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Structural equation modeling of students spatial ability, scholastic aptitude and test-taking skill on academic achievement in geography in Delta state

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Abstract
The academic achievement of students in Geography in Delta State has been on the decline. The study examined the structural equation modeling of spatial ability, scholastic aptitude and test-taking skill on students' academic achievement in Geography in Delta State. Six research questions and two hypotheses tested at .05 level of significance were raised to guide the study. The design of the study was causal correlation. The population size was 3,871 SS two students from public secondary schools in Delta State. A sample size of 1,300 students were selected through multi-stage sampling procedure. Data were collected using the following adopted instruments; Test Taking Skill Inventory by Dooden 2008, Scholastic Aptitude Test by DekaKaushik 2021, and Geography Spatial Ability Test by Erutujiro and Esomonu (2023). The reliability of the three instruments were re-established using Cronbach Alpha and Kuder-Richardson 20. A value of .87, 85 and .88 respectively were found forTest Taking Skill Inventory, Scholastic Aptitude Test and Geography Spatial Ability Test. Students' academic achievement scores in Geography were collected using proforma. The data were analysed using partial least square algorithm with SmartPLS version 4. Research questions were answered using standardized regression weight, adjusted R square and percentage, while hypotheses were tested using t-test standardized regression weight, t-test ofadjusted R square and bias corrected confidence interval at .05 level of significance. The researcher found out that the most meaningful causal model involving scholastic aptitude, spatial ability, test-taking skill and students' academic achievement in Geography in Delta State consist of five paths ways that are significant and meaningful. Scholastic aptitude, spatial ability and test-taking skill have significantdirect positive effect on students' academic achievement in Geography. In term of indirect effect, test-taking skill has significant positive indirect effect on students' academic achievement in Geography. Based on the findings, it was recommended that Geography teachers should place emphasis on test-taking skill and spatial ability when teaching Geography in the classroom among others.

Keywords: Spatial ability, scholastic aptitude, test taking skill, academic achievement, geography

Introduction

Students' academic achievement in Geography in Senior Secondary School Certificate Examination conducted by West African Examinations Council (WAEC) has not being encouraging. For instance, WAEC Chief Examiner's reports has highlighted poor candidates' achievement in Senior School Certificate Examination (SSCE) geography persistently (WAEC, 2019-2022). For instance, from 2018-2022 the percentage pass with credit and above in Geography were 23.0%, 31.0%, 24.94%, 30% and 28.98% respectively (WAEC, 2022). In Delta State, it was also recorded that from 2018-2022 the percentage of students pass with credit and above in Geography were 35.0%, 34.0%, 33.94%, 30% and 27.28% respectively (WAEC, 2022). The enrolment ratio for the period under review was also on the decline. For instance, from 2018-2022 the number of students that offered Geography in Delta State in Senior School Certificate Examination (SSCE)were 1,230; 1,190, 1,092; 935 and 897 respectively (WAEC, 2022).

Researchers have attributed the poor academic achievement in Geography to teachers' factors, shortage of instructional materials, poor learning environment and students' lack of interest in the subject (Adewale, and Babatude, 2020; Ayodele and Adeola, 2020; Eze, Ekpo and Ndem, 2019; Filgona, 2016; Orji and Uka, 2012; Suleiman, 2023) [2, 13, 12, 25]. WAEC Chief Examiner's reports also highlighted topics candidates' have poor achievement in Senior School Certificate Examination (SSCE) geography to include: map reading, longitude and time, drainage patterns, desert landform, reliefs, cross section drawing, mountains, river action, and weather and climate instrument (WAEC, 2022). In contrast, it is belief that the problem of failure in examinations or poor academic achievements goes beyond the aforementioned factors. As such, variables like students' test-taking skill; scholastic aptitude and spatial ability could also be considered as determinants of student's academic achievements in any given subject. But literature is yet to show clearly the extent to which achievement in geography can be influenced by students' test-taking skill, scholastic aptitude and spatial ability on academic achievement in geography directly or indirectly.

Test-taking skill is a cognitive skill that allows students to undertake any test-taking situation in an appropriate manner, and to know what to do before, during, and after the test (Dodeen, 2009). Test-taking skill helps students to translate their knowledge from classroom learning to answering and responding to questions when taking tests. Test-taking skill positively affect students' test-taking competency and hence impact upon their academic achievement. Test-taking skill is transferable skill (Sefcik, Bice and Prerost, 2013), where once acquired, students may be enabled to use these skills across a variety of subjects and within different settings and conditions.

