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Multivariate Analysis of Factors Underlying Female under Representation in Learning Mathematics

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Abstract: ***In this paper, we present the factors underlying female under representation in the study of Mathematics among Senior High School students. This study was cross-sectional in design. Stratified random technique was used to select the sample. By using multivariate analysis, two hundred and ninety-eight (298) female students were selected with a response rate of 100% and questionnaires were administered to them. Some selected factors pertaining to the students' friends, parents, teachers and themselves that are underlying female under representation in learning mathematics were analysed for the study at $p < 0.05$. The results obtained showed that not all the selected factors were significant factors underlying Female Under Representation in Learning Mathematics. We also concluded that teachers should pay more attention to female students in and out of the classroom to raise their interest in learning Mathematics.***

Keywords: Multivariate, Female Under Representation, Mathematics, ANOVA, Students, Friends, Teachers, Parents.

1. Introduction

The development of a society can be judged by measuring the issues that extend gender differences in the educational system of the society. The prevalence of unequal distribution of education in male and female students hinders the development at every stage of a nation. Education is a vital tool in achieving greater autonomy, empowerment of women and men, boys and girls by addressing gender differences in the distribution of various available opportunities and resources. Mathematics is considered the gateway subject for academic development related to the fields of Science, Engineering, and Mathematics (STEM)

[11] and given the current emphasis on increasing our STEM workforce in order to facilitate innovation [4], analyses of gender and mathematics are relevant to the national policy agenda. This is particularly the case given mathematics has a controversial past when it comes to female representation. Unfortunately, national data show that the current picture of Ghanaian female representation in mathematics is not encouraging. Achievement of gender equity in education may require collaborative participation of learners (boys and girls), parents, communities and development partners, the civil society, private sector and the government.

Female Under Representation in mathematics has decreased considerably and is almost non-existent in developed countries such as USA, Japan, and Sweden but it exists in the Sub Saharan Africa which Ghana is part. The question bothering many mathematics educators is whether or not male superiority in mathematics for Senior High School students still exists in Ghana. However, [14] reported that in the nineties, the need to consider other theories and methods to examine gender difference became apparent. Attention has been shifted to the social and cultural processes that boys and girls are subjected to, which affect their Mathematics achievement, participation and performance. Today, female under representation in learning Mathematics continues to be a focus of interest and majority of studies suggest that there is a communal belief that males are better in Mathematics [14].

The purpose of this paper was to identify the factors underlying female under representation among senior high school students in the study of mathematics and to find strategic solution that could best address and alleviate the gender disparities in the study of mathematics among senior high school students in the Berekum Municipality.

The study applied Multivariate Analysis in identifying significant factors underlying female under representation in learning mathematics.

2. Literature Review

A study was undertaken by [1] to assess gender differences in mathematics achievement and retention by using Problem-Based Learning (PBL). The design of the study was pre-post-test quasi-experimental. Four hundred and twenty-eight senior secondary one (SS I) students using multi-stage sampling from ten grant-aided and government schools were involved in the study. Two hundred and sixty-one male students and one hundred and sixty-seven female students were taught algebra using PBL method of instruction. Algebra Achievement Test (AAT) constructed by the researchers was the main instrument used for data collection. Two hypotheses were raised for the study and tested using t-test at .05 level of significance. The study revealed that male and female students taught algebra using PBL did not significantly differ in achievement and retention scores, thereby revealing that male and female students are capable of competing and collaborating in mathematics. In addition, this finding showed that performance is a function of orientation, not gender. The studies recommend the use of PBL by mathematics teachers to overcome the male image of mathematics and enhance students' (male and female) achievement and retention. Guidance and counselling machineries in the school should be energized to encourage more female students' active participation in effective

mathematics learning. Female students should be informed that mathematics could be studied and passed just like any other subjects and that the subject is an essential tool, a prerequisite for further education in a host of vocations.

