Path Analysis of Student-Related Factors Affecting Academic Achievement in Chemistry among College of Education Students in Delta State

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Abstract

The study focused on the path analysis of student-related factors affecting academic achievement in chemistry among college of education students in Delta state. One research question and one hypothesis guided the study. The design adopted for the study was correlation survey with path-analytic research background. The population of the study was 1, 274 chemistry education students in Colleges of Education in Delta state. A sample of 200 SS 2 chemistry education students was involved in the study. The instruments for data collection were Chemistry Test Anxiety Questionnaire (CTAQ), Academic Motivation Scale (AMS), Chemistry Self-Efficacy Scale (SES), Study Habit Scale (SHS), Chemistry Attitude Scale (CAS), Academic Resilience Scale (ARS), Chemistry Interest Scale (CIS), Emotional Intelligence Questionnaire (EIQ), Self-regulated Learning Skills Questionnaire (CSRLSQ), Self-esteem Scale (SES). The instruments were validated by experts in relevant fields. The reliability of the instruments were established using Cronbach Alpha. The data obtained were analyzed using multiple regression analysis, multiple correlations, path analysis and analysis of moment structures. The findings of the study revealed that the joint predict of the 10 variables of achievement in chemistry was significant. The study also found out that the most meaningful path model for predicting achievement in chemistry involved the elimination of attitude and emotional intelligence after trimming the just-identified model. The study recommended that diagnostic analysis of student-related variables should be carried out at the point of admission and as the student progress academically by student affair departments in colleges of education in order to find out the areas the student may need orientation, guidance or counseling.

Keywords: Path-analysis, chemistry achievement, student-related factor, college of education

Introduction

Chemistry is the study of the composition, properties and changes and uses of matter that form the environment around us. The study of chemistry both at the senior secondary and tertiary education levels of education has however been bedeviled by serious and appalling notes. The problem of poor achievement in chemistry is compounded by the fact that fact that students carry the same poor knowledge and understanding of chemistry concepts to the tertiary institution. It is not expected that students should perform better at the tertiary level when they

have no basic understanding and foundation in chemistry. One becomes more disturbed seeing that research studies to improve on the implicated factors to students' achievement in chemistry (example teaching methods and innovations in instructional strategies) have been ongoing. The fundamental question therefore is: what factors actually predict students' achievement in chemistry.

Literature shows that such factors that predict and affect students' achievement could be environmental, psychological, social, cognitive, assessment, teacher, school, parent, location or student related (Hattie, 2009; Kocakaya & Gonen, 2012). Studies have been conducted in all the related factors predicting students' achievement but no proper attention has been given to how these factors interact to predict achievement. There is need therefore, to change the focus of research and channel studies on the causal paths to the prediction of achievement for some selected variables implicated in literature. Some of such student-related variable include academic resilience, attitude, study habit (Bajwa, Gujjar, Shaheen & Ramzan, 2011), self-efficacy and motivation (Mohamed, Mustafa, Abdullah & Hamdan, 2013). The present study focused on students' variables namely: motivation, self-efficacy, study-habit, attitude and academic resilience determined the causal paths of these variables in predicting achievement in chemistry through a path analysis.

Path analysis is a method employed to determine whether or not a multivariate set of non-experimental data fits well with a particular (a priori) causal model (Wuensch, 2016). Structural relations are the hypotheses about the directional effect or causal relationships of multiple variables. In path analysis, the cause and effect relationships between variables are expressed by means of a path coefficient. According to Niemczyk (2014), the coefficient informs which part of the variability of a dependent variable is expressed by the variability of the independent variable assuming the constancy of the remaining factors. Path analysis finds application in all disciplines but has barely been applied in the field of education in Nigeria.

The present study is necessitated by the facts that not only do the student-related variables such as motivation, self-efficacy, study-habit, attitude and academic resilience predict achievement individually but that they may also interact through different pathways to predict achievement of chemistry students. The interaction is informed by research findings, learning theories and principles of temporal order. However, to validate the nature of the interaction, one has to build a path model of the variables and trim the model for only those variables that meaningfully and significantly predict achievement in chemistry through different causal paths. Thus, the present study proposed a hypothetical model wherewith motivation, self-efficacy, study-habit, attitude and academic resilience all interact to predict achievement in chemistry.

