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Causal Modelling of Self-Efficacy and Academic Interest on Students' Achievement in Physics

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Abstract

This study examined the causal modelling of self-efficacy and academic interest on students' achievement in Physics among senior secondary school students in Nsukka Education Zone, Enugu State, Nigeria. Academic interest was examined as a mediating variable in the relationship between the exogenous variable and students' achievement in Physics. Three research questions and three hypotheses guided the study. A model-based correlational survey research design was adopted. The population of the study comprised 1,866 Senior Secondary II (SSII) Physics students in 62 public secondary schools in Nsukka Education Zone. A sample of 329 students was selected using a multi-stage sampling procedure. Instruments used for data collection included the Self-Efficacy Scale (SES), Academic Interest Scale (AIS) and Physics Achievement Test (PAT). The instruments were validated by experts in Science Education and Measurement and Evaluation. Reliability coefficients obtained using Cronbach's alpha ranged from 0.71 to 0.86, while the PAT yielded a KR-20 reliability coefficient of 0.85. Data were analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM). Findings revealed that self-efficacy and academic interest significantly influenced students' achievement in Physics both directly and indirectly through . had the highest direct effect on achievement in Physics. The model explained 34.0% of the variance in students' academic achievement in Physics. The study concluded that students' self-efficacy and interest are important determinants of achievement in Physics. It was recommended that Physics teachers should adopt learner-centred and motivational instructional strategies that enhance students' self-efficacy and academic interest.

Keywords: Self-Efficacy, Academic Interest, Physics Achievement, PLS-SEM

Introduction

Physics is widely regarded as one of the most important science subjects because of its enormous contributions to scientific advancement, industrial growth, technological innovation, and national development. The subject provides the foundation for understanding natural phenomena and serves as the basis for technological inventions in areas such as engineering, medicine, communication technology, transportation, architecture, and space science. Physics also plays a critical role in developing scientific literacy, problem-solving abilities, and analytical thinking skills among students. Consequently, nations that prioritize Physics education often experience faster scientific and technological advancement (Patrick, 2018). In Nigeria, Physics is recognized as one of the core science subjects offered at the senior secondary school level. The Federal Republic of Nigeria emphasized the importance of science education in the National Policy on Education by encouraging the teaching and learning of science-related subjects that can contribute to technological development and economic growth (Federal Republic of Nigeria [FRN], 2014). Physics education is therefore expected to equip students with scientific knowledge, practical competencies, and critical thinking skills required for higher education and employment opportunities in science-related fields.

Despite the recognized importance of Physics, students' achievement in the subject has remained persistently poor over the years. Reports from the West African Examinations Council (WAEC) have consistently shown low performance in Physics examinations among secondary school students in Nigeria (WAEC, 2019–2023). Many students perceive

Physics as a difficult and abstract subject because of its mathematical nature, technical concepts, and problem-solving demands. This poor achievement has continued to generate concern among educators, researchers, parents, and policy-makers because poor performance in Physics limits students' access to science-based careers and slows national technological development. Physics occupies a central position in science and technology education because of its contributions to technological advancement, industrial development, engineering innovations, and scientific literacy. The knowledge of Physics provides learners with the opportunity to understand natural phenomena and apply scientific principles to real-life situations. Physics also serves as a prerequisite for careers in medicine, engineering, computer science, architecture, and several technology-related disciplines. Consequently, the teaching and learning of Physics have continued to attract considerable attention from researchers, educators, and policy-makers.

Several factors have been identified as possible causes of poor achievement in Physics. Previous researchers associated students' poor performance with inadequate instructional materials, ineffective teaching methods, poor laboratory facilities, overcrowded classrooms, insufficient qualified teachers, and students' poor mathematical background (Abbas et al., 2021; Kwari et al., 2023). Although these external factors significantly affect teaching and learning, researchers have increasingly emphasized the importance of psychological variables in explaining students' academic outcomes.

Among the psychological variables associated with academic achievement, self-efficacy and academic interest have attracted considerable attention from educational researchers. Self-efficacy refers to students' beliefs in their capability to successfully perform academic tasks and overcome learning difficulties. According to Bandura (1997), students who possess strong self-efficacy are more likely to exert effort, persist during challenging learning activities, and maintain confidence in their academic abilities. In the context of Physics education, students with high self-efficacy are more likely to engage actively in classroom activities, solve Physics problems confidently, and demonstrate improved academic achievement.

