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A Causal Model of Selected Non-Cognitive Learner's Variables and Achievement in Junior Secondary School Mathematics

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Abstract
This study investigated a causal modelwas used to investigate and explain the direct and indirect effects of eight non-cognitive learner's variables (gender, socio-economic status, self-concept, gender-stereotype, motivation, attitude towards mathematics, self-confidence and problem solving habits) on students' mathematicsachievement. The sample consists of 312 Junior Secondary School Two (JSS II) students drawn from four co-educational schools using purposive sampling technique. Two research instrumentsnamely Student Affective Variable Questionnaire (SAVQ) and Mathematics Achievement Test (MAT) were constructed and validated for data collection.Pathanalysis technique was applied to estimate the coefficients of the structural equations of the hypothesized causal model. The results of the study revealed that the hypothesized causal model is tenable and that socio-economic status,gender-stereotype, motivation, self-confidence and problem solving habits contributed through both direct and indirect effects to students' achievement in mathematics. Finally, attitude towards mathematics only contributed through direct effect to students' achievement in mathematicswhile gender and self-concept contributed to students' achievement in mathematics through indirect effect only.
Keywords: Causal model, direct effect, indirect effect, mathematicsachievement, junior school mathematics.

1. Introduction

Learning in mathematics,is not solely a cognitive affair. A better understanding of the relationship between teaching/learning strategy and outcomes in the cognitive and affective domains seem imperative. There is the need therefore, to improve upon the instructional strategies and develop curriculum that willproduce better learners and creative thinkers. Among such variables that have been found to be related to achievement are: self-concept, gender-stereotype, self-confidence, motivation, attitude towards mathematics and problem solving habits which were considered in this study.

Educators, policy-makers and researchers have long been expressing concern about the under-representation of women in the study of mathematics andmathematics related careers (Leder, 1992).Walford (1980) had earlier submitted that the poor representation of females might not be unconnected with the masculine image given to science subjects especially physics and mathematics. Onocha (1985) reported a non-significant direct effect of gender difference on academic achievement but concluded that gender in conjunction with other home variables influenced academic achievement. However, Fennema and Sherman (1978), Osafehinti (1984) and Fordham (1993) in their studies reported that gender difference predicts academic achievement in favour of male students. The contribution of socio-economic status (SES) to academic achievement was also investigated in this study since SES has long been offered as a primary factor that contributes to the observed differences in student's academic achievement (Thomas, Sammons, Mortimore & Smees, 1997).

Osafehinti (1984) and Onocha (1985) reported that SES affects academic achievement while Erinosho (1988), Wentzel and Feildman (1993) as well as Wilkins (2004) went further to say that parentaleducation and occupation contributed largely to the observed variance or differencein students' academic performance. The academic environment provided by homes where parents are highly educated will favour the children to attain high level of performance in school. High SES parents are able to employ teachers for their wards and Osafehinti (1984) reported that this extra lesson is highly correlated with achievement. A plausible explanation for the observed discrepancies on the effect of SESon achievement might be due to the cultural, social and environmental settings under which the studies were conducted and the variations in research methods adopted.

Research studies on children's school related attitude and their attitude have yielded inconsistent results. Theattitudes of a learner towards mathematics determine the learners' attractiveness or repulsiveness to mathematics which in turn affect the learner's choice and achievement in mathematics (Yoloye, 1999). Chacko (1981) and Aiyelagbe (1989) reported a significant positive effect of attitude on achievement while on the contrary Aghadiuno (1992) and Ogunwuyi (2000) both reported a negative non-significant relationship between attitude and achievement.Theconflicting results obtained from research studies have led to conflicting theories on the casual relationship existing between attitude towards mathematics and achievement. Gordia (1982) reported that when meaningful methods of teaching mathematics are used, change in attitude towards mathematics could be effected since a change in attitude towards mathematics involve the interplay of many variables such as method of instruction, teacher's characteristics, student characteristics, course content, parental and peer influence and the methods used in measuring these changes..