The on-going discourse shows that achievement in chemistry could be predicted by a number of student-related variables through different path ways. Such factors affecting students' achievement in chemistry may do so directly or indirectly. The understanding therefore, of the causative paths, the weights (path coefficients), direct and indirect effects, and the most meaningful model for predicting students' achievement in chemistry is a worthwhile quest.

Purpose of the Study

The purpose of the study was to determine the path analysis of students-related factors affecting academic achievement in chemistry among college of education students in Delta state. Specifically, the study determined:

1. The most meaningful causal model (test anxiety, motivation, self-efficacy, study-habit, attitude, academic resilience, emotional intelligence, self-regulated learning, self-esteem and interest) for the academic achievement of students in chemistry.

Research Question

What is the most meaningful causal model (test anxiety, motivation, self-efficacy, study-habit, attitude, academic resilience, emotional intelligence, self-regulated learning, self-esteem and interest) for the prediction of academic achievement of students in chemistry?

Hypothesis

The extent of prediction of academic achievement in chemistry by the selected factors: test anxiety, motivation, self-efficacy, study-habit, attitude, academic resilience, emotional intelligence, self-regulated learning, self-esteem and interest is not significant ($P < 0.05$).

Formulating the Hypothesized Causal Model

The researcher formulated the confirmatory causal models based the principles for generating a hypothesized causal model namely: temporal order, research findings, theories of learning and opinion or position of researchers and authors. The resultant structural equations from the hypothesized effects of the ten explanatory variables ($X_1 \ldots X_{10}$) and their prediction of the criterion variable (X_{11}) is given in the equation:

$$X_{11} = \beta_1 X_1, \beta_2 X_2 \ldots\ldots\ldots \beta_{10} X_{10}$$

Where;
X_{11} = Academic achievement in chemistry
$X_1, X_2 \ldots\ldots X_{10}$ = Predictor (explanatory, independent) variables
$\beta_1, \beta_2 \ldots\ldots\ldots \beta_{10}$ = Associated Beta Weight (Path Coefficients)

Nine structural equations resulted from all the hypothetical linkages as shown the input path diagram of the causal model of the eleven variables system in figure

$$X_1 = P_{15}X_5 + \varepsilon_1$$
$$X_2 = P_{21}X_1 + \varepsilon_2$$
$$X_3 = P_{32}X_2 + P_{38}X_8 + \varepsilon_3$$
$$X_4 = P_{41}X_1 + P_{42}X_2\, P_{45}X_5 + P_{46}X_6 + P_{47}X_7 P_{49}X_9 + \varepsilon_4$$
$$X_5 = P_{53}X_3 + P_{57}X_7 + \varepsilon_5$$
$$X_6 = P_{62}X_2 + \varepsilon_6$$
$$X_9 = P_{92}X_2 + \varepsilon_9$$
$$X_{10} = P_{103}X_3 + P_{108}X_8 + \varepsilon_{10}$$
$$X_{11} = P_{111}X_1 + P_{112}X_2 + P_{113}X_3 + P_{114}X_4 + P_{115}X_5 + P_{116}X_6 P_{117}X_7 + P_{118}X_8 + P_{119}X_9 P_{1110}X_{10} + \varepsilon_{11}$$

The equation above implies that academic achievement will be predicted by all the ten explanatory variables though the path shown in the path model in Figure 1.

