

School Type, Parental Influence and Mathematics Attitudes-Achievement Relationship: A Quantile Analysis

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Abstract

In this paper, we report the findings of a study on the impact of school category and parental assistance with homework on the mathematics attitude and achievement of senior secondary school students in Botswana. We adopted a quantile regression (QReg) method to analyse the relationship between attitudes and achievement, and also adopted a chi-square and independent sample t-test analyses. The advantage of the quantile regression (QReg) is that it establishes the relationship at the quantile (percentile) levels and does not require the parametric assumptions usually used in the Ordinary Least Square Regression (OReg). The findings showed that positive attitude significantly influenced the mathematics achievement of students across all the achievement quantiles of the QReg. The QReg also indicated that the school category had an effect across all quantiles except at the 5th percentile. Furthermore, the QReg indicated that at the 95th percentile, parental assistance with homework was very crucial in mathematics achievement. These findings implied that the OLS did not sufficiently capture the extreme tail characteristics of the mathematics achievement-attitude relationship. In particular, we observed that at the uppermost tail of mathematics achievements, parental assistance with homework explained better mathematics achievements than attitude. The authors concluded that the QReg method was an innovation to bridge the methodological gaps in previous similar studies.

Keywords: *Mathematics attitudes, achievement, parental influence, homework, school category, quantile regression*

1. Background

The performance of students in mathematics has been linked to several variables (Aiken 1970; Fennema & Sherman 1978, Chionh & Fraser 2009, Forgasz & Rivera 2012, Adeyinka & Kaino 2012; Fennema & Sherman 1976; Hembree 1990; Yan & Lin 2005). Walberg and Tsai (1985) also showed that some factors influence cognitive achievement and attitude of students. These factors include aptitude, instruction and environmental factors. The interactions among these variables remain a domain of interest to scholars till date. However, most studies make in-appropriate assumptions about the distribution of the variables and did not study the relationships at performance niches across the continuum.

Attitude has been defined by several authors (Raymond 1999, Collins 1999). It involves response in a consistent manner to given stimuli which could be differentiated from other stimuli such as moods because of its evaluative nature (Adeyinka & Kaino 2012). In the definition by Colman (2001), it could be noted that attitude is learned and is capable of guiding behaviours. Aiken (1979) specifically noted that attitude towards mathematics could be seen as a composite of personality factors like motivation, enjoyment, fearlessness (confidence) and value.

DeFleur and Westie (1963) were of the view that attitude is a scientific concept that is not uniformly defined despite its wide usage among theorists in the behavioural sciences. Attitude could be seen as a student's internal evaluation of a subject and is known to be a relatively stable predisposition (Olson & Mitchell 2000). Ajzen and Fishbein (1977) argued that attitude towards an object influences the individual's response to the object. Fishbein and Ajzen (1975) also emphasised the relationship between beliefs, attitude and intention as they relate to behaviours. Although, Ajzen and Fishbein (1977) were of the view that results on the attitude-behaviour relationship are increasingly indicating non-significance, mathematics education researchers are increasingly finding attitude to be paramount in the

mathematics achievements of students (Betz & Hackett 1983; Hackett & Betz 1989; Ma & Kishor 1997).

The extent to which students commit to mathematics after class hours could be considered as a measure of their motivation to study mathematics as noted in Carroll (1965), Atkinson (1980) and Berliner (1990). Lovell (1973) considers motivation as an internal process initiated by some needs. The desire to meet these needs and the implications of meeting these needs could be a determinant of the value the student places on mathematics achievements. Consequently, in the context of mathematics, motivation could be the result of the extent to which a student considers mathematics to be relevant to his future expectations like studying a course that could lead to a financially rewarding career. Given the interaction between high paying job and mathematical competencies of students, the intention to get a good job could be a major influence of students' mathematical attitudes as it shapes their value of the subject (Opyene-Eluk & Opolot-Okurut 1995). Walberg and Tsai (1985, p. 159) implicitly defined motivation as the willingness of a student to persevere intensively on learning tasks. This tenacity may be the result of the anticipated reward in the form of future prospects as noted in Malinga (1993).

