The Classroom and New Learning: An Investigation of Interrelationship Among Pre-Service Teachers' Statistical Reasoning, Attitude Towards Statistics, and Learning Approach on Achievement in Statistics

Eluwa, Obukohwo I *,
Asim, Alice E *
Eluwa, Akubuike N **
Abang K. Bekom *

* Department of Educational Foundations, Guidance and Counselling, University of Calabar, Calabar,Nigeria
** Department of Rural Sociology and Extension, Michael Okpara University of Agriculture, Umudike, Nigeria

Abstract The study sought to investigate inter- relationships amongst statistical reasoning, attitude towards statistics, learning approach and achievement in educational statistics. Ex-post facto research design was adopted for the study. The sample consisted of 358 (114 males and 244 females) fourth year pre-service teachers from University of Calabar and Port Harcourt in the South-South Geopolitical Zone of Nigeria. The data for the study was collected using two instruments named: Statistical Reasoning Learning Approach Questionnaire (SRALAQ), and the Educational Statistics Test (EST). Analyses of data were carried out using multiple regression and path analysis. The results showed that: there is a significant composite effect of pre-service teachers' statistical reasoning, attitude towards statistics and learning approach on achievement in educational statistics; and there are significant paths through which the independent variables determine achievement in educational statistics. The strongest of these paths is between statistical reasoning and learning approach and attitude towards statistics and learning approach. Learning approach was found to be a significant direct predictor (β = .225, t = 2.581, p< 0.010) of pre-service teachers' achievement in educational statistics at 0.05 level of significance. A meaningful causal model which could be used to explain the causal relationship amongst the variables in the study also emanated. The causal model showed that pre-service teachers' achievement in educational statistics could be explained directly and indirectly. The direct effect was 81.45% while the indirect effect was 18.55%. The magnitudes of the effects of the predictive variables in the study in order of their importance are 0.429 for learning approach, 0.151 for statistical reasoning and -0.036 for attitude towards statistics. The implications of the research findings are addressed.

Keywords: Statistical reasoning, attitude towards statistics, learning approach, achievement in educational statistics.

Introduction

A detailed analysis of 3rd year pre-service teachers' results in educational statistics reveals a poor performance, and studying the external's reports on students' performance in statistics related topics in the West African Examination Council's results also reveals a poor performance but there is a growing demand for the inclusion of statistics in the training of most discipline (Giesbrecht, 1996 & Ndiyo, 2005).

The understanding and interpretation of statistical reports among specialists in statistics and non-specialists is an essential core skill in the society today. Empirical studies, newspaper articles, journals and magazines commonly describe misinterpretation by the general public of information that is presented in either numerical or graphical formats. This trend in public knowledge has been traced to deficiency in elementary and middle school mathematics and statistics learning. In other words, there is a gap between understanding of basic concepts in statistics and the technical capacity to apply them (Biehler, 1997; WAEC, 2002; WAEC, 2003 & WAEC, 2004).

Understanding basic concepts in statistics involves what the student is able to do with statistical contents like recalling, recognizing, and discriminating among statistics concepts while the technical capacity to apply them has to do with the skills that students demonstrates in using statistics concepts in specific problem solving. Now for us to teach statistics to enhance conceptual learning, it behooves on us to study the way students think and learn. That is, we must study statistical reasoning.

Statistical reasoning in the view of Garfield and Chance (2002) refers to an individual ability to interpret, critically evaluate and when relevant, express their opinion regarding statistical information or data as well as other related argument, and it is a topic of great interest to many types of persons like;

- ➢ Psychologist who study how people make judgment and decision involving statistical information.
- ➢ Doctors and others in the medical profession, who need to understand and interpret risks, chances of different medical outcome and test results.
- ➢ Journalist and science writers who are interested on how to best explain and critique statistical information.
- ➢ Political analysts who are interested in studying and interpreting polls and election results.
- ➢ Statistic teachers who want to teach students not only a set of skills and concepts but also to reason about data and chance.

The concept- "students' statistical reasoning" thus addresses students' ideas and comprehension of statistics. This includes assessing the degree of students understanding of what questions can or cannot be answered using probability and statistics as well as applying probability and statistics concepts in appropriate situations.