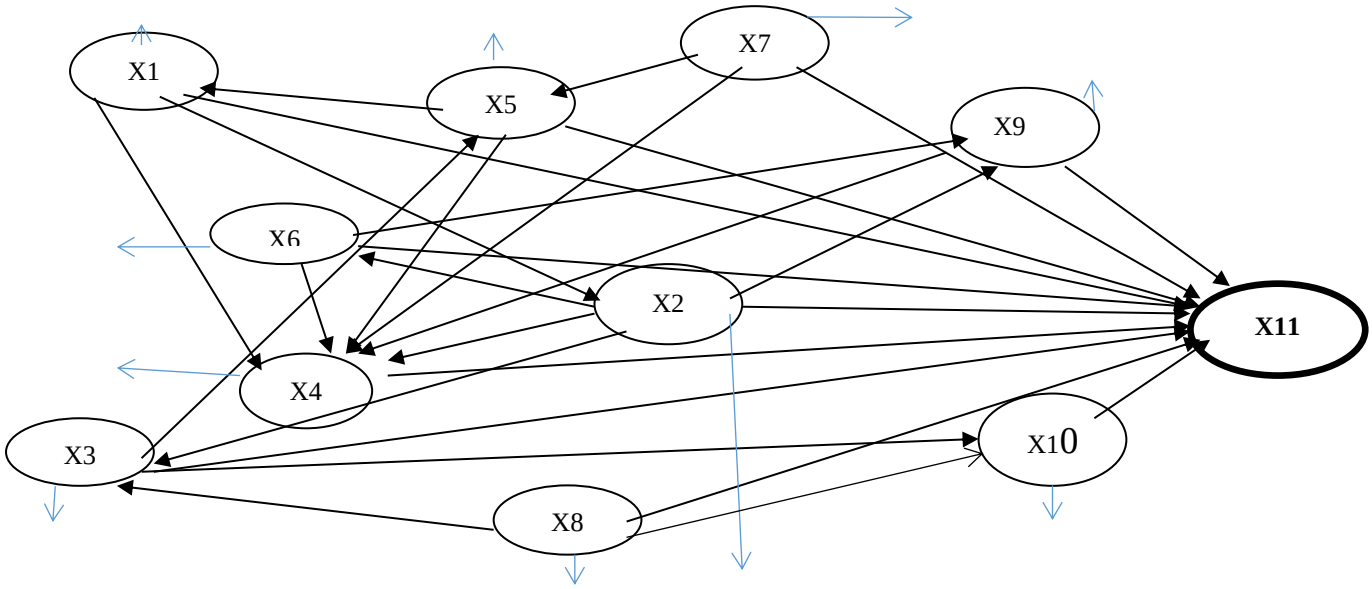


Figure 1: Hypothesized Diagram of Causal Model of an 11 Variables System Method

The design of the study is correlation survey with path-analytic background. The population of the study was 1, 274 (723 males and 551 females) chemistry students in Colleges of Education in Delta State. The sample size for the study was 200 chemistry students. The instruments for the study data collection are: Chemistry Test Anxiety Questionnaire (CTAQ), Academic Motivation Scale (AMS), Chemistry Self-Efficacy Scale (SES), Study Habit Scale (SHS), Chemistry Attitude Scale (CAS), Academic Resilience Scale (ARS), Chemistry Interest Scale (CIS), Emotional Intelligence Questionnaire (EIQ), Self-regulated Learning Skills Questionnaire (CSRLSQ), Self-esteem Scale (SES).

Chemistry Test Anxiety Questionnaire (CTAQ) is a 20 item questionnaire adapted from the Mathematics Test Anxiety Scale developed by Chukwu (2014). The major adaptation was changing the word 'mathematics' to 'chemistry'. Academic Motivation Scale (AMS) was adapted from Njiru (2003) who developed a scale for measuring academic motivation using the Rasch Model. The modification to the original instrument was the removal of the aspects

