Factors Affecting Student Success in GCE Ordinary Level Mathematics: A Case Study in Morawaka Educational Zone, Matara District

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Abstract

This paper attempts to determine the factors that are contributed to the excellence performance of Ordinary Level Mathematics in several selected schools in Morawaka Educational Zone in Matara district of Southern province, Sri Lanka which had reflected the highest failure rates in Ordinary Level Mathematics over the period from 2003 to 2007. Three contributory factors of students' performance were suggested according to the best fit logistic regression model, namely; participation for tuition classes, early preparation for examination and fathers' education level. All factors showed a positive relationship with students' performance. A student who participated for tuition excels four-fold higher than non participants while a well prepared student excels five-fold higher than a student who did not. The mathematical performance of students increases as the father's level of education increases. The first two factors can be controlled and hence policy implications are noted. Authors' suggestions are, firstly, to conduct evening classes at schools which will be benefited for students from low income category and the administration of schools is necessary to take actions to give a superior pre preparation for Ordinary Level Mathematics for a higher rate of success.

Keywords: *Mathematical Success, Logistic Regression, Chi Square, Morawaka Educational Zone*

Background of the Study

The educational achievement of individual students has focused of a large body of empirical research (Hanushek 1986; Haveman and Wolfe 1995). There are several reasons which explain the focus on educational attainment. First, there is a well established link between education and how well a person succeeds in later life. Numerous studies have pointed to the association between educational attainment and post school earnings, employment and occupational status. Second, education is one of the fundamental sources of long-term economic growth. The role of education on economic growth and development is a topic of growing interest among economists (Krueger and Lindahl, 2001).

Student's mathematical achievements have long been a concern of education process in Sri Lanka. Mastering in mathematics has become more significant than ever. It is a well – accepted norm that student with a strong grasp of mathematics has an advantage in educational attainment and in the job market, i.e., mathematical achievement is a key to entrance for higher education and success in the labour market in Sri Lanka. For several decades, a number of studies have been focusing on gathering and investigating information from many variables which affect on the mathematical achievement. The social, economic, and cultural factors that are either in favour of or not conducive to students are not well understood.

This study aims at analysing factors influencing the success of Ordinary Level (O/L) mathematics. This research considers the Morawaka Educational Zone (MEZ) in Matara district of Southern province, Sri Lanka. It was the educational zone which reflected higher failure rates in O/L mathematics in Southern province for the period from 2003 to 2007. Scrutinizing of examination results in the MEZ revealed that average failure rate is over 60 per cent for the entire five-year period from 2003 to 2007. Only 956 students achieved the success among 2456 students sat for the O/L mathematics in 2007. The success percentage is approximately 39. Hundred and eight teachers were available for teaching mathematics in MEZ by 2007. The panel of teachers included graduates, trained and probationary teachers. Consequently the teacher – student ratio was about 1: 23. This is an acceptable teacher student ratio in an O/L class. Therefore, this will make evidence for a less workload for teachers in O/L classes while examination results reveal lower mathematical performance of students. Hence, our focus was on MEZ and this study endeavoured to detect the affective factors for the low or high performance in mathematics.

Literature Review

All of the research reviews support the hypothesis that student performance depends on different socio-economic, psychological, environmental factors. The findings of research studies focused that student performance is affected by different factors such as learning abilities because new paradigm about learning assumes that all students can and should learn at higher levels but it should not be considered as constraint because there are other factors like race, gender, sex that can affect student's performance (Hansen, Joe B., 2000).

For several decades a number of studies have been focusing on gathering and investigating information from many variables which affect on the mathematical achievement. A few studies of this type can be found in Sri Lankan context. Sarojanee (1996) conducted a study to detect the factors affecting low performance in mathematics among students who completes secondary education in Sri Lanka. Sarojanee (1996) included students in grade 6 to grade 11 and revealed that student's gender has no significant effect on performance while teacher's academic qualification, teaching learning process and the curriculum are the main causes for low attainments in mathematics.

The gender differences in mathematical performance and mathematical attitudes were well-researched. Friedman (1989) conducted a meta-analysis of 98 studies which were published over the period 1974 – 1987 regarding gender gaps of school-aged students on mathematical achievement. Friedman's conclusion was that the gender gaps were quite small and declining over the years. Hyde, Fennema, and Lamon (1990) published the results of a meta-analysis of 100 studies conducted within 25 years. The empirical investigations of those studies focused on gender differences in the mathematical performance of students from elementary school through their college years. Since 1990 there were more researches conducted focusing not only on gender differences in students' math performance, but also on gender differences in students' math attitudes and choices, parental math attitudes, and teachers' math attitudes.

