on Physics achievement ( $\gamma$ ) had a value of .64. The direct effect of Physics interest on “neuroticism” ( $\alpha$ ) had a value of 1.00, while the regression slope of “neuroticism” on Physics achievement ( $\beta$ ) had a value of .30. Therefore, the mediation effect due to “neuroticism” ( $\alpha\beta$ ) in the model had a value of .30.

Data in Table 1E shows the posterior values of regression slope between Physics classroom situational interest and achievement in Physics ( $\gamma$ ) and the mediated effect of Physics classroom situational interest through “openness” on achievement in Physics ( $\alpha\beta$ ).

**Table 1E: Extract of the posterior values of “Openness” effect**

$\alpha$ -path coefficient	$\beta$ -path coefficient	$\gamma$ -path coefficient	Mediation evidence ( $\alpha\beta$ )	$1-\alpha\beta$	Bayes-factor( $BF_{10}$ ) mediation index = $\alpha\beta/1-\alpha\beta$	$BF_{10}$ (Critical value)
.48	.73	.59	.35	.65	.54	1.00

The regression slope of Physics classroom situational interest on Physics achievement ( $\gamma$ ) had a value of .59. The regression slope of Physics interest on “openness” ( $\alpha$ ) had a value of .48, while the regression slope of “openness” on Physics achievement ( $\beta$ ) had a value of .73. Therefore, the mediation effect due to “openness” ( $\alpha\beta$ ) in the model had a value of .35.

**Research Question 2:** What are the posterior values of mediation effect of Physics classroom situational interest

**Table 2: Extract of the posterior values of combined personality traits mediated effect**

$\alpha_2$ -path coefficient (Standard Error)	$\beta_2$ -path coefficient (Standard Error)	$\gamma_2$ -path coefficient (Standard Error)	Mediation evidence ( $\alpha_2\beta_2$ )	$1-\alpha_2\beta_2$	Bayes-factor $BF_{10}$ mediation index = $\alpha_2\beta_2/1-\alpha_2\beta_2$	$BF_{10}$ (Critical value)
.88(.01)	.95(.02)	.11(.02)	.84	.16	5.25	1.00

The regression slope of Physics classroom situational interest on Physics achievement ( $\gamma_2$ ) had a value of .11 with standard error of .02. The regression slope of Physics classroom situational interest on “personality” ( $\alpha_2$ ) had a value of .88 with standard error of .01, while the regression slope of “personality” on Physics achievement ( $\beta_2$ ) had a value of .95. Therefore, the mediation effect due to “personality” ( $\alpha_2\beta_2$ ) in the model had a value of .84. See appendix A for sampled histogram and trace plots. The mid-point the histogram and the horizontal trend line of the trace-plot corresponded to the estimated posterior values of parameters in the combined model.

**Hypothesis 1,  $BF_{10}$ :** There is no significant ratio between the alternative and null hypothesis mean posterior values

and achievement in Physics mediated by combined personality traits?

Data in Table 2 shows the posterior values of regression slopes between Physics classroom situational interest and achievement in Physics ( $\gamma_2$ ) and the mediated effect of Physics classroom situational interest through “personality” on achievement in Physics ( $\alpha_2\beta_2$ ).

of mediated path of Physics classroom situational interest and achievement in Physics mediated by each personality trait.

From Table 1A, the estimated Bayes-factor ( $BF_{10}$ ) associated to “extraversion” mediation in favour of alternative ( $i$ ) to null ( $o$ ) hypothesis had a value of .38. The value of .38 is less than the critical  $BF_{10}$  of 1.00. Therefore, the hypothesis of no significant ratio between the alternative and null hypothesis posterior mean values was failed to be rejected. Since,  $BF_{10} = 1/BF_{01}$ , where  $BF_{01}$  represented Bayes-factor in favour of null to alternative hypothesis, the value of  $BF_{10} = .38$  indicated that it was 2.63 times more likely to occur under the null hypothesis

than the alternative hypothesis, given the data. So, the null hypothesis was at the “anecdotal” level.