Spatial ability is the capacity to understand, reason and remember the visual and spatial relations among objects or space. Spatial ability enable students to mentally

manipulate, organize, reason about, and make sense of interrelationships in real and imagined spaces (Newcombe and Shipley, 2014; Omar and Petek, 2011; Uttal *et al*., 2013) [21, 23]. They are commonly used when completing everyday tasks such as assembling furniture or navigating from one location to another. Researchers have found that spatial skills are malleable and can be improved through experience and practice (Filgona, 2016; Galligan, Flouri and Farran, 2020; Uttal *et al*., 2013) [13, 16]. Spatial ability also has significant influence on students' academic achievement (Onah, 2018).

Another variable that is perceived to have influence on academic achievement is scholastic aptitude. Scholastic aptitude is the degree of readiness to learn and perform well in a particular situation or in a fixed domain. Scholastic aptitude encompasses a variety of individual abilities that enable successful study academically. Salkind and Rashmussen (2007) defined scholastic aptitude as a set of characteristics that relate to an individual's ability to acquire knowledge or skills. Scholastic aptitude play significant roles not only in the actual academic achievement but also in the aspirations and plans of secondary school students for their pursuit of higher education. It has been found that the relationship between scholastic aptitude and academic achievement is significant (Thadyoos and Asha, 2018).

Academic achievement is a measure of knowledge gained through educational process usually indicated by test scores, grade point averages and degrees. Academic achievement according to Suleiman (2023) refers to performance outcomes that indicate how far a person has progressed in specific goals of activities in instructional settings, such as school, college, and university. It is conceptualized as the extent or how well a student is accomplishing his or her tasks and studies. It is considered to be an end product of all educational activities. The term academic achievement denotes any desirable learning among students may come within the domain of achievement.

Although the foregoing variables are thought to have a link to students' academic achievement in any given subject, it is not yet clear to the researcher about their contributions to students' academic achievements in Geography in secondary schools. However, the study of the combined effects of all the variables discussed is possible through structural equation modeling. According to Ringle, Sarstedt, Neomi and Rudolf (2023), structural equation modeling is an alternative method for testing understanding of complex relationships. Structural equation modeling is a collection of procedures that tests hypothesized relationships among latent variables. In particular, it encompasses covariance structure analysis, confirmatory factor analysis, confirmatory composite analysis, path analysis, and latent (growth) curve analysis (Basmin, 2021; Chine, 2010; Cohen, 1988; Hair, *et al*, 2017; Kline, 2016, Muhammed, 2021) [3, 17, 18].

There are two major approaches to structural equation modelling. These are the Covariance-Based Structural Equation Modelling (CS-SEM) and Partial Least Square Structural Equation Modelling (PLS-SEM). The study adopted the partial least square structural equation modelling. Partial least structural equation modelling is useful for structural equation modelling in applied research projects especially when there is small sample size, complex mode model and the data distribution is skewed. Furthermore, this approach also helps to avoid the problem of model identification. Explicitly, partial least square structural equation modelling can relate set of latent independent variables to multiple latent dependents variables and handle many latent independent variables, even when latent predictors display collinearity. In the light of the forgoing benefits of PLS-SEM, this present study intends to find out both the direct and indirect effects of scholastic aptitude, spatial ability and test-taking skillas well as the moderating effect of gender and school location on students' academic achievement in Geography in Delta State using Partial Least Square Structural Equation Modelling (PLS-SEM).

Research Questions

The following research questions guided the study

1. What is the most meaningful causal model involving scholastic aptitude, spatial ability, test taking skill and students' academic achievement in geography in Delta State?
2. How reliable is the measurement aspect of the hypothesized causal model for the study?
3. How valid of the measurement aspect of the hypothesized causal model for the study?
4. What are the direct effects, indirect and total effect of the latent variables on students' academic achievement in Geography in the hypothesized causal model?
5. What is the proportion (percentage) of the total effect of the variables that is (a) direct and (b) indirect?