The value of mathematics to students has a major impact on their achievements as noted by Fuligni (1997). However, a student may value mathematics but not necessarily enjoy the subject but for the need to pass the course as a prerequisite for further studies although it tends to be that students will focus attention on what they find to be fun. Another vital attitude to mathematics achievement is confidence. The involvement of parents in their children's school experiences were the focus of other studies (Hill et al. 2004; Yan & Lin 2005). The extent to which the involvement is fulfilling could impact on attitude in that if the assistance leads to a perception of mathematics as an enjoyable subject then achievement may be enhanced.

It is reasonable to expect that the socio-economic status of students' parents will have impact on their performance. In the work of Fuligni (1997), it was observed that attitudes and behaviours regarding education had more prominent influence on the academic achievements of immigrant families in the USA. The author noted further that the high socio-economic status of immigrant families might have played a role in the success of students from these families. However, based on another study by Caplan et al (1991), the effect of these socio-economic factors may be limited and therefore insufficient to explain the variance in performance. These socio-economic factors may have impacts on the after school hour attention students give to their studies which includes home work.

A homework model was proposed by Trautwein et al (2006) (In Dettmers et al 2010). In the model, homework was linked to students' motivation and beliefs. The amount of time a student spends on school work has been found to influence students' performance in mathematics (Fuligni & Stevenson 1995). In their study, Fuligni and Stevenson (1995) noted that Chinese students spent more time than American students including after-school classes on their school work. In another study, Fuligni (1997) affirmed that time spent studying every week has a major impact on students' achievement. One would expect that besides the quantity of time spent on these out of school activities, the people engaged in these activities with them could have some influence on the quality of their after school academic experiences. This support which could be gleaned from the work of Fuligni (1997) as parental aspirations for their children's academic progress was also noted to have impact on achievement. The work of Yan and Lin (2005) also affirmed that parental involvement is an important educational input moreso that it impacts on the attitudes of students. The study concluded that there is the tendency for adolescents to perform excellently well in schools when their parents frequently interact with them and expect them to perform well. In particular, it was noted that parental involvement and close parent-teenager relationship explained significant amount of variations in students' mathematics achievements.

The study by Walberg and Tsai (1985) revealed that beside attitude, the quality of instructional experience, the home and classroom social group could influence students' performance. In a related study, Simpson and Steve Oliver (1990) reiterated that in addition to attitude, home and school environments impact significantly on achievements. In particular, classroom environment and the attitude of peers were found to be highly correlated with science achievement. Consequently, it will be reasonable to consider the effect of school category (public and private) on students' mathematics achievements as students may differ in their achievements as a result of the differences in the learning experiences they are exposed to in both types of school. The differences in the learning experiences could result from the expectation that there are differences in the instructional quality although the syllabus under which both schools are operating may be the same. Similarly, since private schools are generally more expensive than public schools, it could be that the environmental factor favours private school students both at home and in school. The home front may be beneficial in two ways. First because students may be getting additional quality supports from their parents who were more likely to be educated themselves and secondly because they are likely to be more nutritionally nourished, a situation which also has a significant influence on performance (Symons et al. 1997). Similarly, Evertson et al. (1980) found that teaching behaviours has prominent impact on achievement particularly in mathematics.

However, the results on the interaction between achievement-attitude relationship and these variables are mixed. In particular, Hill et al. (2004) noted that parental involvement in the education of students was influential in the achievements of students across middle and high school although previous studies have reported that parental influence is of no importance in elementary school. The impact of parental involvement was also found to differ across ethnicity and parents' education levels (Hill et al 2004).

In the work of Aiken (1976, p. 302), it was implicitly suggested that attitude towards mathematics could be learned and he cited Leake (1970) who observed that there was a complex interaction among student and teacher characteristics, course content, method of instruction, instructional materials, parental and peer support affect attitudinal changes. An important conclusion that requires further attention in Aiken (1976) was the adoption of suitable statistical techniques in studying this complex interaction.

Most studies have adopted the classical Ordinary Least Square Regression (OReg) in the analysis of the mathematics achievement-attitude relationship (LaRocque, Kleiman & Darling 2011; Walberg & Tsai 1985). An important omission in the study of the relationship is that of studies that do not only consider multivariate modeling of the relationship but also capture the complex interactions at different achievement levels. In previous studies, researchers have implicitly assumed that students' responses to this web of complex interaction are uniform across the achievement levels. The OReg assumes a uniform slope across the continuum of students' achievements. The implication is that the model generalizes the relationship among these variables to all niches of students' performance. Hence, previous models tended to assume that the distribution of achievement and attitude are normally distributed. The implication of this assumption is that what happens at the extreme upper tail happens at the extreme lower tail.