From Table 1B, the estimated Bayes factor ( $BF_{10}$ ) associated to “agreeableness” mediation in favour of alternative ( $i$ ) to null ( $o$ ) hypothesis had a value of .28. The value of .28 is less than the critical  $BF_{10}$  of 1.00. Therefore, the hypothesis of no significant ratio between the alternative and null hypothesis posterior mean values was failed to be rejected. The value of  $BF_{10} = .28$  indicated that it was 3.57 times more likely to occur under the null hypothesis than the alternative hypothesis, given the data. So, the null hypothesis was at the “moderate evidence” level.

From Table 1C, the estimated Bayes-factor ( $BF_{10}$ ) associated to “conscientiousness” mediation in favour of alternative ( $i$ ) to null ( $o$ ) hypothesis had a value of .14. The value of .14 is less than the critical  $BF_{10}$  of 1.00. Therefore, the hypothesis of no significant ratio between the alternative and null hypothesis posterior mean values was failed to be rejected. The value of  $BF_{10} = .14$  indicated that it was 7.14 times more likely to occur under the null hypothesis than the alternative hypothesis, given the data. So, the null hypothesis was at the “moderate evidence” level.

From Table 1D, the estimated Bayes-factor ( $BF_{10}$ ) associated to “neuroticism” mediation in favour of alternative ( $i$ ) to null ( $o$ ) hypothesis had a value of .43. The value of .43 is less than the critical  $BF_{10}$  of 1.00. Therefore, the hypothesis of no significant ratio between the alternative and null hypothesis posterior mean values was failed to be rejected. The value of  $BF_{10} = .43$  indicated that it was 2.33 times more likely to occur under the null hypothesis than the alternative hypothesis, given the data. So, the null hypothesis was at the “anecdotal evidence” level.

From Table 1E, the estimated Bayes-factor ( $BF_{10}$ ) associated to “openness” mediation in favour of alternative ( $i$ ) to null ( $o$ ) hypothesis had a value of .54. The value of .54 is less than the critical  $BF_{10}$  of 1.00. Therefore, the hypothesis of no significant ratio between the alternative and null hypothesis posterior mean values was failed to be rejected. The value of  $BF_{10} = .54$  indicated that it was 1.85 times more likely to occur under the null hypothesis than the alternative hypothesis, given the data. So, the null hypothesis was at the “anecdotal evidence” level. Moreover, each of the individual personality traits showed

no significantly meaningful mediation between the Physics situational interest and Physics achievement in the structural equation model.

**Hypothesis 2,  $BF_{20}$ :** There is no significant ratio between the alternative and null hypothesis mean posterior values of mediated path of Physics classroom situational interest and achievement in Physics mediated by combined personality traits.

From Table 2, the estimated Bayes-factor ( $BF_{10}$ ) associated to “personality” mediation in favour of alternative ( $i$ ) to null ( $o$ ) hypothesis had a value of 5.25. The value of 5.25 is more than the critical  $BF_{10}$  of 1.00. Therefore, the hypothesis of no significant ratio between the alternative and null hypothesis posterior mean values was rejected. The value of  $BF_{10} = 5.25$  indicated that it was .19 times more likely to occur under the alternative hypothesis than the null hypothesis, given the data. So, the alternative hypothesis was at the “anecdotal evidence” level.

#### **Discussion of Findings**

The result of data analysis indicated that each of the personality traits: extraversion, agreeableness, conscientiousness, neuroticism and openness did not have meaningful mediation effect, controlling the influence of any other personality trait in the structural model. The meaning of the result is that the prediction power of Physics classroom situational interest on Physics achievement cannot be boosted when any of the personality traits mediates between the predictor and the major dependent variable in the structural model. However, when all the personality traits are combined in hierarchy to represent a unit concept of personality, the mediation effect arising from the influence of Physics classroom situational interest (PCSI) on Physics achievement (PA) in the model was statistically meaningful. The mediation effect was observed to be greater than the direct effect of PCSI on PA. Interest in Physics concepts within the context of classroom situations has been found to be boosted by an intervening Psychological variable, termed personality. The result indicated that the personality traits were combined in the mediation process before full mediation was attained. The result of the study showed that Physics classroom situational interest promotes achievement in Physics (Kolovie et al., 2014; Rotgans et al., 2018). On the contrary, Safdar et al., (2015) indicated that academic achievement had no relationship with personality trait.