Thestudy alsoexamined the effect of self-concept as a personality construct on the students' achievement. Pascarella(1985) and Bachman, O'Malley and Johnson (1986) reported a non-significant relationship between students' academic achievement and their self-concept of ability. However, Yoloye (1999) reported that self-concept influences students' attitude, learning and performance in a subject. Problem solving habits was also considered in this study as one of the key research areas which has attracted a lot of interest. Ajogbeje (2012) opined that students do not learn how to solve problems but merely memorize solutions explained by teachers in line with the traditional method of teaching. Mathematics as a subject is computational and quantitatively inclined, hence the researcher considered problem solving habits as a possible influential factor affecting students performance in mathematics in this study.

Ajogbeje (2012) sees students' self-confidence as a potential factor affecting students' achievement. Confidence may be looked at as the lack of fear. Ashcraft and Faust (1994) and Levine (1995) opined that mathematics anxiety is the feeling of tension, helplessness, mental disorganization and dread one has when required to manipulate numbers, shapes and solve mathematical problems. Jackson and Leffingwell (1999) also linked mathematics anxiety to prior experience withformal instruction in mathematics at the elementary and secondary level while Satake and Amato (1995) and Ma (1999) reported a significant relationship between mathematics anxiety and mathematics achievement. Tapia (2004) also reported that students with low mathematics anxiety scored significantly higher in motivation than students with high mathematics anxiety. Finally, Okoye (1985) opined that motivation holds the keyto the understanding of humanbehavior while Broussard and Garrison (2004) as well as Skaalvik and Skaalvik (2004, 2006) reported that a significant relationship exists between academic performance andmotivation

Availableliteratures revealed that researches had not attained a reasonable degree of success in identifying the causal relationshipsand strengths of interactions between these variables (self-concept, gender-stereotype, problem solving habits, self-confidence, motivation and attitude towards mathematics) and achievement. This study therefore explored the direct and indirect contributions and the causal relationship between the following variables: gender-stereotype, self-concept, problem solving habits, self-confidence, motivation and attitude towards mathematics on students' achievement in mathematics

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2. Research Questions

Thestudy was designed to addressthe following research questions:

1. To what extent will the eight selected non-cognitive learners' variables acting together predict students'achievement in mathematics?
2. What are the relative contributions of the individual non-cognitive learners' variables to students'achievement in mathematics?
3. Which of the contributions from the eight selected non-cognitive learners' variables to students' achievement are through direct or indirect effects?
4. What proportions of the contributions of the eight selected non-cognitive learners' variables to students' achievement are through direct or indirect effect?

3. Research Method

The study employed ex-post facto research design. The sample for the study consisted of 312 junior secondary school two (JSS II) students selected from four co-educational junior secondary schools using purposive sampling techniques. Two research instruments namely: Students Affective Variable Questionnaire (SAVQ) and Mathematics Achievement Test (MAT) were used for the collection of all revelant data. The MAT is a forty multiple-choice achievement test with four options (A, B, Cand D) constructed by the researchers based on the depth coverage of the selected topics for discussion. The test was designed to assess learners' mastery or otherwise of the content covered during instruction. The SAVQ which was divided into two parts was designed to measure affective outcomes of respondents. Part A was designed to elicit information about the respondents' age, sex, parental' occupation and educational background while Part B contained sixty four-point scale (Strongly Agree, Agree, Disagree and Strongly Disagree) items divided into six sub-divisions designed to measure respondents' affective variables (self-concept, attitude towards mathematics, problem solving habits, gender-stereotype and self-confidence) and socio-economic status.

The face and content validities of MAT and SAVQ were ensured while the construct validity of SAVQ was established by trial testing a neat copy of the SAVQ on 96 JSS II students from two junior secondary schools outside the sampled schools. The two schools possessed all the criteria earlier used for the selected sampled schools. The convergence method of comparing measurements from two different groups of similar traits was used. Using Product Moment Correlation a high and significant convergence coefficient of 0.67 was obtained for SAVQ which shows that the instrument has construct validity. Areliability coefficient of 0.72was obtained for MAT using Kuder Richardson formula 21 (KR_{21}). Path Analysis was used to answer the research questions raised.

4. Results

Research Question 1: To what extent were the learners' variables acting together predict academic achievement in mathematics?

The total contribution of the nine learners' variable, the prediction of academic achievement in mathematics is as shown in Table 1.