Logistic regression was used by [10] to examine the expected causes of gender difference in the performance of mathematics among boys and girls in mixed senior high schools in the Upper East Region of Ghana. The results indicated that, boys' performances outweighed that of girls', as it was evident that girls lack of self-confidence was a contributing factor or a major cause of the difference in performances. Furthermore, perceived gender difference caused school drop-out and poor choices of girls relative to boys. Research shows that parental support can be particularly valuable in positively influencing minority students' future aspirations, expectations concerning education and academic achievement, and self-efficacy concerning career decisions [6, 7, 8 and 9]. Parents of minority students have high aspirations for their children's academic attainment and success [13], and other family members also can influence the pursuit of education. Research has shown that Latino students who have high-quality relationships with and receive academic support from their siblings report higher levels of academic motivation than do those who do not [2].

A study by [3] explored sex differences in mathematics performance of students in the final year of high school and changes in these differences over a 3-year period in Ghana. A sample of 182 students, 109 boys and 72 girls in three high schools in Ghana was used. Mathematics performance was assessed using their classroom marks in the first and third year. The results revealed that there was a significant difference between mathematics performance between boys and girls. Some of the socio-cultural factors in Ghana may be considered to explain the gap between the sexes. The large sex differences in mathematics performance in Ghana may be attributed to social perception. The information gathered is that families looked forward to the sex of a new born baby to predict its future, based on cultural expectations and sanctions. Therefore, the male dominance factor in African societies cannot be underestimated in mathematics ability and conceptual developments. In most African societies of which Ghana is of no exception, boys are expected to be socially mobile because parents generally invest more money into their education than the girl child. Girls are generally looked upon to preserve the status quo of tradition, thus, in many cases, girls' education are curtailed by early marriage.

3. Materials and Methods

3.1 Institutional Setting

The data for the study to analyse female under representation was taken from the Berekum Municipality. Berekum Municipality came into existence as a semi-autonomous spatial unit by virtue of the decentralization policy adopted by the Government of Ghana in 1988 [5]. Geographically, the Municipality can be located in the Western part of Ghana in the Brong-Ahafo Region. It lies between latitude $7^0 15^0$ South and 8^0 North and longitudes $2^0 25^0$ East and 25^0 West [5]. Berekum Municipal is blessed with Nursery, Primary, Junior High Schools, Secondary Senior Schools and even Teacher Training College and a Midwifery Training College [5]. The dominant economic activity in employment in the Berekum Municipal is agriculture which employs approximately 57% of the population [5]. The average rainfall is 88.99cm.

Figure 1 below shows the location of Berekum Municipality on the map of Ghana.

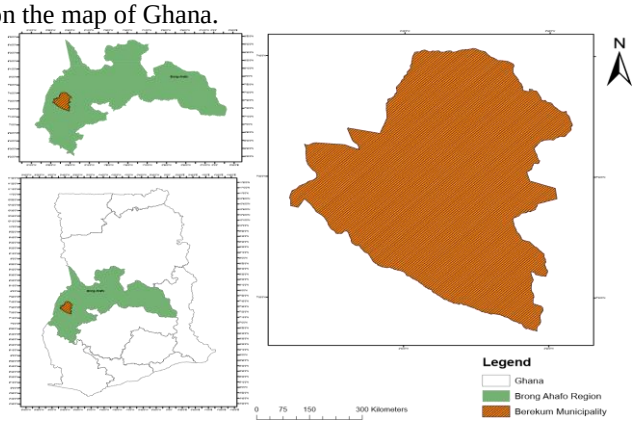

Figure 1: Map of Berekum Municipality

3.2 Population and Sample

Females in the Senior High Schools (SHSs) in the Brong-Ahafo Region of Ghana constitute the population. The sample of the study includes two hundred and ninety-eight(298) female SHS students from the Berekum Municipality in the Brong-Ahafo Region which has a total of eight(8) Senior High Secondary schools. To ensure generalizability of results from the sample to the population, all the eight (8) senior high schools were selected in the Berekum Municipality with at least sixty (60) SHS female student selected in each of the schools in the Municipality was chosen for study.

The selection was done in proportion to the size of the female in each school. The sample size of 298 was distributed according to the female population in the eight schools. The school with the highest female population had the highest representation and the school with the lowest female population had the lowest representation.

Female students in each school were selected from General Arts (GA), Home Economics (HE) and General Science (GS) using the stratified sampling technique where allocation was done proportionately.

3.3 Data Collection Procedure

The questionnaire is a two paged document and there are twenty-seven (27) items and the selected female students were supposed to tick whether they STRONGLY AGREE, AGREE, UNDECIDED, DISAGREE or STRONGLY DISAGREE.