The Quantile Regression (QReg) is an alternative modelling approach that captures the disparity in relationship among dependent and independent variables at extreme tails (Hao & Naiman 2007; Koenker 2005). The methodology has been widely used in finance, actuarial sciences and environmental sciences (Adeyinka et al. 2013; Cade & Noon 2003; Jing, Daoji & Yuanyuan 2008; Sankaran et al. 2005). Among the very few studies that have recently adopted the techniques in educational researches include Adeyinka and Kaino (2012) and Penner and CadwalladerOlsker (2012). Additionally, since the statistical techniques adopted in most analysis are usually parametric in nature, the OReg may not be an appropriate tool when the parametric assumptions are violated. Hence, the QReg provides an alternative means of modelling the relationship among variables when the parametric assumptions are violated and when the researcher is interested in the behaviour of the model at performance niches of theoretical interest.

2. Hypotheses

Although, the impact of school category and parental influence on the mathematics achievement-attitude relationship of students remain issues of interest and are well captured in this study, our hypothesis focuses on comparing the estimation of the relationship by OReg and QReg:

H₁: The OReg regression mis-estimates the relationship between mathematics attitudes and achievement in the presence of parental assistance on homework and school category at some achievement levels.

3. Methodology

We adopted the quantitative design and data was collected using a questionnaire and a mathematics test. We targeted private and public senior secondary school students in Botswana. Random sampling technique was adopted in the selection of two schools from each of the school categories as there were only five private and four public senior secondary schools in Gaborone at this time. Students from public schools were used as the reference group in creating the dummy variable. Also, students who indicated that they were assisted by their parents were compared with those who were assisted by others using the non-parent assisted group as the reference group.

After the random selection of the schools, convenience sampling was used to select the students from the schools because this form of sampling permits the use of available respondents (Gay & Airasian, 2003). We targeted twenty boys and twenty girls from each school, the responses from a total of one hundred and fifty six respondents were analysed. The achievement test was constructed with the intent of measuring students' cognitive knowledge of mathematics. Bloom's (1956) taxonomy of educational objectives was used to select the questions from the five modules in the Senior Secondary Mathematics Instructional Materials and Development Guidelines of Botswana. The questionnaire was used to gather information relating to the five attitudes of interest. The test was administered to the students after the responses from the questionnaires have been collated in order to ensure that the students did not carry any bias from the

test into their responses to the questionnaire items. We used a five-point Likert-scale ranging from '1' (Strongly Disagree) to '5' (Strongly Agree). The scores on the questionnaire were taken as proxies to measure the underlying attitudinal constructs. The scorers for positive attitudes were derived by clustering 19 variables on motivation, confidence, enjoyment and values. At the end of the analysis, only 136 responses were valid for analysis.

4. Validity and Reliability

We adopted content validity for the achievement test items and construct validity for the questionnaire items. Content validity determines the degree to which the constructed test measured appropriate content area (Gay & Airasian, 2003; Nitko, 2004). This type of validity was done by expert judgment. The achievement test used in the study was also validated by an expert in mathematics education. In addition, to obtain the intended questions on the achievement test, 30 questions were initially administered at the pilot school besides the four schools in the sample and the scores were used in calculating "Item difficulty index (P value)". The item difficulty index measures the extent to which the items were considered difficult. It was used to eliminate ten questions found as inappropriate such that the twenty intended questions were retained. Item difficulty index is given as:

$$P = \frac{No.C_a}{N}$$

Where P = the item difficulty index, No.Ca = number of students choosing the right alternative, and N= the total number of students taking the test.

When the values of difficulty index are high, it means that the test is too difficult whereas low index implies too easy item. Since item difficulty index ranges from 0 to 1, an item giving a P value of 1.00 meant that all students got it right, or with very low P value approaching zero implied that very few students got the item right. Items at either extreme were eliminated so as to avoid too easy or too difficult questions.