Empirical studies have shown that self-efficacy significantly predicts students' achievement in science subjects. Lee et al. (2022) reported that students who possessed high levels of academic self-efficacy performed significantly better in science-related tasks than students with low self-efficacy. Similarly, Schunk and DiBenedetto (2021) observed that self-efficacy enhances students' motivation, persistence, and academic engagement. Another important psychological factor influencing students' academic achievement is academic interest. Academic interest refers to students' enthusiasm, curiosity, and willingness to participate in learning activities. Interest motivates students to devote attention, effort, and time to academic tasks. Hidi and Renninger (2022) explained that students who develop interest in a subject are more likely to demonstrate sustained engagement and deeper understanding of concepts. In Physics education, students who are interested in learning Physics are likely to pay greater attention during lessons, participate actively in laboratory activities, and invest more effort in solving problems.

Studies have also established positive relationships between academic interest and students' achievement. Linnenbrink-Garcia et al. (2023) found that students' interest in learning significantly predicted their academic engagement and achievement outcomes. Interest encourages students to participate actively in classroom activities and enhances their intrinsic motivation to learn. The combined influence of self-efficacy and academic interest on students' achievement in Physics is particularly important because both variables are motivational constructs that influence students' learning behaviours and academic engagement. Students who possess strong confidence in their academic capabilities and demonstrate genuine interest in Physics are more likely to achieve positive learning outcomes.

Theoretical and empirical evidence suggest that self-efficacy and academic interest may not only directly influence academic achievement but may also influence achievement indirectly. Students who possess strong self-belief in learning are more likely to develop interest that enables them to cope with academic difficulties effectively. However, many previous studies examined these variables independently using conventional statistical methods such as regression and correlation analysis. Such approaches fail to capture the complex interrelationships among psychological variables. Therefore, there is a need for studies that employ advanced multivariate techniques capable of examining direct and indirect relationships simultaneously. Partial Least Squares Structural Equation Modelling (PLS-SEM) is considered appropriate for such investigations because it enables researchers to examine complex causal relationships

among latent variables. Consequently, this study employed PLS-SEM to examine the causal modelling of self-efficacy and academic interest on students' achievement in Physics.

Partial Least Squares Structural Equation Modelling (PLS-SEM) is a powerful analytical technique that allows researchers to examine multiple relationships among latent variables simultaneously. PLS-SEM is particularly suitable for predictive and exploratory studies involving complex causal relationships. Therefore, this study employed PLS-SEM to examine the causal relationships among self-efficacy, academic interest, and students' achievement in Physics.

Statement of the Problem

Students' academic achievement in Physics has remained poor and inconsistent despite several interventions aimed at improving science education. Previous studies have concentrated mainly on external factors such as teaching methods, instructional materials, and school environment, while less attention has been paid to the combined influence of students' psychological characteristics.

Although studies have established relationships between self-efficacy, academic interest, and academic achievement, many of these studies examined the variables separately. Empirical evidence exists regarding how self-efficacy and academic interest jointly influence students' achievement in Physics. In addition, many previous studies relied on conventional statistical methods that do not adequately explain causal pathways among variables.

This study therefore sought to fill this gap by examining the causal modelling of self-efficacy and students' achievement in Physics with academic interest serving as a mediating variable.

Purpose of the Study

The main purpose of this study was to examine the causal modelling of self-efficacy and academic interest on students' achievement in Physics.

Specifically, the study sought to:

1. Develop a causal model explaining the influence of self-efficacy and academic interest on students' achievement in Physics.
2. Determine the magnitude of the parameter estimates of self-efficacy and academic interest on students' achievement in Physics.
3. Determine the mediating influence of on the relationship between the exogenous variables and students' achievement in Physics.

Research Questions

The following research questions were posed for the study:

1. What is the causal model explaining the influence of self-efficacy and academic interest on students' achievement in Physics?
2. What are the parameter estimates of self-efficacy and academic interest on students' achievement in Physics?
3. What is the mediating effect of academic interest on students' achievement in Physics?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

1. The developed causal model significantly fits the empirically validated data.
2. Self-efficacy and academic interest do not significantly influence students' achievement in Physics.
3. does not significantly mediate the relationship between the exogenous variables and students' achievement in Physics.