Before the actual administration of research instruments and data collection, the researcher visited sampled schools to verbally explain the purpose of the study. The researcher discussed with mathematics teachers and sought for their

assistance towards administration and filling of questionnaires. A total of 298 female students from the 8 schools did the filling of the questionnaires. This was done at the time agreed upon by the school authority and the researcher, to avoid inconveniencing the school time table. The instruments were administered through personal visits on appointment with teachers in the selected schools through their respective school principals.

The questionnaires were given to selected students to fill. The students filled the questionnaires as requested by the researcher. The respondents were given instructions and assured them of confidentiality and anonymity after which they were given enough time to fill in the questionnaire. The researcher then collected the completed questionnaires from the student.

3.4 Data Analysis Plan

The data collected were analysed using quantitative statistics. The results from filled questionnaires by students provided data which were scrutinized and then coded for computer data analysis. Analysis of data concerning students' views on gender difference in mathematics among Senior High Schools in the Berekum municipality was done by calculating mean scores on the scale. To achieve this, numerical scores were assigned to five response options given to each item on the scale. For positively stated items, the score values were assigned as follows: Strongly Agree (SA) = 5; Agree (A) = 4; Undecided (U) = 3; Disagree (D) = 2; Strongly Disagree (SD) = 1. The data were keyed into SPSS data editor for analyses.

3.5 Dependent and Independent variables

Individual level factor variables were selected. These mainly consisted of student factor variable, friends' factor variable, parental factor variable and teacher factor variable that may influence the learning of mathematics among female SHS students.

The independent variables were the program of study of the selected SHS schools which the female students were offering. These are General Arts (GA), Home Economics (HE) and General Science (GS). Table 1 below shows the list of all the selected variables.

Table 1: Codes for questionnaire items

Constructs	Variable Codes	Statements
Parents Perception and Expectation (P)	P1	My parents have high expectations in my performance in mathematics
	P2	My parents advise that taking mathematics related courses will delay my time in marriage
	P3	My parents supply our learning needs equally
	P4	My parents often pay my brothers fees before mine
	P5	My parents pay attention to my brothers assignment in mathematics than mine
	P6	My parents often encourage my brothers to learn hard in the sciences
	P7	Performing better in mathematics than other subjects makes parents happy
Teachers Perception and Expectation (T)	T1	Teachers answer questions of male students than females in class
	T2	Teachers often make girls perceive mathematics as a subject for boys
	T3	My teachers seems to encourage more males to learn mathematics than females in class
	T4	Teachers give both male and female students equal attention in learning mathematics
	T5	Teachers sometimes are inpatient to females students during mathematics lessons
	T6	My mathematics teachers motivate me in learning mathematics
	T7	Teachers give verbal rewards to males in learning mathematics than females
	T8	The method used by my mathematics teacher meets my learning needs
	T9	My teachers punishes me when I get assignment wrong
Friends Perception and Expectations (F)	F1	Friends laugh at me when I contribute to class discussions
	F2	My friends always say mathematics is for boys
	F3	I am often persuaded by my friends to absent myself from mathematics class because it is difficult
	F4	My colleagues tease me when I perform well in mathematics test
	F5	Males often ask if I often see female engineers
	F6	I am mostly threatened by males not to do better than them in class
	F7	Males often ask if I often see a female mathematics professor
Students own Perception and Expectation (S)	S1	I think mathematics are made for boys not girls
	S2	I have never been taught by a female mathematics teacher before
	S3	I feel encourage to learn mathematics
	S4	I find mathematics useful in other subjects
	S5	I enjoy learning mathematics

In Table 1, a code is dedicated to each questionnaire item which is used in tagging the item for subsequent analysis. Based on literature review, the main constructs considered in this study include parent's perception and expectations (P), teacher's perceptions and expectations (T), friend's perceptions and expectations (F), and student's own perceptions and expectations.

3.6 Statistical analysis

The mean, standard deviation, and standard error of various plausible causes of female under representation in mathematics relating to self, parents, friends and teachers were calculated. Analysis of variance (ANOVA) was conducted to determine whether the causes of under representation had a relationship with programme of study. Patterns of causes of under representation were obtained by exploratory factor analysis for 27 possible causes of female

under representation in mathematics. Factor analysis-α multivariate statistical technique-was used for the identification of factors in a set of measurements.