The 30 questions constructed were distributed using a content-by-process matrix table. There were 5 attitudes with five questions for each attitude at the pilot stage. Construct validity was used to validate the questionnaire items. In the validation process, one of the five questions measuring, Value was removed. Finally, we estimated the reliability of the questionnaires with Cronbach alpha (α) coefficients resulting in the following values; Confidence (.651), Enjoyment (.837), Motivation (.467) and Values (.607). The Kuder-Richardson 21 (K-R 21) test was used to measure the reliability of the mathematics achievement test questions the result of which is 0.52.

5. Data Analysis

The descriptive analysis of the attitudinal scale shows that private school students with a mean of 69.55 points had more positive attitude than public school students with 67.92 points but the mean difference of -1.6384 was not significant ($P > 0.05$). The variance in the attitude of public school students was higher (13.07533 > 10.73113) while the variance in the attitude of parent assisted students was higher than that of non-assisted students (12.39773 > 11.86024). Assisted students scored 3.3337 marks on the average above their unassisted counterparts but this was found to be insignificant statistically. The overall mean was 68.6985% for all the 136 students and the overall variance in attitude was 11.9965.

The public school students were on average scoring 9.0312 below their private school counterparts. This difference was found to be statistically significant. The variance in the achievement of private school students is 17.43808 which is higher than the 12.46403 for public school students. Parent assisted students were 3.7836 marks above their unassisted colleagues but the difference was not statistically significant. On average, the average score was 44.375 with a variance of 15.6990.

Table 1: Descriptive and t-test statistics of scores and attitudes

Variables	School category	n	Mean	SD	Mean difference	P
Attitude	Public	71	67.9155	13.07533	-1.6384	0.428
	Private	65	69.5538	10.73113		
	Non-parent assisted	109	68.0367	11.86024	-3.3337	0.197
	Parent assisted	27	71.3704	12.39773		
	All	136	68.6985	11.9965		
Score	Public	71	39.9296	12.46403	-9.0312	0.000*
	Private	65	49.2308	17.43808		
	Non-parent assisted	109	43.6239	15.15157	-3.7836	0.264
	Parent assisted	27	47.4074	17.72495		
	All	136	44.375	15.6990		

*Significant at alpha = 0.05

There were 71 (52.21%) students out of the 136 respondents from public schools while the remaining 65 (47.79%) were from private schools. Most of the students were parent assisted (n=109, 80.15%). However, the proportions of students assisted by their parents were not significantly different in both schools (Chi = 0.151, df = 1, P = 0.697).

Table 2: Cross tabulation and Chi-square analysis of school category and assistance

Variables	Public	Private	Total
Non-parent assisted	56	53	109
	51.4%	48.6%	100.0%
Parent assisted	15	12	27
	55.6%	44.4%	100.0%
Total	71	65	136
	52.2%	47.8%	100.0%
Pearson chi	0.151		
P	0.697		

The Ordinary Least Square (OReg) analysis shows that attitudes and school category were having significant influence on students' performance. The amount of variance explained by these variables in the OReg amounts to 21.86% and 19.48% when adjustment is made for the number of covariates in the model. The analyses further showed that for every unit increase in positive attitude, there was an increment of 0.45% in scores and this was found to be significant along with school category. The analysis indicated that students from private schools scored 9.15% marks above the public school students used as the base group. Parental assistance was found to be statistically insignificant although students who were assisted by their parents scored 3.8223% above their un-assisted colleagues.

Table 3: Ordinary Least Square Regression for mathematics achievements and attitude, parental help and school category.

Variables	β Coefficient	t	P	R square
Attitude	.4511	4.42	0.000*	21.86% (Adj. R square = 19.48%)
Parental help	3.8223	0.93	0.356	
School category	9.1460	3.37	0.001*	
Parental help and school category	-2.6109	-0.43	0.669	
Constant	8.4840	1.20	0.233	

*Significant at alpha = 0.05

Only attitude significantly explains the variance in achievements at the 5th percentile level (P<0.05). A unit increase in attitude increased performance by 0.51%. The Pseudo-R square for the relationship of the variables with performance was 18.10% meaning that attitude, parental help and school category explained a statistically significant amount of variations in students' mathematics achievement at this quantile. Students at the 5th quantile who were assisted by their parents were 1.22% below those who were not assisted but there was a 6.02% additional mark for students from private schools. At the 10th percentile, attitude and school category were very significant in determining students' mathematics achievements but parental help was not statistically significant. The pseudo-R-square shows that at the 10th percentile, 14.37% of variation in students' mathematics achievement was explained by the variables. A unit increase in attitude

increased performance by 0.45% and students from private schools outperformed their public counterparts by 6.36% while those who were assisted by parents were 1.82% better off. The interaction between school category and parental help were found to be insignificant.