Theoretical Framework

This study was anchored on Bandura's Social Cognitive Theory. The theory emphasizes the reciprocal interaction among personal factors, behaviour, and environmental influences. Self-efficacy is considered a major determinant of students' motivation and achievement.

The theory explains that students who possess strong beliefs in their academic capabilities are more likely to engage actively in learning activities, persist through difficulties, and achieve academic success.

Methodology

A model-based correlational survey research design was adopted. The population comprised 1,866 SSII Physics students in 62 public secondary schools in Nsukka Education Zone, Enugu State. A sample of 329 students was selected using a multi-stage sampling technique. Data were collected using five instruments: Self-Efficacy Scale (SES), Academic Interest Scale and Physics Achievement Test (PAT). Face and content validity were established. Reliability coefficients using Cronbach's alpha were 0.86 (SES) and 0.71 (AIS), while the PAT yielded a KR-20 reliability index of 0.85.

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Data were analyzed using WarpPLS software for Partial Least Squares Structural Equation Modeling (PLS-SEM).

Results

Research Question One: What is the causal model for the explanation of the influence of self-efficacy and academic interest on students' academic achievement in Physics?

A recursive model was developed in this study to answer the above, as can be seen in Figure 1. The model is recursive because some variables that are exogenous (self-efficacy and academic interest) to the endogenous variable (students' academic achievement in Physics) were found to be endogenous to other exogenous variables. The result of the trimmed model is presented in Figure 1.