Table 1: Regression of variable 9 on variables 1 to 8 Summary of regression analysis

R	R Square	Adjusted R Square	Standard Error of Estimate
0.621	0.402	0.382	6.205

Analysis of variance (ANOVA)

Source	Sum of Squares	df	Mean Square	F cal.	F tab.
Regression	4155.078	8	519.385	19.602	2.016
Residual	8028.187	303	26.496		
Total	12183.265	311			

The results showed that the nine independent variables jointly contributed 0.621 to the prediction of students' achievement in mathematics. They jointly accounted for 40.2% of the total variance ($R^2 = 0.402$) in the achievement of the students. That is, the fitted model explains only 40.2% of the total variation in students' achievement in mathematics. The F-ratio ($F = 19.602$) showed that the variance of the dependent variable was highly significant.

Research Question 2: What was the relative contribution of the individual learners' variables to the prediction of academic achievement in mathematics?

The relative contribution of the individual learners' variable to the prediction of students' academic achievement in mathematics is as shown in Table 2.

Table 2: Relative contribution of nine learners' variables to the prediction ofachievement in Mathematics

Variables	Beta	Remark
Gender (X_1)	-0.012	NM
Socio-Economic Status (X_2)	0.128	M
Self-Concept (X_3)	0.006	NM
Gender-Stereotype (X_4)	-0.051	M
Motivation (X_5)	0.130	M
Self-Confidence (X_6)	0.068	M
Problem Solving Habits (X_7)	0.072	M
Attitude towards Mathematics (X_8)	-0.174	M

M = Meaningful NM = Not Meaningful

The results showed that only six variables SES ($\beta = 0.128$), gender-stereotype ($\beta = -0.051$), motivation ($\beta = 0.130$), self-confidence ($\beta = 0.068$), problem solving habits ($\beta = 0.072$), and attitude towards mathematics ($\beta = -0.174$) contributed significantly and meaningfully to the prediction of academic achievement in mathematics while self-concept ($\beta = 0.006$) and gender
($\beta = -0.012$) had no meaningful contribution to the prediction of academic achievement in mathematics.

Research Question 3: Which of the contributions from the learners' variables to the prediction academic achievement in mathematics are through direct effect or indirect effect?

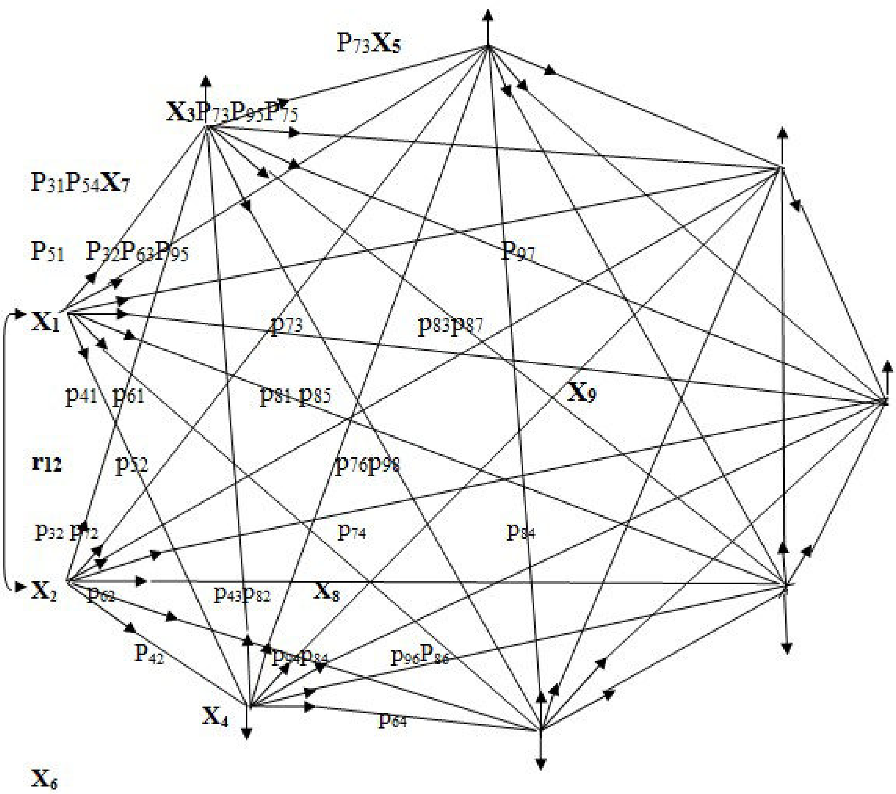
Table 3 revealed that the beta weights for the hypothesized paths ranged between – 0.185 for P54 and 0.256 for P85. Testing the significance of the path coefficient in the hypothesized recursive model at 0.05 alpha level of significance, 25 out of the 35 hypothesized paths met the criteria for significance.