At the 25th percentile, the median (50th percentile) and the 75th percentile, attitude and school category were significantly impacting students' achievements. The strengths of the relationship were 9.94%, 11.67% and 15.67% for the 25th, 50th and the 75th percentiles respectively. About 0.31% increment in achievement was observed per unit increase in attitude at the 25th percentile while 4.69% and 7.19% were noted for students who were assisted by parents and those from private schools respectively. At the median, students who were assisted by their parents at home were found to be 1.67% above their non-parent assisted counterparts while those from private schools scored 7.92% above those from the public schools though these were found to be rather due to random error in that they were not statistically significant.

The 90th percentile analysis showed that attitude and school categories were having significant impacts on achievements. It was noted that every unit increment in attitude lead to 0.59% increase in achievements. Students at the 90th percentile who were assisted by their parents had 8.24% higher marks than those who were not while private school students were having 16.76% marks above the public school students. The strength of the relationship at this quantile was 17.20%. At the 95th percentile, a unit increase in attitude resulted in 0.48% increment in achievements. Students who were assisted had 22.58% marks above those who were not while those who were from private schools had 21.29% above their public school colleagues. It was noted that all the three variables were impacting significantly on achievements at this percentile. As much as 22.89% of the variations in achievements were explained by these three variables. In all the quantiles, as in the OReg, the interaction between school category and assistance by parents were statistically insignificant.

Table 4: Ordinary Least Square and Quantile Regression Analyses of mathematics achievement-attitude relationship with school category and parental help with homework.

Quantiles	Variables	β Coefficient	t	P	Pseudo-R-squares
5 th	Attitude	0.5102	3.92	.001*	0.1810
	Parental help	-1.2245	-0.27	0.786	
	Sch cat	6.0204	0.74	0.460	
	Parent help & sch cat	-0.6122	-0.07	0.941	
	Constant	-11.4286	-1.15	0.251	
10 th	Attitude	0.4545	4.11	0.000*	0.1437
	Parental help	1.8182	0.33	0.742	
	Sch cat	6.3636	2.09	0.038*	
	Parent help & sch cat	-0.4545	-0.06	0.955	
	Constant	-5.4545	-0.60	0.548	
25 th	Attitude	0.3125	2.07	0.040*	0.0994
	Parental help	4.6875	0.88	0.382	
	Sch cat	7.1875	2.67	0.009*	
	Parent help & sch cat	-3.125	-0.36	0.717	
	Constant	8.75	0.85	0.396	
50 th	Attitude	0.4167	2.20	0.03*	0.1167
	Parental help	1.6667	0.28	0.778	
	Sch cat	7.9167	2.74	0.007*	
	Parent help & sch cat	-6.2500	-0.71	0.477	
	Constant	11.25	0.92	0.360	
75 th	Attitude	0.4878	3.43	0.001*	0.1564
	Parental help	4.5122	0.58	0.561	
	Sch cat	9.0244	2.41	0.017*	
	Parent help & sch cat	1.8293	0.13	0.900	
	Constant	13.5366	1.50	0.135	
90 th	Attitude	0.5882	3.45	0.001*	0.1720
	Parental help	8.2353	0.81	0.421	
	Sch cat	16.7647	3.25	0.001*	
	Parent help & sch cat	-13.2353	-0.70	0.485	
	Constant	13.2353	1.23	0.222	
95 th	Attitude	0.4839	2.89	0.004*	0.2289
	Parental help	22.5806	2.05	0.042*	
	Sch cat	21.2903	3.70	0.000*	
	Parent help & sch cat	-5.0000	-0.27	0.786	
	Constant	22.90323	2.16	0.033	

*Significant at alpha = 0.05

6. Discussion

The OReg captured the impact of attitude and school category on mathematics achievements, which was prevalent across most of the quantiles but did not reflect the disparity at the 5th and 95th percentiles. The major contribution of this paper is that the OReg does not capture the tail behaviours of students' achievements. Hence, previous models relating achievement with attitude and other variables need to be reviewed. The OReg assumes that attitude and school category uniformly contribute to mathematics achievements at all quantiles or achievement levels. The QReg however shows that at the extreme tails, the trend does not follow the pattern modelled by OReg.