Hypotheses

The following hypotheses were tested at .05 level of significance

1. There is no significant direct and indirect effect of the independent and mediating variable on academic achievements of students in geography in the hypothesized model
2. There are no significant contributions of the independent and mediating variables to the prediction of students' academica achievement in geography

Materials and Methods

The design of the study was causal correlation. The population size was 3,871 SS two students from public secondary schools in Delta State. A sample size of 1,300 students were selected through multi-stage sampling procedure. Data were collected using the following adopted instruments; Test Taking Skill Inventory by Dooden 2008, Scholastic Aptitude Test by DekaKaushik 2021, and Geography Spatial Ability Test by Erutujiro and Esomonu (2023) [11]. The reliability of the three instruments were re-established using Cronbach Alpha and Kuder-Richardson 20. A value of .87, 85 and .88 respectively were found forTest Taking Skill Inventory, Scholastic Aptitude Test and Geography Spatial Ability Test. Students' academic achievement scores in Geography were collected using proforma. The data were analysed using partial least square algorithm with SmartPLS version 4. Research questions were answered using standardized regression weight, adjusted R square and percentage, while hypotheses were tested using t-test standardized regression weight, t-test of adjusted R square and bias corrected confidence interval at .05 level of significance.

Results

Research Question 1: What is the most meaningful causal model involving scholastic aptitude, spatial ability, test-taking skill and students' academic achievement in geography in Delta State**?**

Table1: Model Fit Statistics of the Hypothesized Causal Model

Measures	Estimates	Cuff-off criteria	Interpretation
NFI	.963	>.90	Excellent
SRMR	.020	<.08	Good
Chi/df,	2.234	<5	Excellent

The overall fits indices of the initial hypothesized causal path model were all examined. The model fit was assessed using a variety of indicators and tests, more famous is the Normed Fit Index (NFI), standardized root mean square residual (SRMR) and-Chi-square and degree of freedom. Table 1 shows that the Normed Fit Index (NFI) is .963 represents adequate fit to the data (values above .90 being indicative of good fit). Similarly, the hypothesized causal model has a value of .020 for standardized root mean square residual (SRMR) (which was less than .08), implying that the model is an acceptable fit. The ratio of goodness of fit (Chi/df, 2.234) to degrees of freedom is within the recommended fit of less than 5. Thus, all the fit statistics, taken together supported the idea that the model is satisfactory.

However, examination of the initial hypothesised causal path model shows five path ways were significant and meaningful while one path way was not significant and meaningful. The five path ways that were significant and meaningful have path co-efficient t-values > 1.96; while the one path way that is not significant and meaningful has path co-efficient t-value < 1.96. The five paths that were significant and meaningful include: path ways from scholastic aptitude to academic achievement, scholastic aptitude to test taking skill, test taking skill to students' academic achievement, test-taking skill to academic achievement, spatial ability to test-taking skill and spatial ability to students' academic achievement. The path way that is not significant and meaningful is from scholastic aptitude to spatial ability. See Table 2 and Fig 2.

Table 2: Paths Ways of the Hypothesised Causal Model

Path ways	Path co-efficient	t-test	Remark
Scholastic aptitude >>> Academic achievement	.211	10.350	Meaningful
Scholastic aptitude>>>>Test taking Skill	.310	13.837	Meaningful
Scholastic aptitude>>>>Spatial ability	.001	1.011	Not Meaningful
Test taking Skill>>>>>Academic achievement	.231	4.419	Meaningful
Spatial ability >>>>> test taking skill	.247	12.680	Meaningful
Spatial ability >>> academic achievement	.550	25.250	Meaningful