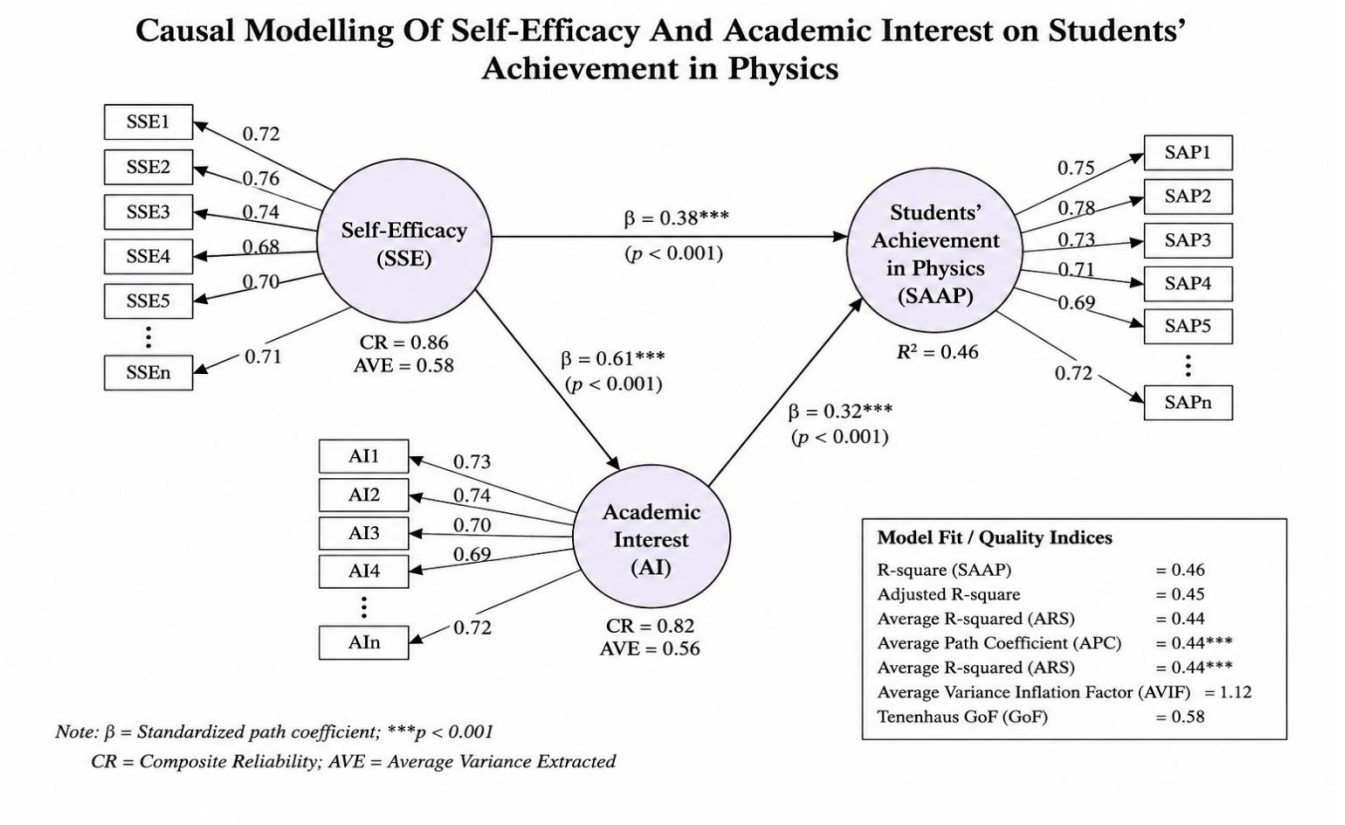

Figure 1: The Trimmed PLS-SEM Model"

The developed model showed that self-efficacy significantly influenced academic interest and students' achievement in Physics. Academic interest also significantly influenced and students' achievement in Physics. had a significant direct influence on students' achievement in Physics.

The measurement model assessment showed acceptable convergent validity and discriminant validity. All factor loadings were above the acceptable threshold of 0.40. Composite reliability values exceeded 0.70, while Average Variance Extracted (AVE) values exceeded 0.50. The proposed path model for the study illustrates the direct causal relationships among Self-Efficacy (SSE), Academic Interest (AI), and Students' Achievement in Physics (SAAP). The model specifies that self-efficacy directly influences academic interest and students' achievement in Physics, while academic interest also directly influences students' achievement in Physics.

Figure 2 presents the structural model with the standardized path coefficients generated using Partial Least Squares Structural Equation Modelling (PLS-SEM).

Table 1
Convergent Validity of the Variables

Variables	Indicators	Composite Reliability	AVE
Self-Efficacy (SSE)	SSE1–SSE28	0.89	0.54
Academic Interest (AI)	AI1–AI16	0.78	0.53
Students' Achievement in Physics (SAAP)	SAAP1–SAAP5	0.81	0.56

Note: AVE –average variance extracted

The results as shown in Table 1 indicates that the indicators of the various latent variables in the model are reliable. This is because all the items loadings were greater than 0.40 (> 0.40). The result also shows that all the composite reliabilities are greater than the threshold value of 0.60 (> 0.60). This implies that all the variables in the model have convergent validity after the unreliable indicators were trimmed off from the model. In addition, the variables further demonstrate satisfactory convergent validity since the values of AVE for all the variables were greater than 0.50 (> 0.50). To further determine the strength of the measurement model, the discriminant validity of the variables in the model was also assessed.

Research Question Two: What are the parameter estimates of the decomposed variables on students' academic achievement in Physics?

Table 2
Parameter estimates of the decomposed variables on students' academic achievement in Physics

S/N	Path	β	Standard Error	Effect Size (f^2)	Magnitude of influence	t-values	p-values	Decision
4.	SSE> AI	0.627	0.047	0.393	Large	13.281	0.001	S
6.	SSE>SAAP	0.159	0.050	0.030	Small	3.159	0.001	S
8.	AI>SAAP	0.167	0.050	0.059	Small	3.313	0.001	S

Note: β =Beta coefficient, S= Significant, NS = Not Significant; $f^2 \geq 0.35$ implies Large effect, $\geq$ 0.15 implies Medium effect, and $\geq$ 0.02 implies Small effect

The results in Table 4 show the parameter estimates of the decomposed variables on students' academic achievement in Physic. The results based on the beta (β) weights (coefficients) obtained showed that students' academic interest (AI) had the highest direct influence on their academic achievement in Physics with a path coefficient (β) of 0.167 (f^2= 0.059). This means that 1 unit change in students' academic resilience will result in a 0.167 (small) increase in their academic achievement in Physics. The next variable was students' self-efficacy (SE) which had the second direct influence on academic achievement in Physics (SAAP), with a path coefficient of 0.157 (f^2= 0.030). This means that 1 unit change in students' academic interest (AI) would account for 0.157 (small) considerable effect on their academic achievement in Physics. Thus, it can be noted that the parameter estimates of the decomposed variables on students' academic achievement in Physics in the developed causal model are either small or medium but substantial."