We also noted that unlike the results from Adeyinka and Kaino (2012), the relationship between students' mathematics achievements and attitude was stronger at the 95th percentile than at the 5th percentile in the presence of school category and parental assistance with homework. Only attitude accounted for the achievement of students at the lowest percentile. Attitude and school category were statistically significant in explaining the variance in achievement at the 10th to the 90th percentile. It was interesting to note that parental assistance actually had negative effects at the 5th percentile but not to a significant extent. At the 95th percentile, not only were attitude and school category essential but parental assistance also showed statistical significance. The implication is that a student needs supports at home to be able to push beyond his or her mathematics achievement possibility frontiers into the highest performance niche. This finding confirms that parents have a role to play in the academic success of their children as noted in previous studies (Hill et al. 2004; Parsons, Adler & Kaczala 1982; Yan & Lin 2005) but we have successfully disaggregated the impact of parental influence on achievement niches across the attitude-achievement continuum.

Another implication of this study is that school change will not in any way change the performance of students at the lowest achievement quantile because the causes may be more intrinsic than extrinsic. One may note that the effect of school category on the performance of students was well captured in the independent sample t-test and the OReg, but the disparity in performance at the extreme tails was not captured. It seems that there may be more fundamental issues with the 5th percentile students than regular intervention could amend more so that they responded negatively to parental assistance unlike students at every other achievement quantile although this effect was not significant statistically.

Furthermore, the relationship between mathematics achievement and the variables considered in this study were strongest at the 95th percentile followed by the 5th percentile. The implication is that very high performers and very low performers in mathematics were the most influenced by these variables.

The chi-square analysis shows that parental support does not depend on whether a student attends public or private schools. This same conclusion was captured in the QReg but was disaggregated by quantiles. The implication is that there is no interaction between school category and assistance from parents. One would have expected that private school students were getting more help from home than their public counterparts, but our findings showed that this is not necessarily true.

We concluded that the OReg mis-estimates the achievement-attitude relationship at the quantiles in the presence of school category and parental assistance. Similarly, one could confidently conclude that attitude has a statistically significant impact on students' mathematics achievements because it is the only variable that is significant in the OReg and across all the quantiles in the QReg. We also noted that school category may only impact students' achievements in mathematics if and only if they have a reasonable measure of potentials. In essence, there is no use sending a mongol to the most expensive school. Finally, the t-test analysis showed that private school students did not differ to a significant extent in their attitude from the public school students but there was a significant difference in their performance in mathematics. This finding could be the result of environmental differences noted in previous studies (Simpson & Steve Oliver 1990; Walberg & Tsai 1985). It is also worth noting that the QReg captures the higher performance of private school students as revealed by the t-test and the relative differences across the quantiles was unveiled.

7. Conclusion

In this study, we have established the advantages of using the QReg method in the analysis of the relationship between attitudes and achievement. From the findings obtained, the authors concluded that positive attitudes significantly influenced the mathematics achievement of students across all the achievement quantiles of the QReg. The school category had an effect at all quantiles levels except at the 5th percentile and parental assistance with homework was very crucial in mathematics achievement at the 95th percentile. Furthermore, it was concluded that the QReg method was an appropriate method to use than OReg that could not sufficiently capture the extreme tail characteristics of the

mathematics achievement-attitude relationship.

8. Recommendation

Given the small sample size considered in this analysis, it is recommended that future studies should consider larger sample sizes in the analysis of the extreme tail characteristics of the mathematics achievement-attitude relationship in the presence of other theoretically relevant variables. The fact that private school students performed better than their public school counterparts yet they were not significantly different in attitude and parental assistance suggests that there must be some other variables that are causing these achievement differentials. These factors may include pedagogical differences in both schools. The achievement differentials could be an area for further researches.

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