and sub-aspects while retaining the items since the study is not interested in the various dimensions of motivation measurement. Chemistry Self-Efficacy Scale (CSES) was adapted from the Webb-Williams (2006) self-efficacy scale. The instrument required the students to rate their belief or perception that they are capable of performing specific chemistry task on a scale of one (not at all) through five (very well). Study Habit Scale (SHS) was adapted from Gordon (2002). The instrument was designed to generate information on study habit, requiring the students to rate and indicate how each habit applies to them using a five-point response scale. The scale ranged from Never (1) through, to Very Often (5). Chemistry attitude Scale (CAS) was adapted from Myra's (2006) 42-item Chemistry Attitude Survey and Jassem's (2014) 21-item attitude questionnaire. The researcher adapted items from both questionnaires to form the 30 items in CAS. Items from both instruments were paraphrased. CAS requires the students to state their degrees of agreement to statements that describe their attitude to chemistry on four-point scale. The scales ranged from are Strongly Agree (SA) to Strongly Disagree (SD). Academic Resilience Scale (ARS) is 30-item scale on which the students are to rate the academic resilience on a five-point scale. The scale ranges from likely (5 points) to unlikely (1 point). Chemistry Interest Scale (CIS) is a 20-item scale developed by the researcher. The response scale ranged from very much likely to unlikely.

Emotional Intelligence Questionnaire (EIQ) adapted from Mayer, Salovey, and Caruso (2004) Emotional Intelligence Test (MSCEIT) is a 36 items questionnaire with a four-point scale ranging from SA to SD. EIQ requires the students to indicate their degree of agreement or disagreement with the statements. Chemistry Self-Regulated Learning Skills Questionnaire (CSRLSQ) was adapted from Maruff (2010) Distance Learners' Self-Regulations Skills Scale (DLSRSI). CSRLSQ is a 15-item scale drawn on four-point response scale ranging from SA to SD. Self-Esteem Scale (SES) is adopted from the Rosenberg (1965) self-esteem scale as re-validated Okwaraji, Nduanya, Obiechina, Onyebueke and Okorie (2018) using Nigerian

students. SES requires the students to give a self-report by rating themselves on the ten items with four-point response scale ranging from SA to SD. The instrument is composed of negatively and positively worded items that describe students' academic resilience on which the students are to rate their degrees of resilience based on the statements.

The instruments were validated by three experts from Nnamdi Azikiwe University, Awka. The reliability of each instrument was established using single administration method. The generated scores were subjected to Cronbach alpha technique. The coefficients of internal consistency obtained for the instruments are: 0.67 for AMS, 0.81 for CSES, 0.62 for SHS, 0.91 for CAS, and 0.78 for ARS. The instruments were administered with the aid of four research assistants. All relating to the study were analyzed using Analysis of Moment Structures (AMOS) and Statistical Package for Social Sciences (SPSS) version 25. Data relating to the research questions and hypotheses were analyzed using confirmatory causal modeling involved multivariate analytical techniques of multiple regression (zero-order, backward or stepwise elimination procedure) and path analysis. The hypothesis was tested at 0.05 level of significance. The decision was where P-value or t-value is less than or equals 0.05, reject null hypothesis, otherwise, do not reject. The proposed equation of prediction was:

$$Chemistry\ Achievement\ (CA) = a + b_1TA_1 + b_2MT_2 + b_3SE_3 + b_4SH_4 + b_5AT_5 + b_6AR_6 + b_7IT_7 + b_8EI_8 + b_9SR_9 + b_{10}ST_{10}$$

Where: $b_{1\text{-}10}$ = regression weights of the relative contributions of the predictor variables and TA = Test anxiety, MT = Motivation, SE = Self-efficacy, SH = Study habit, AT = Attitude, AR = Academic resilience, IT = Interest, EI = Emotional Intelligence, SR = Self- regulated learning skills and ST = Self-esteem.

Results

The hypothesized model shown in Figure 1 is reproduced as Figure 2 with the path coefficient and the zero-order correlation coefficients (standardized beta coefficients) and as Figure 3 with no standardized beta coefficients.