Such factors would correspond to indicators, and all variables were considered simultaneously, each one in relation to the others. For the applicability of factor analysis, the uniformity of sample was tested by examining the distribution of variables in a loading plot, contrasting the value observed against those expected in a normal distribution which was verified by Kaiser-Meyer-Olkin (KMO) measurement of adequacy. A KMO value of more than 0.50 was considered acceptable. The presence of correlations between item-groups was tested using the Bartlett test of Sphericity (homogeneity of variance). The Bartlett test statistic is approximately distributed with chi-square and was accepted when it is significant at p <0.05. PCA was used for extraction of factors and orthogonal rotation (varimax option) to derive non-correlated factors (4). This varimax method attempts to minimize the number of indicators that have high loading on one factor (5). The first factor extracted is the one that accounts for the maximum possible variance in the dataset. The second component, independent of the first, will be the one that explains the largest possible share of the remaining variance and so on, without the components being correlated with each other (6).

Kaiser criterion, namely Eigen value of >1.0, is the widely-used criterion for the choice of the number of factors in factor analysis. It was also based on the Eigen plot (scree plot), which shows the total variance associated with each other. Statistical analysis was performed using the SPSS software (version 20.0).

4. Results

This section presents analysis and interprets the findings underlying Female Under Representation in Learning Mathematics among five secondary school female students in Berekum Municipality. It focused on the influence of students' perception and expectations, parental perception and expectations, friends' perception and expectations, and teachers' expectations, characteristics and perceptions on their learning of mathematics.
Table 2 below shows the output or results from the KMO and Bartlett's Test.

Table 2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin	Measure of Sampling Adequacy	0.668
	Approx. Chi-Square	1001.812
Bartlett's Test of Sphericity	df	378
	Sig.	0

Kaiser-Meyer-Olkin (KMO) test is used to measure the adequacy of a sample. KMO test numbers are between 0 and 1. Zero means that sum of correlations for parts of the sample are large in comparison with sum of all correlations, so factor analysis is likely inappropriate. Kaiser suggests that values greater than 0.5 are acceptable. For this study, we observe from Table 2 that the KMO is 0.668 which is acceptable.

Table 3 below shows the Factor loadings and reliability analysis.

Table 3: Factor loadings and reliability analysis

Loaded variables	Loadings	Eigen values	% of variance explained	Cronbach's Alpha
Parents Perception and Expectation		7.714	28.92	0.783
P1	0.704			
P2	0.636			
P3	0.631			
P4	0.606			
P5	0.59			
P7	0.59			
Teachers Perception and Expectation		4.074	17.165	0.797
T1	0.712			
T2	0.701			
T3	0.673			
T5	0.658			
T6	0.65			
T9	0.619			
Friends Perception and Expectations		1.462	11.54	0.753
F1	0.619			
F3	0.604			
F4	0.6			
F5	0.549			
F6	0.504			
F7	0.501			
Students own Perception and Expectation		1.071	5.332	0.802
S1	0.575			
S3	0.568			
S4	0.556			
S5	0.482			

Table 3 illustrate the number of loaded items in rotated component matrix. Using varimax rotation, the focus is on fitting each indicator to one and one component (factor). Thus, loadings which are less than 0.4 are suppressed by our criteria in SPSS. Reliability analysis is conducted using Cronbach's alpha coefficient for internal consistency. The results are summarized in Table 3. The coefficients for parent's perception and expectations, teacher's perceptions and expectations, friend's perceptions and expectations, and student's own perceptions and expectations are 0.783, 0.797, 0.753, and 0.802 respectively. In summary, the reliability coefficients for the four constructs employed in this study exceed the minimum threshold value of 0.7 suggested by Nunally (1978). The loaded variables in Table 3 are the identified factors underlying female under representation in mathematics in the study area.