Table 3: Paths, their coefficients and effects on mathematics achievement

Paths	Path Coefficient	Nature of path	Remark	Paths	Path Coefficient	Nature of path	Remark
P31	-0.013	-	NS	P75	0.192	Indirect	S
P32	-0.074	Indirect	S	P76	0.148	Indirect	S
P41	-0.027	-	NS	P81	0.061	Indirect	S
P42	-0.055	Indirect	S	P82	0.007	-	NS
P43	-0.065	Indirect	S	P83	-0.172	Indirect	S
P51	-0.021	-	NS	P84	0.234	Indirect	S
P52	0.014	-	NS	P85	0.256	Indirect	S
P53	-0.119	Indirect	S	P86	0.182	Indirect	S
P54	-0.185	Indirect	S	P87	0.058	Indirect	S
P61	-0.007	-	NS	P91	-0.012	-	NS
P62	-0.023	-	NS	P92	0.128	Direct	S
P63	-0.093	Indirect	S	P93	0.006	-	NS
P64	0.120	Indirect	S	P94	-0.051	Direct	S
P65	0.126	Indirect	S	P95	0.130	Direct	S
P71	-0.005	-	NS	P96	0.068	Direct	S
P72	-0.061	Indirect	S	P97	0.072	Direct	S
P73	-0.072	Indirect	S	P98	-0.174	Direct	S
P74	0.111	Indirect	S				

S – Significant NS – Not Significant

Table 3 also revealed that only those variables with standardized beta weight equal to or greater than 0.05 ($\beta \geq 0.05$) are considered as having direct effect on students' achievement in mathematics. The hypothesized model is presented in Figure 1.



Key: X_1 = Gender; X_2 = Socio-Economic Status; X_3 = Self-Concept; X_4 = Gender-Stereotype; X_5 = Motivation; X_6 = Self-Confidence; X_7 = Problem Solving Habits; X_8 = Attitude Towards Mathematics; X_9 =Mathematics Achievement.

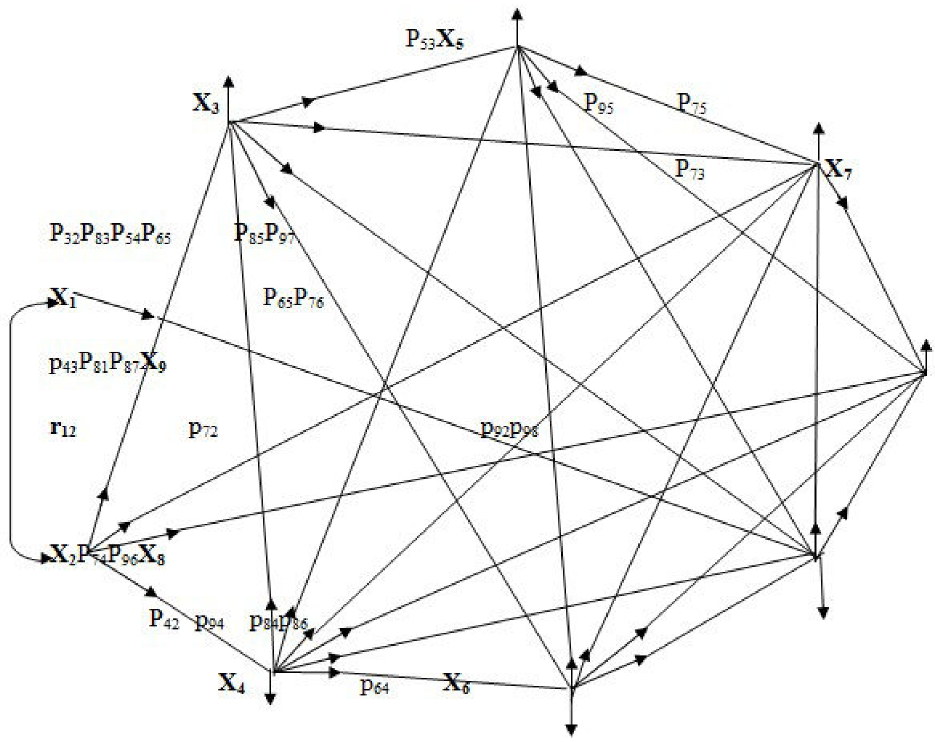
Figure 1: Hypothesized causal model for the ten variables with their path coefficients