With regard to parental stereotypes concerning their children and mathematics, Jacobs (1991), Jacobs and Weisz (1994), Frome and Eccles (1998), and Herbert and Stipek (2005) found that parents hold stereotypes of gendered mathematical abilities, that they are prone to interpreting the mathematical performance of their children based on those gender stereotypes and not on their children's actual achievement, and that those parental attitudes have more impact on their children's self-evaluation with regard to math than their actual achievement in mathematics. Jacobs (1991) found that for mothers, regardless of the strength of endorsement of gender stereotypes, the mere fact of the stereotypes endorsement meant underestimation of their daughters' mathematical abilities. For fathers,

however, the strength of held stereotypical beliefs was related to the estimate of their daughters' mathematical abilities, such that only strong beliefs lead to underestimation of their daughters' abilities whereas less stereotypical beliefs lead to more accurate judgments. Frome and Eccles (1998) as well found that being guided by stereotypes in estimation of their daughters' mathematical abilities was more characteristic of mothers than of fathers. Similarly to Jacobs, Frome and Eccles also found that when parents underestimated daughters' mathematical abilities, the daughters underestimated them as well, even when they were achieving better than boys in mathematics.

Logistic regression procedure used by many researchers to study the academic performance in many disciplines (Kang et al., 1990; James, 2006; Peter and Brian, 2007; Maria et al., 2008) Peter and Brian (2007) used the logistic regression procedure to study the mathematics performance and the role played by affective and background factors. Peter and Brian concluded that gender; prior achievements of mathematics and attitudes towards learning mathematics are vital factors for the mathematics performance. Maria et al. (2008) employed linear and logistic regression to predict the university students' academic performance and showed that logistic regression was the best with compared to the linear regression model. However, the choice of the model depends on the nature of the data, in particular the type of the response variable. According to the data available for this study the binary logistic regression procedure was employed for the statistical analysis.

Purpose of the Study

The purpose of this study was to determine the factors affecting the performance in mathematics and to measure their impact at O/L examination. The findings of the research will be benefited to potential students, parents, teachers, practitioners and researchers in education and related disciplines.

The literature reviewed above has identified that a range of factors, including socioeconomic, demographic, personal, familial and school environmental related to student's mathematical performance. However, the studies reported in Sri Lanka have generally lacked rigorous quantitative analysis, and have been primarily based on descriptions of the variables and their impact. Further, to the best of authors' knowledge it is hard to find a study that has been incorporated the factors effects on mathematical performance such as parental education level, school support and acquisition of extra knowledge to enhance the performance in mathematics and hence this study tries to fill this literature gap.

Materials and Methods

Sample

The MEZ constitutes three divisional education offices, namely, Kotapola, Morawaka and Pasgoda. There are 52 schools those have facilities for GCE O/L education and these schools were considered as the population for the study. The Two Stage Cluster Sampling procedure was utilized in selecting sampling units. Ten schools amongst 52 were randomly selected at the first stage and then 300 students were randomly selected amongst the 10 schools selected at the first stage. Primary data on student's characteristics were collected using a structured questionnaire prepared for the purpose and a schedule was utilized for the collection of information from schools.

Variables

This study utilized six main covariates; father's education level, mother's education level, those come under the category of family causal factors. Students' gender was amongst the personal causal factors. Participation for tuition classes in order to enhance the mathematics knowledge, well preparation for examinations and school support for mathematics knowledge enhancement were involved under the academic environmental factors. Table 1 summarizes the data encoding and data labels for the variables used in this research.

Table 1: Description of variables, labels and encodings

Variable labels	*Description*
Gender	Gender of respondents: Dummy coded; 0 = Female and 1 = Male
FEDU	Father's education level: Scaled with values; 1 = No schooling, 2 = Primary, 3 = O/L pass, 4 = A/L or higher
MEDU	Mother's education level: Scaled with values; 1 = No schooling, 2 = Primary, 3 = O/L pass, 4 = A/L or higher
SSM	School support for enhancement of mathematical performance: Scaled with values; 1 = Weak, 2 = Moderate, 3 = High
PT	Participation for tuition classes: Dummy coded; 0 = No, 1 = Yes
PEX	Preparation for examination: Scaled with values; 1 = Weak (Score <25), 2 = Moderate (Score between 25 - 59) 3 = Satisfactory (Score ≥ 60)
MathP	Mathematical achievement: Dummy coded; 0 = Fail, 1 = Pass

The questionnaire was included the question "What is the highest education qualification attained by your mother and father" to search the parents' education level and generated a created a categorical variable as Table 1 explains. Table 1 describes of these variables as well as labels assigned and encodings used forming the basis for this study. Although the father's education level with 5 scales was used at the beginning of data analysis, it has amalgamated last two categories of this variable due to lack of information. In case of mother's education level the last category was removed from the analysis since there were not included any counts. The indexes for the variable "early preparation for examination" were constructed which based on specific questions included in questionnaire. Response variable was treated as categorical variable with two levels due to data limitations.