Table 4: Analysis of variance

Statement	Group Means			Overall Mean	F-value	P-value
	GA	HE	GS			
P1	3.96	3.93	4.41	3.98	1.198	0.303
P2	4.0949	3.9237	3.9091	4.0134	0.738	0.479
P3	2.3165	2.6525	1.2727	2.3725	8.773	0
P4	3.2089	2.9831	3.5	3.1409	1.349	0.261
P5	3.7975	3.7627	3.5455	3.7651	0.315	0.73
P7	4.2468	4.1271	4.7273	4.2349	2.303	0.102
T1	2.9114	3.2966	2.2273	3.0134	5.613	0.004
T2	3.1329	3.3814	3.3636	3.2483	0.796	0.452

T3	2.4114	2.5169	2.3182	2.4463	0.247	0.781
T5	3.8608	3.6017	3.7727	3.7517	0.99	0.373
T6	3.5443	3.0085	3.5	3.3289	4.006	0.019
T9	1.962	2.1356	2	2.0336	0.532	0.588
F1	4.0063	3.5678	4.1364	3.8423	3.683	0.026
F3	3.4367	2.9068	3.3636	3.2215	3.746	0.025
F4	3.6835	3.6525	4	3.6946	0.49	0.613
F5	3.5063	3.1695	3.8636	3.3993	2.567	0.078
F6	3.2089	3.2034	2.6818	3.1678	1.027	0.359
F7	3.0316	3.1695	3.1364	3.094	0.27	0.763
S1	4.2405	3.9831	4	4.1208	0.257	0.774
S3	1.8481	1.8983	1.2273	1.8221	2.674	0.071
S4	3.2658	3.0085	3.7273	3.198	2.109	0.123
S 5	1.9747	2.4407	1.3636	2.1141	7.231	0.001

From table 4, we can see that there exist some differences in the opinions between the groups.

In statements P1, P2, P5, P7, T5, F1, F4, S1; all the students agreed to this statement at p >0.05. In statements T9, S2, S5; all the students disagreed to this statement at p >0.05. In statements T3, F6, F7; all the students are undecided to this statement at p >0.05. In statement P3; HE students are undecided whiles the GS and GA students disagreed to this statement at p >0.05. In statement P4; GS students agrees whiles the GA and HE students are undecided to this statement at p >0.05. In statement T1; GS students disagrees whiles the GA and HE students are undecided to this statement at p >0.05. In statement T2; GS and HE students agrees whiles the GA students are undecided to this statement at p >0.05. In statement T7; GS and GA students agrees whiles the HE students are undecided to this statement at p >0.05. In statement F3; GS students agrees whiles the HE and GA students are undecided to this statement at p >0.05. In statement F5; GA and GS students agrees whiles the HE students are undecided to this statement at p >0.05. In statement T7; GS students agrees whiles the HE and GA students are undecided to this statement at p >0.05.

5. Conclusions and Recommendations

5.1 Conclusions

The results and analysis from the Rotated Component Analysis and ANOVA test shows that, teachers', students', parental and friends' expectations, characteristics and perceptions were significant factors underlying female under representation in the learning of mathematics at p <0.005. The analysis revealed that teachers' expectations, characteristics and perceptions were the factors having the highest influence on females under representation in the learning of Mathematics. To solve the problem of female under representation in the learning of mathematics, parents and especially teachers should have necessary and needed skills to motivate female students for them to have more interest in their pursuit of Mathematics.

5.2 Recommendations

From the findings of the study the following recommendations were made:

a) To solve the problem of female under representation in the learning of mathematics, parents and especially teachers should have necessary and needed skills to motivate female for them to have more interest in their pursuit of mathematics.
b) The study also recommends teachers of Mathematics should give female students equal opportunities in the classroom so that their confidence and interest in the subject will be high.
c) It is recommended that further studies should be conducted to carefully investigate the individual contribution of each of these conjectures or combinations of these on gender differences, using standardized achievement tests to explain the way these factors affect the mathematics achievement level.
d) It would be interesting to investigate the effect of the socio-economic status on female under representation in learning of mathematics in Ghana.

5.3 Limitations

The study covered only one Municipal in the Brong-Ahafo Region of Ghana. Other Regions and Municipalities could be studied to explore other Factors underlying Female Under Representation in Learning Mathematics. This comparative study would highlight any similarities or differences and reasons for the situations. It would also show the extent of inequalities in the Municipal in terms of Female Under Representation in Learning Mathematics. The study on Female Under Representation in Learning Mathematics among Senior High School Female students has raised many questions and answers. Further research on the topic could be supplementary or complementary.

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