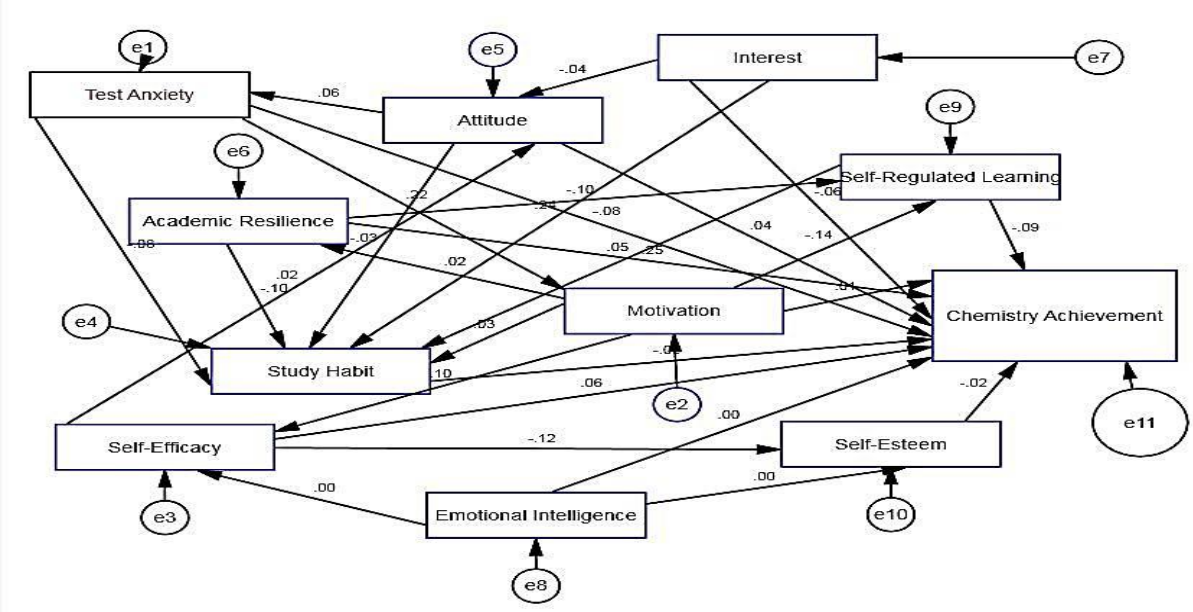


Figure 2: Just-Identified (Full, Saturated) Path Model of an 11 Variables system showing Path Weights using Standardized Beta Coefficient