None of the sub-constructs of personality trait had meaningful mediation. However, it was observed that “conscientiousness” sub-construct had positive relationship with academic achievement. Personality trait showed a meaningful mediation effect between Physics classroom situational interest and achievement in Physics. The combined Personality traits increased the prediction of Physics achievement by situation interest. The regression slope between situation interest and achievement in Physics was smaller than the product of the regression slopes due to situation interest and personality, and personality and achievement in Physics.

### **Educational Implications**

The findings of the study have educational implications to the students, Physics teachers and governments. The implication of this finding is that all the facets of personality traits discussed in this study should be encouraged among the students by their teachers to boost their situational interest in Physics, so that Physics achievement can be pushed to the next level.

The teaching and learning of Physics should partly be directed towards filling personality gap that may exist between students from different backgrounds. In this direction the governments should provide the needed infrastructural supports to the students. The welfare of every Physics student should be protected by the government to eliminate any possible gap in personality profiles of Physics students. More guiding counselors should be employed by the government to close personality gaps among students.

The problem of students’ poor achievement in Physics in external examinations in Nigeria can partly be solved by developing personality traits among the Physics students by the governments.

### **Summary and Recommendations**

None of the individual personality traits showed statistically meaningful mediation. The combination of the traits did show statistically meaningful mediation. Classroom situational interest in Physics is boosted through students’ personality traits. It is recommended that Physics students’ personality profiles should be boosted by practicing Physics teachers in the classroom or laboratory as a way of enhancing Physics achievement.

### **References**

Aebischer, P. (n.d). Universities: Increasing global prayers in UNESCO Science Report, Perspectives on

Emerging Issues.pp3 [online Manuscript]. UNESCO.

[https://en.unesco.org/sites/default/files/usr15\\_perspectives\\_on\\_emerging\\_issues.pdf](https://en.unesco.org/sites/default/files/usr15_perspectives_on_emerging_issues.pdf)

Agbaje, R. O. & Alake, E. M. (2014). Students’ variables as predictor of secondary school students’ academic achievement in science subjects. *International Journal of Scientific and Research publications*, 4(9), 1-9. IJSRP. <http://www.ijsrp.org>

Borghana, L., Angela, L. D., Hackman, J. J., & Weel, B. (2008). The Economics and Psychology of personality traits. *The Journal of Human Resources*, 43(4): 972-1059

Edward, M. M. & Kwabena, A. L. (2016). Assessing the impact of personality traits on academic performance: Evidence from Tertiary students in Ghana. *International Journal of Engineering IT and Social Sciences*, 6 (3), 1-17.

European Union, (2016). Horizon 2020: Work programme 2016- 2017: Science with and for society. European commission Decision C (2016) 1349 of 9<sup>th</sup> March 2016.

Goldberg, L. R (1993). *The structure of phenotypic personality traits*. keynote address to the Sixth European Conference on Personality, sponsored by the European Association of Personality Psychology on June 16-19, 1992, in Groningen, The Netherlands. COLORADO. [http://psych.colorado.edu/~carey/courses/psyc5112/readings/psnstructure\\_goldberg.pdf](http://psych.colorado.edu/~carey/courses/psyc5112/readings/psnstructure_goldberg.pdf)

Hasni, A., Bousadra, F., Belletete, V., Benabdallah, A., Nicole, M. C., & Dunamis, N. (2016). Trends in Research on project-based science and Technology teaching and learning at K-12 levels: A systematic Review. *Studies in Science Education*, 52 (2), 199-231. <https://doi.org/10.1080/03057267.2016.1226573>