Suffice to say that the teaching and learning of statistics is not only hampered by cognitive variables in this case-statistical reasoning but some non-cognitive variables such as attitude towards statistics and learning approach. Attitude is a learned predisposition to respond positively or negatively to a given object, situation, concepts or person. As such, it possesses cognitive, affective and performance dimensions. In other words, attitude involves negative or positive feelings that results from positive or negative experiences over time in learning a topic, in this case statistics. Learning approach is the typical way students tend to study. That is, their learning strategies. But why pre-service teachers?

Pre-service teachers are the focus of this study because they are the tools to use if we are to achieve the growing demands for the inclusion of statistics teaching in the training of most discipline. This is so because on graduation, they would either teach at the Nursery, Primary, Secondary or Tertiary levels of learning.

Purpose of Study

The general purpose of this study is to evaluate the interrelationships among pre-service teachers' statistical reasoning, attitude toward statistics, and learning approach on achievement in educational statistics. Specifically, the study sought answers to the following research questions:

1. What is the composite effect of pre-service teachers' statistical reasoning, attitude towards statistics, and learning approach on achievement in educational statistics?
2. What are the significant paths through which pre-service teachers' statistical reasoning, attitude towards statistics and learning approach determines achievement in educational statistics?
3. What is the most meaningful causal model involving pre-service teachers' statistical reasoning, attitude towards statistics, and learning approach on achievement in educational statistics?
4. What proportion of the effect of pre-service teachers' statistical reasoning, attitude towards statistics and learning approach on achievement in education statistics is direct and indirect?

Methodology

Subject

The subjects for this study involved, 358 4th year undergraduate students from Faculty of Education University of Calabar and University of Port Harcourt (114 males and 244 females), selected through proportional stratified random sampling procedure.

Instrumentation

A questionnaire tagged "Statistical Reasoning Attitude Learning Approach Questionnaire" (SRALAQ) with Cronbach alpha reliability coefficient ranging from 0.72 to 0.87 for each of the sub-dimensions of the instrument and an achievement test tagged "Educational Statistics Test" (EST) with reliability index of 0.83 were used for data collection. The questionnaire consisted of four major parts. The first part sought information about the students' demographic variables (gender, school, and department), while the second part of the questionnaire is on students' statistical reasoning with 20 items, attitude towards statistics (36 items), and learning approach (20 items)

Procedure for Data Analysis

Path analysis was utilized to explain the connections between statistical reasoning, attitude towards statistics, learning approach and achievement in educational statistics. The basic aim of path analysis is to provide an estimate of the magnitude and significance of hypothesized causal connections between sets of variables and it is achieved through the use of input and output path diagrams (Wright, 1934 & Asim, Uwe, Ekuri, Asuquo, & Ekpiken-Ekanem 2007). The statistical procedure (utilizing the statistical package for social science program-SPSS) was computed to provide answers to the research questions.

Path Analysis

The linear relationships among the three independent variables and the dependent variable form the basis for hypothesizing a theoretical model which addressed the linkages between the sets of variables in this study as shown in Figure 1. Causal modeling as defined by Wright (1934) is a technique for selecting those variables that are perceived to be determinants (causes) of the effects and then attempting to isolate the separate contributions to the effects made by each cause through the application of path analysis technique.
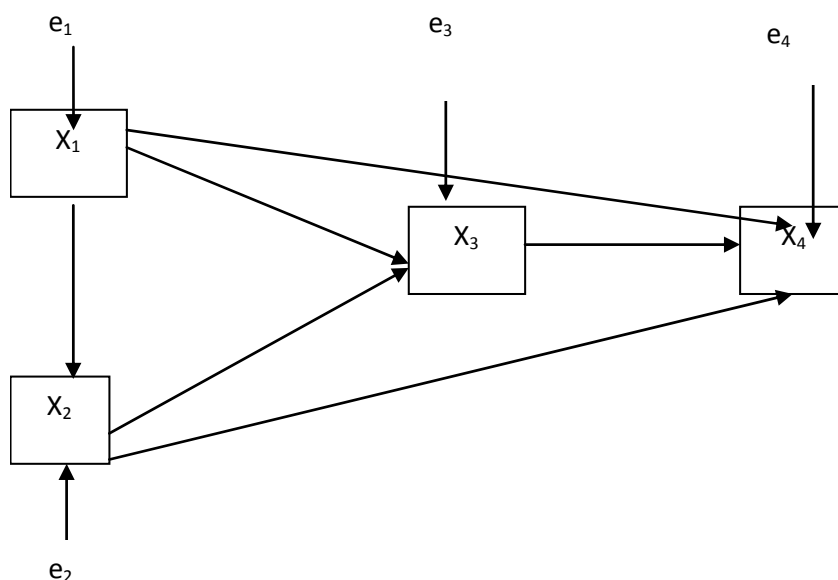
Figure 1: Hypothesized causal model