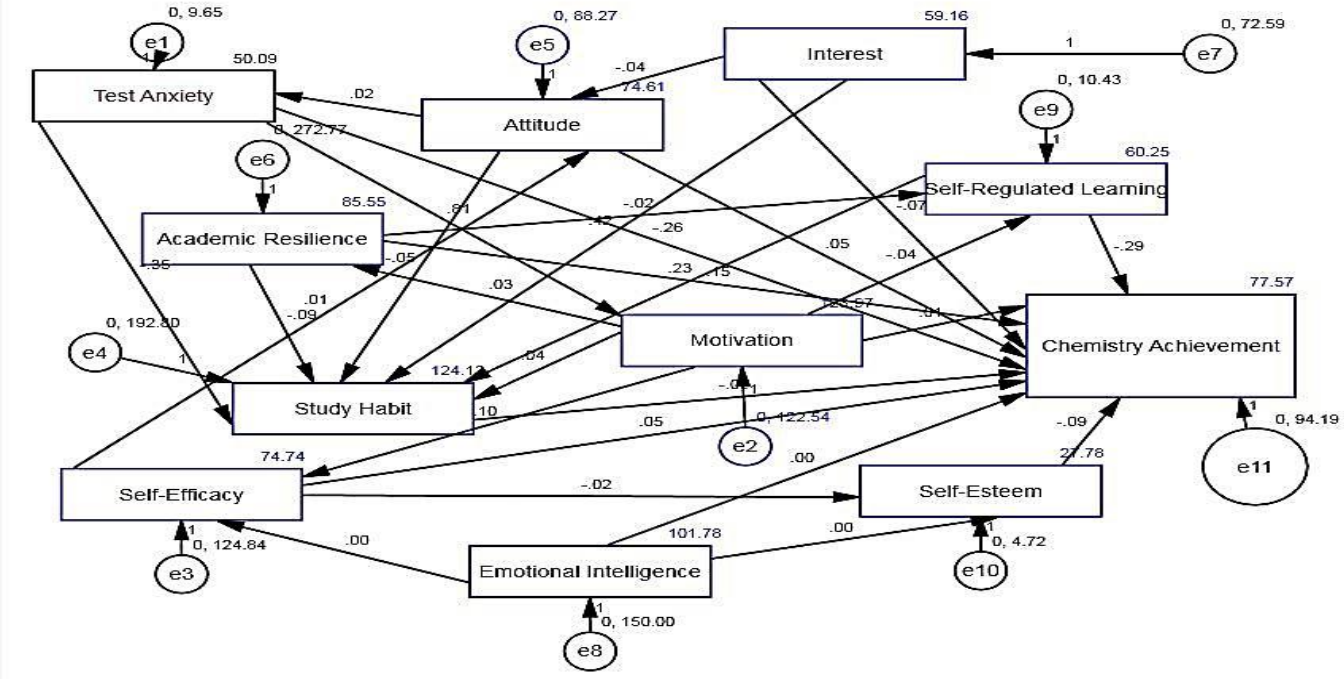


Figure 3: Just-Identified (Full, Saturated) Path Model of an 11 Variables system showing Path Weights using Non-standardized Beta Coefficient, Variances and Residual Values

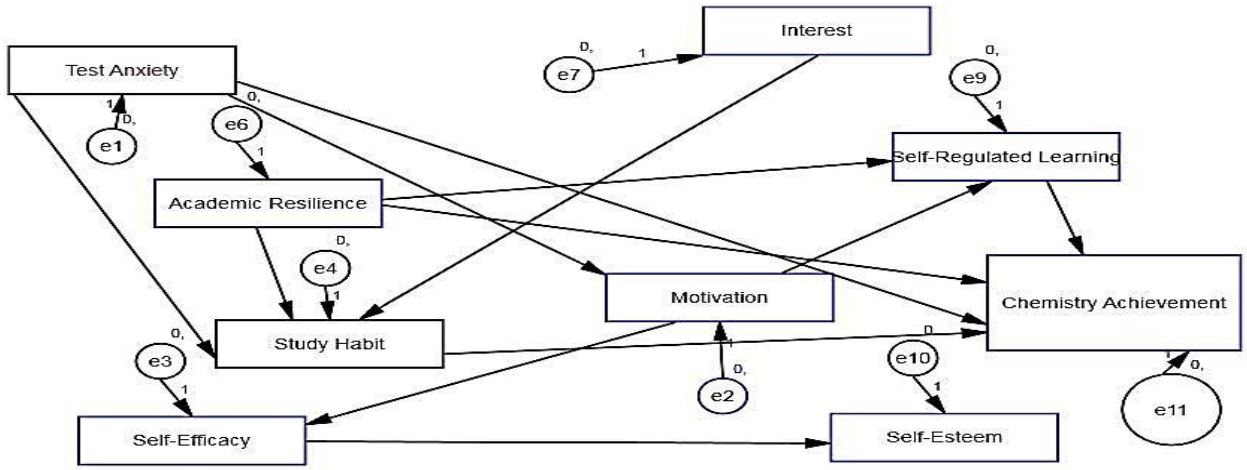


Figure 4: Over-Identified (Reduced) Path Model of 11 Vars System showing the most causal model of student-related variables affecting achievement in chemistry

Key: MS = meaningful and significant; M = Meaningful

To trim the paths in the model, paths and path coefficient are considered meaningful if path coefficient is less than 0.5 and paths are considered significant if the P value is less than 0.05. The decision for each path and their path coefficients is shown in Table 1.