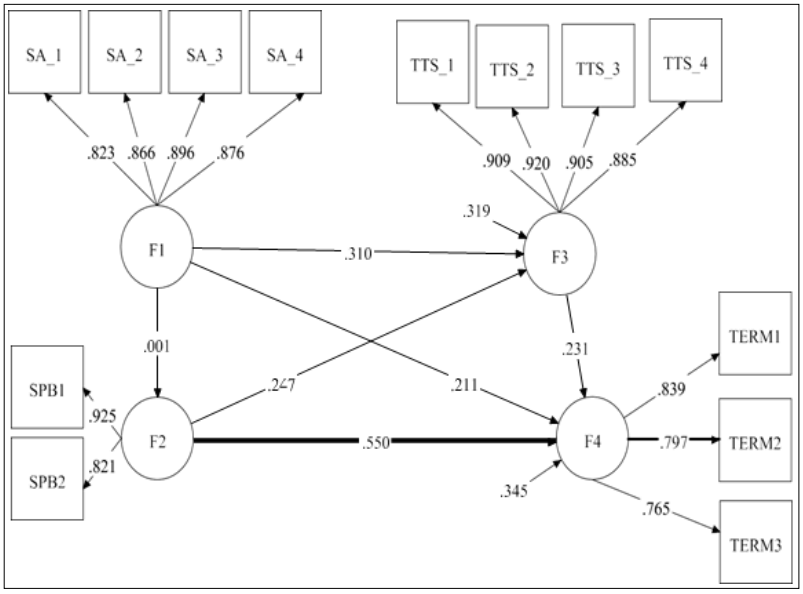

Fig 1: Hypothesized Path model

Note F1= scholastic aptitude, F2= Spatial ability, F3= Test taking skill, F4= Academic achievement in Geography,SA-1 to SA-4 represents dimensions of scholastic aptitude,SPB1 and SPB2 represents dimensions of spatial ability, TT_1 to TTS_4 represents dimensions of test taking skill, while TERM1 to TERM3 represent achievement of first, second and third term respectively. SA-1 =scientific ability, SA-2=mathematical ability, SA-3 =general ability, SA-4=verbal ability. SPB1-Graphic ability, SPB2--Diagram interpretation ability. TT_1= Preparation before test, TT_2 =Time management, TT_3=composition during test, TT_4= composition after test.

After deleting the path way of scholastic aptitude to spatial ability that is not significant and meaningful in the hypothesised path causal model, the model was rerun. Thereafter, model fit indices, meaningful and significant path ways in the causal model were examined again. The model fit was assessed using a variety of indicators and tests. The rerun model shows a Normed Fit Index (NFI) of .966 which represents adequate fit to the data (values above

.90 being indicative of good fit). Similarly, the rerun causal model has a value of .021 for standardized root mean square residual (SRMR) (which should be less than .08), implying that the model is an acceptable fit. The ratio of goodness of fit (Chi/df, 1.650) to degrees of freedom is within the recommended fit of less than five. Thus, all the tests and measures, taken together supported the idea that the model is satisfactory. The various paths ways in the rerun model were also examined. The final model shows that all the paths ways were significant and meaningful. The five path ways that were significant and meaningful have path co-efficient t-values > 1.96. Therefore, the most meaningful causal model involving scholastic aptitude, spatial ability, test taking skill and students' academic achievement in geography in Delta State consist of five paths ways that are meaningful and significant. See Fig 2 and Table 3 for details.

Table 3: Paths Ways in the Modified/Trimmed Causal Model

Path ways	Path co-efficient	Unstandardized	t-test	Remark
Scholastic aptitude >>> Academic achievement	.317	.417	9.350	Meaningful
Scholastic aptitude>>>>Test taking Skill	.365	.230	7.801	Meaningful
Test taking Skill>>>>>Academic achievement	.239	.341	4.419	Meaningful
Spatial ability >>>>> test taking skill	.347	.220	2.680	Meaningful
Spatial ability >>>>> Academic achievement	.450	1.405	5.250	Meaningful

Intercept: academic achievement= 3.262, test-taking skill= 10.141, Normed Fit Index (NFI)= .966, standardized root mean square residual (SRMR)=.021, (Chi/df, 1.650).