Identifying and Trimming the Paths in the Model

The investigators identified the important paths in the model by constructing the resultant structural equations using the technique of path analysis theorem and Wright's law. For the trimming of the paths in the model,

the theory of statistical significance and meaningfulness were used in order to provide a more adequate testing of the theory under consideration. According to Land (1969), for the model to be meaningful, the absolute value of the path coefficient should be at least .05.

Structural Equations for the Hypothesized Model

The equations implied in the hypothesized model in Figure 1 are: $X_1 = e_1$
$X_2 = p_{21} X_1 + e_2$
$X_3 = p_{31} X_1 + p_{32} X_2 + e_3$
$X_4 = p_{41} X_1 + p_{42} X_2 \ p_{43} X_3 + e_4$

The New Parsimonious Model and it's Structural Equations

To determine the path coefficients in the hypothesized path model, path analysis procedures was utilized. Table 1 show the various path coefficients (expressed in beta weights) in the path model and their level of significance. Path whose coefficients are significant at .05 probability level were retained otherwise, they were trimmed. This made it possible to have the most meaningful model.

Table 1 shows the paths in the hypothesized recursive model, the standardized path coefficients and the level of significance for each of the path coefficients. The result showed that the standardized path coefficients ranged from -.036 for P41 to .429 for P21. The result further revealed that out of the six paths in the hypothesized model, two paths (P21 and P42) were significant at .05 levels. On the basis of the theory meaningfulness of a model, the paths P32 and P43 were retained while the other two paths (P31 and P41) were trimmed out since they were considered weak and thus not strong enough to be included in the new model.

Table 1:A Table showing Path Strengths and Significance Levels (P-Values) of the Independent Variables in the Study that explains Pre-Service Teachers' Achievement in   Education Statistics

Paths	Beta weights (β)	p-value
P_{21}	.429*	.000
P_{31}	.006	.921
P_{32}	.104	.077
P_{43}	.073	.167
P_{42}	.151*	.010
P_{41}	-.036	.538

*Significant at 0.05 level

Structural Equations for the New Parsimonious Model

The resulting path equations arising from the new most meaningful model are as follows:
X_1 = e_1
X_2 = $p_{21} X_1 + e_2$
X_3 = $p_{32} X_2 + e_3$
X_4 = $p_{43} X_3 + p_{42} X_2 + e_4$

Based on the above equations, the new hypothesized model was obtained as shown in Figure 2. The figure shows that only four out of the six hypothesized paths survived the trimming exercise.