Table 3 equally revealed that in trimming the paths in the hypothesized causal model, all the path coefficients that were not meaningful, that is, those path coefficients whose standardized beta weights were less than 0.05 were eliminated. Only those variables with standardized beta weight equal to or greater than 0.05 ($\beta \geq$

0.05) were considered as significant and meaningful at 0.05 level.

Research Question 4: What proportions of the contributions of the learners' variables to the prediction of academic achievement in mathematics are through direct or indirect effect?

The new path model obtained is presented in Figure 2 and only 25 out of the 35 hypothesized paths survived the trimming exercise. The trimming was done to produce a more parsimonious path model, that is, one with the minimum paths that would produce the same effect as the hypothesized path model.



Key: X_1 = Gender; X_2 = Socio-Economic Status; X_3 =Self-Concept;X_4=Gender-Stereotype;X_5 =Motivation; X_6 =Self-Confidence; X_7 = Problem Solving Habits; X_8 =Attitude Towards Mathematics; X_9 = Mathematics Achievement.

Figure 2: A more parsimonious causal model ofeightvariables and mathematics achievement

To verify the efficacy of the new model, the original correlation data were reproduced using the new set of normal equations generated and the computed path coefficients in the more parsimonious model. The original and reproduced correlation matrix is shown in Table 4.The original correlation coefficients occupy the upper half of the matrix while the lower half of the matrix represents the figures for the reproduced correlation coefficients.

Table 4: Original and reproduced correlation matrix for the prediction of mathematics Achievement

Var.	1	2	3	4	5	6	7	8	9
1		-0.013[a]	-0.009	-0.029	0.021	-0.001	0.005	-0.067	-0.004
2	-0.013[b]		-0.070	-0.072	-0.170	-0.074	-0.127	-0.027	0.193
3	0.002	-0.070		0.281	0.211	0.240	0.245	0.326	-0.068
4	0.004	-0.072	0.281		0.093	0.210	0.281	0.321	-0.122
5	0.004	-0.172	0.211	0.005		0.385	0.265	0.197	0.085
6	0.005	-0.084	0.249	0.200	0.385		0.314	0.212	0.047
7	0.003	-0.112	0.238	0.239	0.249	0.314		0.046	0.068
8	-0.061	-0.033	0.325	0.267	0.254	0.116	0.046		-0.168
9	0.007	0.196	-0.021	-0.077	0.147	0.079	0.117	-0.168	

The differences between the original and the reproduced correlations were minimal (less than 0.05) indicating that the pattern of correlation in the observed data are consistent with the more parsimonious model. The model was therefore considered tenable in explaining the causal interaction between the independent variables (X_1 to X_8) and the dependent variable (X_9). The thirty-five (35) hypothesized paths (Figure I) were reduced to twentyfive (25) significant and meaningful paths (Figure 2). The efficacy of the new model was established by reproducing the original correlation matrix of the variables, and differences between the original and the reproduced correlation was minimal, showing that the original correlation data was consistent with the new model. Hence the new model was retained.

Table 5 depicts the contributions of the eight selected variables and their effects (direct and indirect) on mathematics achievement. Table 5 equally reveals the total effect and the proportion of it that is direct and indirect respectively.