Research Question Three: What is the magnitude of the composite influence of the exogenous variables (self-efficacy and academic interest) on students' academic achievement in Physics?

Table 3
Magnitude of the composite influence of the exogenous variables (self-efficacy and academic interest) on students' academic achievement in Physics

Composite effect	R-Square	Adjusted R-Square	Average R-squared (ARS)	Bootstrapped p-value
Model	0.340	0.333	0.316	0.001

The result in Table 5 shows the magnitude of the composite influence of the exogenous variables (self-efficacy and academic interest) on students' academic achievement in Physics. The result shows that the R-square value obtained was 0.340, which implies that 34.0% of the variance in SAAP (students' academic achievement in Physics) is explained collectively by the exogenous variables (self-efficacy and academic interest).

Discussion

The findings of this study showed that the causal model for the explanation of the influence of self-efficacy and academic interest on students' academic achievement in Physics is recursive. Further findings revealed that there is a significant model fit between the empirically observed data and the theoretical model proposed for the study. The significant model fit between the hypothesized model and the empirical data suggests that the theoretical assumptions underpinning the model were well-founded and that the selected exogenous variables meaningfully capture the predictors of Physics achievement among senior secondary school students. This outcome may be attributed to the appropriateness of the theoretical framework (Hume, 1739; Lewis, 1973), adequacy of sample size, and rigour in the model development process.

The findings of the study showed that the parameter estimates of the decomposed variables in the causal model developed, such as students' self-efficacy and academic interest were small on students' academic achievement in Physics. It was further revealed that there are significant influences of the parameter estimates of the decomposed variables (self-efficacy and academic interest) on students' academic achievement in Physics. This finding that parameter estimates of the decomposed variables were small but substantial indicates that while no single factor was overwhelmingly dominant, each contributed meaningfully to explaining variance in students' academic achievement. This distribution of influence is likely due to the interplay of multiple cognitive and affective factors that shape learning in complex subjects like Physics. The modest size of these estimates may also reflect the multifactorial nature of academic achievement, which is influenced by variables both inside and outside the school setting.

The study also found that the exogenous variables (self-efficacy and academic interest academic) collectively explained 34.0% of the variance in students' academic achievement in Physics (SAAP). It was further revealed that there is a significant composite influence of the exogenous variables on the students' academic achievement in Physics. This indicates that the collective contribution of these psychological and cognitive variables is substantial and meaningful, especially considering the complex and multifaceted nature of academic achievement in science subjects like Physics.

Conclusion

The study established that self-efficacy and academic interest are significant predictors of students' achievement in Physics. Their combined influence highlights the need for integrated instructional strategies.

Educational Implications

The findings of this study have several educational implications for students, teachers, school administrators, and policy-makers. For teachers and educators, the findings imply that students' academic achievement in Physics will continue to be poor if Physics teachers do not foster students' self-efficacy while also nurturing their academic interest.

For students, the findings imply that students' academic achievement in Physics will continue to be poor if they do not develop strong academic interest and self-efficacy. This is because these factors account for substantial amount of changes in students' learning and academic achievement in Physics.

For school administrators and counsellors, the mediating role of interest implies that guidance and counselling services would need to be enhanced in schools to provide students with coping strategies, emotional support, and tools to manage academic pressure. Otherwise, students' academic interest and self-efficacy will continue to pose problems to their academic achievement in physics.

Recommendations

1. The Ministry of Education, in collaboration with school administrators and teacher-training institutions, should organize workshops and in-service training for Physics teachers to help them apply strategies that enhance student interest and self-efficacy.
2. Physics teachers, under the supervision of school administrators and curriculum

implementers, should adopt participatory, inquiry-based, and motivational teaching methods that build students' confidence while sustaining their interest in the subject.

3. School authorities should strengthen guidance and counselling units to support students in developing academic interest and self-efficacy, especially in challenging subjects like Physics.
4. Education stakeholders and curriculum planners should integrate the training of students in areas of self-efficacy and ways of boosting their interest in the learning of Physics.

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