Validation of the New Model

To verify the efficacy of the new model, the reproduced correlation coefficient (using the new path equations) were compared to the original correlation coefficients as shown in Table 2. Table 2 shows that the discrepancies between the original and reproduced correlation are very negligible and thus is an indication that the pattern of correlation in the observed data is consistent with the most meaningful model.
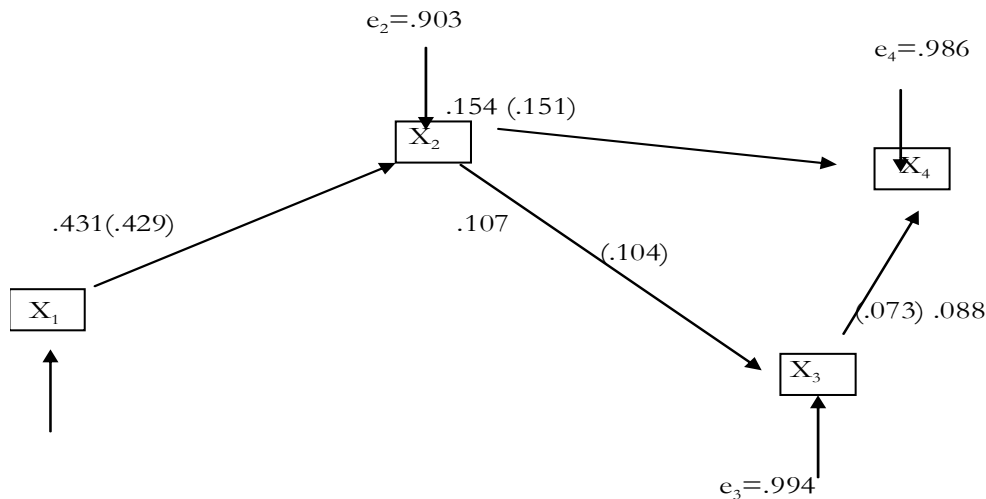
Figure.2: The most meaningful model in the study

Table 2: The Original and Reproduced Correlation Matrix of Pre-Service Teachers' Statistical Reasoning, Attitude towards Statistics, and Learning Approach on Achievement in Educational Statistics

	1	2	3	4
1	1.000	.431	.051	.033
2	.429	1.000	.107	.154
3	.045	.104	1.000	.088
4	.069	.159	.089	1.000

Discussion of Findings

The results of path analysis in Table 1 revealed a significant composite effect of pre-service teachers' statistical reasoning, attitude towards statistics and learning approach on achievement in educational statistics. The results of the regression ANOVA showed that the test is statistically significant ($F=3.241$, $p<0.022$) at 0.05 level of significance. The predictive equation arising from the analysis in Table 1 showed that learning approach is a significant direct predictor ($\beta=.225$, $t=2.581$, $p<0.010$) at 0.05 level of significance of pre-service teachers' achievement in educational statistics as such, it contributed highly in its' individual and composite capacity to the predictive equations. Since the magnitude of beta weights is taken to be directly proportional to the degree of effects of the independent variable, it can be seen from Table 3 that two variables ($X2$ and $X3$) have direct causal effect on students' achievement in educational statistics. In all, the direct effect is about 81.45% while the indirect effect is only 18.55%.

Table 3: Proportion of Total Direct and Indirect Effects of the Variables in the Study

S/N	Variable	Total effects	Direct effects	% of direct effect	Indirect effect	% of indirect effect
1.	Attitude towards statistics	.033	-	-	.033	12.00
2.	Learning approaches	.154	.151	54.91	.003	1.09
3.	Statistical reasoning	.088	.073	26.54	.015	5.46
	Total	**.275**	**.224**	**81.45**	**.051**	**18.55**

Conclusion

Based on the outcomes of this study it could be concluded that pre-service teachers' statistical reasoning, attitude towards statistics and learning approach had significant influence on achievement in educational statistics. This implies that achievement in educational statistics can be explained based on the variables in the study and thus, the investigators posits that in order to change students' achievement in educational statistics, a direct causal change would be more meaningful and spontaneous than the indirect strategy.

Recommendations

In order to enhance students' achievement in educational statistics, statistics teachers/ instructors should adopt more practical teaching strategies that would encourage students to develop positive attitudes and adopt learning approaches that will enhance their achievement in the subject. This can be actualized by giving students learning tasks in form of projects, classroom paper presentations which would make them to focus on the main ideas, principles, and subsequent applications. In addition, the government through statistics institutions and statistics agencies such as the National Bureau of Statistics should draw up statistics curriculum that would incorporate in the teaching of statistics practical projects that would help the students to draw on real life experiences in order to solve statistics puzzles.

More so, statistics departments in schools and statistics agencies such as National Bureau of Statistics should organize regular seminars and workshops to counsel students on the importance of statistics to any economy. Such seminars and workshops should lay emphasis on learning strategies that will encourage deep approach vis-à-vis surface learning approach to learning which is a catalyst to higher achievement in statistics as well as measures of developing positive attitude of students towards statistics.

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