Table 5: Contributions of the eight independent variables to the prediction of mathematics achievement

Variables	Total Effect (TE) **A**	Direct Effect (DE) **B**	% of DE Relative to TE $\left[\frac{b}{Ta}x100\right]$	Indirect Effect (IE)	% of IE Relative to TE $\left[\frac{a-b}{Ta}x100\right]$
Gender (X_1)	0.011	-	-	0.011	4.089
Socio-Economic Status (X_2)	0.188	0.121	44.981	0.067	24.907
Self-Concept (X_4)	-0.026	-	-	-0.026	- 9.665
Gender-Stereotype (X_5)	-0.098	-0.052	- 19.331	-0.046	- 17.100
Motivation (X_6)	0.157	0.122	45.353	0.035	13.011
Self-Confidence (X_7)	0.089	0.058	21.561	0.031	11.524
Problem Solving Habits (X_8)	0.113	0.060	22.305	0.053	19.703
Attitude Towards Mathematics (X_9)	-0.165	-0.165	- 61.338	-	-
Total	0.269	0.144	53.531	0.125	46.469

The results show that two variables gender and self-concept had no direct effect on mathematicsachievement but they contributed 4.09% and – 9.67% respectively to students' achievement in mathematics through indirect effect. Attitude towards mathematics has no indirect effect on the criterion variable but contributed – 61.34% through direct effect to students' achievement in mathematics. Socio-economic status (SES), gender-stereotype, motivation, self-confidence and problem solving habits contributed 44.98%, –19.33%, 45.35%, 21.56% and 22.31% through direct effects and 24.91%, – 17.1%, 13.01%, 11.52% and 19.70% through indirect effects to students' achievement in mathematics. Finally, the nine independent variables taken together contributed 53.53% through direct effects and 46.47% through indirect effects to students' achievement in mathematics.

5. Discussion

The results of the study show that 40.2% of the total variance in students' achievement in mathematics was accounted for by the eightindependent variables. This implies that there other variables or major factors apart from these eight selected variables, which also contributed to the variation in students' achievement in mathematics. The efficient predictions of achievement in mathematics by these variables are in line with the findings of some studies which had identified each of the variables as predictors of achievement. For example, Onocha (1985) reported that SES significantly affects academic achievement. Osafehinti (1984) and Fordham (1993) unanimously agreed that gender predicts academic achievement. Similarly, Chacko (1981) reported a significant positive effect of attitude on achievement whereas findings from the studies carried out by Okwilagwe (1999),Umoinyang and Okpala (2001) as well as Ajogbeje (2012) show that affective factors predict students learning outcomes. Hence, the result obtained that the eight independent variables, when taken together, effectively predicted mathematics achievement among junior secondary students was expected.

In the new model,onlysix variables (SES, gender-stereotype, motivation, self-confidence, problem solving habits and attitude towards mathematics) out of the eight independent variables significantly and meaningfully determined students' achievement in mathematics either directly or indirectly or both, while the remaining two variables (gender and self-concept) only determined students' achievement in mathematics indirectly through other variables. Attitude towards mathematics had only direct effect on students' achievement in mathematics with a path coefficient of – 0.174 and its direct effect relative to the total effect accounted for – 61.34%. This finding agreed with Umoinyang and Okpala (2001) and Ajogbeje (2012) but contrasted that of Chacko (1981) and Aiyelagbe (1989) who observed a significant positive effect of attitude on achievement.

The results of the study also revealed that motivation had direct causal influence on achievement in mathematics with a path coefficient of 0.130. Its direct effect relative to the total effect accounted for 45.35%, while its indirect effect relative to the total effect also accounted for 13.01%. Ajogbeje (2012) opined that motivationindirectly affects students' achievement in mathematics through self-confidence, problem solving habits and attitude towards mathematics which supported the findings of Satake and Amato (1995) and Ma

(1999) which reported motivation to be a significant predictor of achievement.SEShad a path coefficient of 0.128 and its direct effect relative to the total effect accounted for 44.98%, while its indirect effect relative to the total effect accounted for 24.91%. SES indirectly affects students' achievement in mathematics through gender stereotype, motivation and problem solving habits. This finding agreed with that of Onocha (1985) who reported that socio-economic status influences academic achievement.