Table 1: Meaningfulness and Significance of Paths and their Coefficients

S/N	Paths	Path Coefficients	P-value	Decision
1	P111	-.078	.017	MS
2	P112	.006	.931	M
3	P113	.056	.431	M
4	P114	-.048	.014	MS
5	P115	.042	.554	M
6	P116	.246	.001	MS
7	P117	-.059	.423	M
8	P118	-.002	.974	M
9	P119	-.095	.005	MS
10	P1110	-.020	.781	M
11	P103	-.118	.009	MS
12	P108	-.003	.968	M
13	P92	-.139	.046	MS
14	P96	-.104	.001	MS
15	P62	.022	.754	M
16	P53	.017	.810	M
17	P57	-.039	.579	M
18	P41	-.076	.027	MS
19	P42	.030	.671	M
20	P45	-.032	.639	M
21	P46	-.104	.008	MS
22	P47	.244	.000	MS
23	P49	.052	.454	M

24	P32	.101	.044	MS
25	P38	.001	.986	M
26	P21	.221	.001	MS
27	P15	.059	.403	M

Based on the criteria, the hypothesized path model (just-identified model) is reproduced with the 12 meaningful and significant paths in Figure 4.

Table 2: Analysis of Variance (ANOVA) of the Regression

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Regression	1939.306	10	193.931	1.946	.041 [b]
Residual	18838.614	189	99.675		
Total	20777.920	199			

a. Dependent Variable: Achievement
b. Predictors: (Constant), ST, EI, MT, AR, AT, SR, IT, SE, TA, SH

Table 2 shows that the R^2 value of .093 obtained from the regression analysis is significant. At 10df numerator and 199df denominator, the F-value is 1.946 with a P-value of 0.41 which is less than 0.05. The null hypothesis is therefore rejected. Thus, the extent of prediction of academic achievement in chemistry by the selected factors: test anxiety, motivation, self-efficacy, study-habit, attitude, academic resilience, emotional intelligence, self-regulated learning, self-esteem and interest are significant.

Discussion

The findings of the study showed that the most meaningful causal model for predicting students' achievement in chemistry by student-related factors has 12 pathways, with discrepancies between original and reproduced correlation matrix implying that the observed data is consistent with the new model. Thus, achievement in chemistry can be predicted: directly by test anxiety but also indirectly through the pathways of motivation to self-regulated learning, study-habit; directly by academic resilience but also indirectly through self-regulated learning, study-habit; directly by study habit and self-regulated learning. It is important to know that the prediction of achievement in chemistry by self-regulated learning and study habit is because they have a common antecedent which is academic resilience, thus, their interaction is

spurious. Study habit interacts with interest, a latent exogenous variable in the model in predicting achievement in chemistry. Motivation interacts directly with self-regulated learning skills in predicting achievement in chemistry but indirectly with self-efficacy which is interacting with another latent variable, self-esteem. The interaction of motivation which is both direct and indirect with variables preceding before and proceeding after it in the model made the new path model non-recursive. The elimination of emotional intelligence and attitude from the model does not imply that they do not predict achievement in chemistry but suggests that they are highly collinear with other variables in the path model. The findings of the study show that there are four direct and eight indirect pathways representing 30% and 21.25% of the total effects of the selected variables in prediction achievement.

The findings of the study further reveals that the reproduced path model for predicting achievement in chemistry fit the data significantly. The model therefore fits the data and is considered tenable in explaining the pathways through which the selected student-related variables predict achievement in chemistry. The most meaningful pathways however, are those that have interaction with academic resilience, self-regulated learning skills, test anxiety and study habit. The findings of the study support that finding of Saddler and William (1993) whose path model for predicting achievement revealed that study habit interacted with other variables in the model while predicting achievement directly. The findings of the study also support that of Asanee (2013) whose model showed that self-regulated learning and achievement have a common antecedent.

Conclusion

The study conclude that academic resilience self-regulated learning skills, study habit and all their pathways are very keys in the achievement of chemistry students.

Recommendations

Based on the findings of the study, the following recommendations are made:

1. Academic institutions should organize orientation exercise for fresh chemistry students at the point of admission to teaching them about the need for academic resilience and well-formed study pattern. Such orientation should also emphasize the importance of developing a facilitating test anxiety towards assessments.
2. Diagnostic analysis of student-related variables should be carried out at the point of admission and as the student progress academically by student affair departments in colleges of education in order to find out the areas the student may need orientation, guidance or counseling.

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