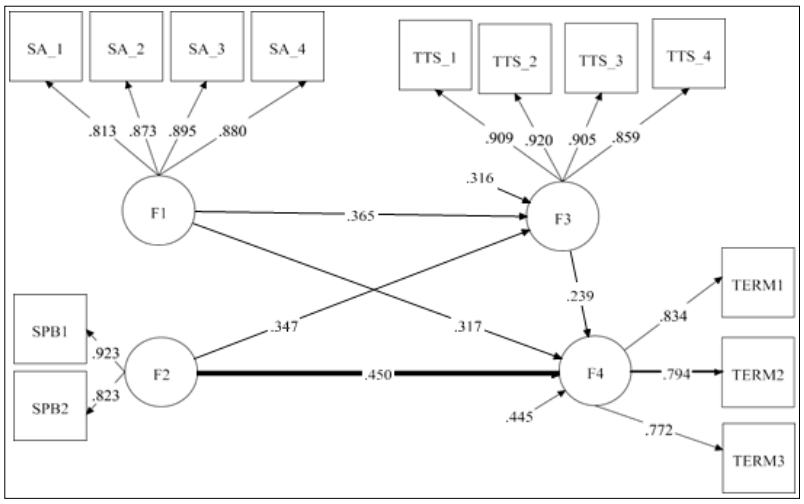

Fig 2: Trimmed Path Model

Note F1= scholastic aptitude, F2= F3= Spatial ability, F3=Test taking skill, F4= Academic achievement in Geography, SA-1 to SA-4 represents dimensions of scholastic aptitude, SPB1 and SPB2 represents dimensions of spatial ability, TT_1 to TTS_4 represents dimensions of test taking skill, while TERM1 to TERM3 represent achievement of first, second and third term respectively**.** SA-1 =scientific ability, SA-2=mathematical ability, SA-3 =general ability, SA-4=verbal ability. SPB1-Graphic ability, SPB2--Diagram interpretation ability. TT_1= Preparation before test, TT_2 =Time management, TT_3=composition during test, TT_4= composition after test.

Research Question 2: How reliable is the measurement aspect of the hypothesised causal model for the study?

Table 4: ReliabilityAnalysis of the Various Constructs in the Hypothesised Model

Constructs	Dimensions	Loadings	CompositeReliability	Cronbach Alpha
Scholastic aptitude	SA_1	.813	.821	.749
	SA_2	.873		
	SA_3	.895		
	SA_4	.880		
Spatial ability	SPB1	.923	.778	.821
	SPB2	.823		
Test taking skill	TTS_1	.909	.718	.747
	TTS_2	.920		
	TTS_3	.905		
	TTS_4	.859		
Academic Achievement	Term_1	.834		
	Term_2	.794		
	Term_3	.772		

Note: SA-1 =scientific ability, SA-2=mathematical ability, SA-3 =general ability, SA-4=verbal ability. SPB1-Graphic ability, SPB2--Diagram interpretation ability. TT_1= Preparation before test, TT_2 =Time management, TT_3=composition during test, TT_4= composition after test. TERM1 to TERM3 represent achievement of first, second and third term respectively

Table 4 reveals that composite reliability has values between 0.718 and 0.821. The composite reliability is normally used by researchers instead of Cronbach Alpha that makes the equality assumption among all the constructs because of its sensitivity to a number of items embedded in the scale. For this study, the composite reliability of scholastic aptitude, spatial ability and test taking skill are .821, .778 and.718 respectively. The above values shows that the measurement model is reliable.

Research Question 3: How valid is the measurement aspect of the hypothesised causal model for the study?

The validity of the proposed causal model was examined using 2 statistics: The Fornell-Larcker Criterion and Heterotrait-Monotrait ratio of correlations.

Table 5: Discriminant validity Test of the Causal Model

	SA	SB	TTS	Ach
	Fornell–Larcker			
SA	.80			
SB	.72	.79		
TTS	.39	.68	.87	
Ach	.28	.49	.72	.86
	Heterotrait-Monotrait			
SA	.86			
SB	.72 .82			
TTS	.39 .68 .78			
Ach	.28 .49 .72			.73
AVE	.89	.88	.93	.92

Note FornellLacker: The bold slash text is the square root value of AVE, and the rest are the correlation coefficients between the various constructs in the model. SA= scholastic aptitude, SB=spatial ability, TTS=Test-taking skill, Ach=Academic achievement.

Discriminate validity was tested using the criteria suggested by Fornell and Larcker (1981) [15]. The square root of AVE (average variance extracted) should be greater than the correlations among the constructs; that is, the amount of variance shared between a latent variable and its block of indicators should be greater than the shared variance between the latent variables. Table 5 shows the inter-correlations of the constructs and variance shared between the latent variables and their indicators. The diagonal elements in Table 5 are the square root of the AVE (average variance extracted). This showed that the square roots of each AVE (average variance extracted) value were greater than the off-diagonal elements. For the HTMT, Table 5 shows that the highest HTMT value was 0.86, which indicates that all values are below 0.90, and according to Hair *et al*. (2020 [30], the discriminant validity is ensured and can be declared to be good. Thus, the measurement model had a reasonable degree of discriminate validity among all of the constructs.