Self-confidence had a path coefficient of 0.068 with the direct effect relative to the total effect accounting for 21.56%, while the indirect effect relative to the total effect also accounted for 11.52%. This result agreed with the findings of Hallowell and Dutch (1991) who reported that the experimental group showed a significant gain in confidence about learning and performing well in mathematics than the control group.Self-confidencealso affects students' achievement indirectly through problem solving habits and attitude towards mathematics.Problem solving habits also had direct influence on students' achievement in mathematics with a path coefficient of 0.072. Thedirect effect relative to the total effect accounted for 22.31%, while the indirect effect relative to the total effect accounted for 19.70%. This result agreed with the findings of Shepardson (1991). Problemsolving habits indirectly affects students' achievement in mathematics through attitude towards mathematics.Gender-stereotype had direct influence on students' achievement in mathematics with a path coefficient of – 0.051 and the direct effect relative to the total effect accounted for – 19.33%, while the indirect effect relative to the total effect also accounted for – 17.10%. This result agreed with Fennema and Sherman (1978)and Maduabum (2006). Gender-stereotype indirectly affects students' achievement in mathematics through self-confidence, problem solving habits and attitude towards mathematics.

The result also revealed that self-concept had no direct effect on achievement but acted in conjunction with other variables. It had a path coefficient of 0.006 with the indirect effect relative to the total effect accounting for – 9.67%. The indirect effect of self-concept mediated through gender-stereotype, motivation, self-confidence, problem solving habits and attitude towards mathematics. This result agreed with Maruyuma, Rubin and Kingsburg (1981) who found no causal relationship between self-concept and achievement and Okwilagwe (1999) who found self–concept as a moderating variable, moderating the effects of other variables to bring about positive enhancement in achievement. However, the findings contrasted the findings of Aghadiuno (1992) as well as Umoinyang and Okpala (2001) that self-concept exerted a direct positive influence on academic achievement. A person's self-image was expected to be highly positive, as no individual would see himself as a failure. Rather, a person would consider himself as an ideal. Self-concept was found to have direct effect on problem solving habits. The findings of Yoloye (1999) and Okwilagwe (2001) agreed with this assertion and the finding was established on the basis that self-concept had been found to have a motivational component. When a student is properly motivated, his self-concept receives a boost, which invariably affects his problem solving habits, and in the long run indirectly affects his achievement in mathematics.

The study also revealed that gender acted in conjunction with other variables: SES, self-concept, gender-stereotype, motivation, self-confidence, problem solving habits and attitude towards mathematics singly or in groups to influence achievement in mathematics. It had a path coefficient of 0.012 with the indirect effect relative to the total effect accounting for 4.09%. This result supported the findings of Miller (1971). The finding that gender acted in conjunction with other variables also agreed with Onocha (1985). Therefore, the variations in students' attitude towards mathematics, SES, self-concept, gender stereotype, motivation, self-confidence and problem solving habits between male and female students account for the effects observed when gender acted through them.Finally, the results revealed that the direct effect relative to the total effect accounted for 53.53% while the indirect effect relative to the total effect accounted for 46.47% of the eight variables on achievement in mathematics.

6. Conclusion

Curriculum designers should take into cognizance both cognitive and non-cognitive variables while designing the learning tasks for learners in mathematics. The results of this study have shown that these non-cognitive variables play significant roles in learners' appreciation and subsequent learning of mathematics. Thereis need therefore to use methods/strategies and material/media which make mathematics learning very practical, active, investigative and adventurous. Such methods must take into account individual student characteristics such as motivation, self-concept, self-confidence and attitude towards mathematics as important factors influencing achievement in Mathematics.

7. Recommendations

The knowledge of the most meaningful causal model for students' achievement in Junior School Mathematics would be useful for the teachers and parents in identifying thosenon-cognitive learner's variables that should be encouraged and developed in the students to perform better in mathematics. Similarly, a knowledge of the non-cognitivelearner's variables that have significant and meaningful direct and indirect effects on students' achievement will provide the direction of efforts to the students to improve their achievement in mathematics. Studentsshould be exposed early in their Junior Secondary School to research based counseling sessions directed at improving their self-concept, problem solving habits, self-confidence and attitude towards mathematics.

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