- Irina, A. N. & Alexandra, A. V. (2017). Big five factors and academic achievement in Russian students. *Psychology in Russia: State of the Art* 10 (4), 93-106.
- Jeffery, H. (1961). *Theory of probability Theory of probability*. Oxford University press
- John, O. P., & Srivastava, S. (1999). The big five trait taxonomy: History, measurement and theoretical perspectives. In O. P. John & L. A. Pervin (Eds). *Handbook on Personality: Theory and Research*, Guilford press
- Kolovie, P. J., Joe, A. I. & Okoto, T. (2014). Academic Achievement prediction: Role of interest in learning and attitude towards school. *International Journal of Humanities and Social Sciences and Education* 1(11), 73- 100.
- Lavonen, J., Ávalos, B., Upadyaya, K., Araneda, S., Juuti, K., Cumsille, P., Inkinen, J., & Salmela-Aro, K. (2021). Upper secondary students' situational interest in Physics learning in Finland and Chile, *International Journal of Science Education*, 1-20 <https://doi.org/10.1080/09500693.2021.1978011>
- Lopes, H. F., & Polson, N. G.(2018). Bayesian hypothesis testing: Redux. *Online Manuscript*. HEDIBERT. <http://hedibert.org/wp-content/uploads/2018/08/lopes-polson-2018.pdf>
- Nandi, A., Nicoletti, C. (2009). Explaining personality pay gaps in the UK. *Applied Economics*, 1-37, <https://doi.org/10.1080/00036846.2014.922670>
- Nuijten, M. B., Watzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E. (2014). A default Bayesian hypothesis test for mediation. *Behavior Research Methods*, 1-36. <https://doi.org/10.3758/s13428-014-0470-2>
- Ortega, A., Navarrete, G. (2017). Bayesian hypothesis testing: An alternative to null hypothesis significance (NHST) in Psychology and Social Science. *Bayesian Inference (Eds)*, 235-254. Researchgate. [https://www.researchgate.net/publication/320808936\\_Bayesian\\_Hypothesis\\_Testing\\_An\\_Alternative\\_to\\_Null\\_Hypothesis\\_Significance\\_Testing\\_NHST\\_in\\_Psychology\\_and\\_Social\\_Sciences](https://www.researchgate.net/publication/320808936_Bayesian_Hypothesis_Testing_An_Alternative_to_Null_Hypothesis_Significance_Testing_NHST_in_Psychology_and_Social_Sciences)
- Rotgans, J. I., & Schmidt, H. G. (2018). How individual interest influences situational interest and how both are related to knowledge acquisition: A microanalytical investigation. *The Journal of Educational Research*, 111(5), 530-540. <https://doi.org/10.1080/00220671.2017.1316710>
- Safdar, R. G., Gulap, S. & Saif, U. (2013). Relationship between students, personality traits and their academic achievement in Khyber Pakhtunkhwa, Pakistan. *Journal of Educational and Social Research*. 3 (2), 437-444
- Schreiner, C., & Sjoberg, S. (2004). *The Relevance of Science Education*. Department of Teacher Education, University of Oslo. Unipublishers AS. Roseproject. <https://roseproject.no/key-documents/key-docs/ad0404-sowing-rose.pdf>
- Teo, T., Tsai, L. T., & Yang, C. (2013). Applying Structural equation modeling (SEM) in Educational research: An introduction. In Khine, M. S. (Ed.) *Application of structural equation modeling in Educational Research and practice*. Sense Publishers.
- Toegel, G. & Barsoux, J. L. (2012). How to become a better leader. *MIT Sloan Management Review* 53(3), 51- 60.
- Watzels, R., & Wagenmakers, E. (2012). A default hypothesis test for correlations and partial correlations. *Psychological Bulletin* Review, 19, 1057-1064. Springer. <https://link.springer.com/content/pdf/10.3758/s13423-012-0295-x.pdf>

West African Examinations Council (2016). *Chief Examiners' Report*. Lagos, WAEC press

Yu, J. L., Chia, H.C., & Ching, Y. C. (2011). The Influence of interest in learning and learning hours on learning outcomes of vocational college students in Taiwan: Using a teachers' instructional attitude as the moderator: *Global Journal of Engineering Education*, 13(3), 140 – 153.

Yuan, Y. & Mackinnon, D. P., (2009). Bayesian Mediation Analysis. *Psychological Methods*, 14(4): 301-322. <https://doi.org/10.1037/a0016972>

**Appendix A: The samples of histogram and trace plots indicating values of parameter estimates in the combined model**