Next the researcher tested the convergent validity, which is the degree to which multiple items measuring the same concept are in agreement. The researcher used factor loadings and the average variance extracted (AVE) to assessed convergent validity. The loadings for all dimensions on the construct exceeded the recommended value of 0.50. The AVE (average variance extracted), which indicates that the latent construct accounts for at least 50% of the variance in the items (Hair *et al*., 2014), the AVE (average variance extracted) exceeded the recommended value of 0.5 (Hair *et al*., 2014). As such, both tests indicate an adequate degree of validity

Research Question 4: What are the direct, indirect and total effects of scholastic aptitude, spatial ability and test taking skill on students' academic achievement in geography?

The direct and indirect effect of variables on students' academic achievement in geography in the causal model are presented in Table 6 for discussion. A t value of path co-efficient < 1.96 indicates no effect.

Table 6: Direct and Indirect Effects of variables in the Causal Model

Variables	Path co-efficient	T	p-value
Direct effect on Academic Achievement			
Scholastic aptitude	.317	8.033	.000
Spatial ability	.450	9.117	.000
Test-taking skill	.239	5.210	.001
Total direct effect	.335	4.590	.002
Indirect effect on Academic Achievement			
Test taking skill	.294	9.344	.001
Total effect	.629	6.211	.002

Table 6 shows that scholastic aptitude, spatial ability and test-taking skill have positive direct effect on students' onstudents' academic achievement in geography. A t values of standardized estimates of each variable is > 1.96 criteria recommended. In term of indirect effect, test-taking skill has positive indirect effect on students' academic achievement in geography.

Research Question 6: What is the proportion (percentage) of the total effect of the variables that is (a) direct and (b) indirect?

Table 7: Relative and Composite Contribution of Variables in the Causal Model

Relative contributions of each Variables	R^2	Adjusted R^2	Rank	Remark
Scholastic aptitude	.325	.299 (29.9%)	3rd	High
Spatial ability	.337	.301 (30.1%)	2nd	High
Test taking skill	.320	.312 (31.2%)	1st	High
Total direct effect	.357	.322 (32.1%)		High
Mediating variable				
Test taking	.215	.199 (19.9%)		High

NB-- Adjusted R^2 below .1 is low, .11 to .30 is moderate, .31 to .50 high while .51 and above very high (Cohen, 1988).

The result in table 7 shows that all the variables yielded an adjusted R squared of 32.1%. This implies that total direct in the hypothesised causal model contributes 32.1% of variance students' academic achievement in geography. While the total indirect contribution of mediating variable (test taking skill) to students' students' academic

achievement is 19.9 % variance. In line with Cohen (1988) guidelines for interpreting the contributions of variables to dependent variables in causal modeling, the independent and mediating variables have meaningful contributions to variance of students' academic achievement in the hypothesised causal model. In term of relative direct contributions of each variable to academic achievement in the hypothesised model, test taking skill has the highest contribution to variance in students' students' academic achievement (31.2%), followed by test spatial ability (30.1%) and scholastic aptitude to students' academic achievement (29.9%), In term of contribution of the mediating variable, test taking skill contribute 19.9% to variance of students' academic achievement in geography.

Discussion of Findings

The most meaningful causal model involving scholastic aptitude, spatial ability, test- taking skill and students' academic achievement in geography in Delta State consist of five paths ways that are significant and meaningful. The path ways are: scholastic aptitude to academic achievement, scholastic aptitude to test taking skill, test taking skill to academic achievement, spatial ability to test taking skill and spatial ability to academic achievement in geography in the hypothesised causal model. The path co-efficient of the above paths ways were greater than .10. The above finding is in line with Nwanze, and Okoli (2020) [22] study that reported that paths ways and path coefficient are considered meaningful if path coefficient greater than .10 with P value less than .05. Similarly, Omar and Petek (2011) [23] also reported that the most meaningful path models are the one with all path significant with good theoretical foundation.

The researcher also found out that composite reliability of the constructs in the hypothesised causal model values range between 0.718 and 0.821. The above finding is line with Hair *et al*. (2017) [17] suggestions that the lower the composite reliability, the higher is the level of random error. Kline (2023) [19] also suggested that acomposite reliability coefficient above .70, average variance above .50 and factor loading above .40 criteria must met for measurement part of hypothesised causal model to be reliable.

The researcher also found out that validity of the measurement model was adequate. The square roots of each AVE (average variance extracted) value were greater than the off-diagonal elements. The measurement model, thus, had a reasonable degree of discriminate validity among all of the constructs. The loadings for all dimensions on the construct exceeded the recommended value of 0.50. The AVE (average variance extracted), which indicates that the latent construct accounts for at least 50% of the variance in the items, were in the range of 0.600 and 0.744 which exceeded the recommended value of 0.5. As such, both tests indicate an adequate degree of validity. The above finding is in line with Chin (2010) [4] suggestion that discriminant validity is achieved when the square root of the AVE (average variance extracted) of a construct is larger than its correlation with other constructs. The second discriminant validity criterion is achieved when the loadings of an item/sub-scale within a construct are greater than its loadings on any other construct. Similarly, Kline (2023) [19] also suggested that an average variance above .50 was necessary to established convergent validity.

The researcher found out that scholastic aptitude, spatial ability and test taking skill have direct positive effect on students' academic achievement in geography in Delta State. In term of indirect effect, test taking skill has positive indirect effect on students' academic achievement in geography. The corresponding hypothesis on significance of direct and indirect effect of variables shows that scholastic aptitude, spatial ability and test-taking skill have significant direct effect on students' academic achievement in geography. The above finding is in with Eze, Ekpo and Ndem (2019) [12] study that reported that' scholastic aptitude, spatial ability and test taking skill have direct positive effect on students' onstudents' academic achievement. Similar finding were also reported by Dodeen (2014) that spatial ability and test taking skill have significant effect on students' academic achievement among secondary school students. Furthermore, test-taking skill has both direct and indirect significant effect on students' academic achievement in geography (Ayodele and Adeola, 2020) [2].

The researcher found out that all the variables yielded an adjusted R squared of 32.2%. This implies that total direct effect in the hypothesised causal model contributes 32.2% of variance students' academic achievement in geography. While the total indirect contribution of mediating variable (test taking skill) to students' students' academic achievement in geography is 19.9 % variance. In line with Cohen (1988) guidelines for interpreting the contributions of variables to dependent variables in causal modeling, the independent and mediating variables have meaningful contributions to variance of students' academic achievement in geography in the hypothesised causal model. In term of relative direct contributions of each variable to academic achievement in the hypothesised model, test-taking skill has the highest contribution to variance in students' academic achievement in geography (31.2%), followed by test spatial ability (30.1%) and scholastic aptitude to students' academic achievement (29.9%), In term of contribution of the mediating variable, test-taking skill contribute 19.9% to variance of students' academic achievement in geography in Delta State.

The corresponding hypothesis on significance of contribution shows that the contribution of all the variables in the hypothesised causal model to students' academic achievement in geography was statistically significant, while the composite contribution of the mediating variable to students' academic achievement in geography was also statistically significant. The above finding is line with Muhammed (2021) study that reported that students' spatial ability contributes about 21 % variance to students' academic achievement in secondary schools. Basmin (2021) [3] also reported that students' academic achievement is determine by test-talking skill, spatial ability and scholastic aptitude. Galligan, Flouri and Faran (2020) [16] and Adewale and Babatunde (2023) [1] in their separate studies also reported that scholastic aptitude, spatial ability and test-taking skill have direct positive effect on students' academic achievement in geography in secondary schools.

Conclusion

Based on the findings, the study concludes that scholastic aptitude, spatial ability and test taking skill have significant direct positive effect on students' academic achievement in geography in Delta. State. Similarly, test-taking skill has significant indirect positive effect on secondary school

students' academic achievement in geography in Delta. State.

Recommendations

Based on the findings of the study, the following recommendations were made

1. Based on the finding that scholastic aptitude, spatial ability and test-taking skill have positive direct effect on students' onstudents' academic achievement in geography. It was recommended that students should considered the aforementioned variables as salient variables that could influence students' academic achievement in geography in secondary schools.
2. Based on the finding that test-taking skill variables in the hypothesised causal model contributes 35.1% of variance students' academic achievement in geography in senior secondary school. It was also recommended that government should direct curriculum experts to include test-taking skills in the geography curriculum as it will help students to improve academic achievement in geography.
3. Based on the finding that all the exogenous variables contributes to academic achievement in geography in the causal model, the guidance counsellors in various schools should provide supports to students to help them develop test-taking skill and spatial ability. This will help the students perform well in geography both in internal and external examinations

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