Methods

Chi square test and logistic regressions are the two main data analysis procedures employed in this paper. The first technique helps to analyse dependency of variables while second technique helps to model the existing relationship between response variable and covariates. The equation 1 illustrates standard form of multiple logistic regression model used in this study.

$$\hat{\pi} = \frac{\exp(\eta)}{1+\exp(\eta)} \quad \text{..... (1)}$$

Where;

$$\eta = \exp\left(\hat{\beta}_0 + \hat{\beta}_1 Gender + \hat{\beta}_2 FEDU + \hat{\beta}_3 MEDU + \hat{\beta}_4 SSM + \hat{\beta}_5 PEX + \hat{\beta}_6 PT\right)$$

π	= Probability of success in mathematics
Gender	= Gender of respondent
FEDU	= Father's level of education
MEDU	= Mother's level of education
SSM	= School support for enhancement of the knowledge of mathematics
PEX	= Early preparation for examination
PT	= Aquitision of extra mathematical knowledge

The equation 1 was estimated using the step – wise regression procedure available for binary regression which selects the parsimonious model automatically.

Empirical Results and Discussions

Overview of survey data

The data which were collected through questionnaires were supplemented by the institution's information. A usable sample of 300 students provided enough information to create variables representing family environment, personal characteristics and academic environmental factors.

A preliminary analysis was conducted to scrutinize the factors associated with mathematical performance at O/L examination. Table 2 illustrates the composition of performance in the sample and reveals that approximately half of the students (around 54 per cent) were unsuccessful in their O/L mathematics in 2007. This amount is rather below the failure rates reported (61 per cent) in MEZ for the study time horizon.

Table 2: Student's O/L mathematics performance in MEZ in 2007

Performance of O/L Mathematics	*Count*	*%*
Pass	139	46.3
Fail	161	53.7
Total	300	100

The association of gender and mathematics performance is statistically significant ($P < 0.05$) under the chi square test.

Acquisition of extra knowledge for mathematics is vital for the success at O/L examination. As Table 4 illustrates there is a positive association of attending tuition and performance in mathematics. This is confirmed by the chi squared test by rejecting the null hypothesis of "no Association" even in 1 percent level of significant ($P = 0.000$) giving evidence for the above conclusion.

Table 3: The relationship of Gender and Mathematics performance

Performance of O/L mathematics		*Gender*		*Total*
		Female	*Male*	
Pass	Count	68	93	161
	Percentage	42.2%	57.8%	100%
Fail	Count	78	61	139
	Percentage	56.1%	43.9%	100%
Total	Count	146	154	300
	Percentage	48.7%	51.3%	100%
Chi-Squared value	5.769			
P -Value	0.016			

The breakdown of gender and mathematical performance for the sample is presented in Table 3. Male students outperform their female counterparts in the sample from MEZ.

Table 4: Acquisition further knowledge in mathematics and Mathematical performance

Performance of O/L mathematics		*Acquisition of mathematical knowledge via Tuition*		*Total*
		No	*Yes*	
Fail	Count	73	88	161
	Percentage	45.3%	54.7%	100%
Pass	Count	21	118	139
	Percentage	15.1%	84.9%	100%
Total	Count	94	206	300
	Percentage	31.3%	68.7%	100%
Chi-Squared value	31.692			
P -Value	0.000			

The examination of the characteristics depicted in Table 4 reveals that coherent positive relationship in the variables and results of chi square test confirmed the association between participating for tuition and mathematics performance. Hence, there is an obvious impact of tuition on mathematics performance.

Panels A and B in Table 5 summarize the surveyed data on father's education level and mother's education level by giving the relationship with mathematics performance.

Table 5: Parents' education and Mathematics performance

Panel A : father's level of education

Performance of O/L mathematics		*No schooling*	*Primary*	*O/L Pass*	*A/L or Higher*	*Total*
Pass	Count	19	88	39	9	155
	Percentage	12.3%	56.8%	25.2%	5.8%	100 %
Fail	Count	8	67	43	16	134
	Percentage	6.0%	50.0%	32.1%	11.9%	100 %
Total	Count	27	155	82	25	289
	Percentage	9.3%	53.6%	28.4%	8.7%	100 %

Chi-Squared value 7.99
P -Value 0.046

Panel B : Mother's level of education

Performance of O/L mathematics		*No Schooling*	*Primary*	*O/L Pass*	*A/L or Higher*	*Total*
Pass	Count	7	94	46	14	161
	Percentage	4.3%	58.4%	28.6%	8.7%	100%
Fail	Count	5	63	48	23	139
	Percentage	3.6%	45.3%	34.5%	16.5%	100%
Total	Count	12	157	94	37	300
	Percentage	4.0%	52.3%	31.3%	12.3%	100%

Chi-Squared value 7.111
P -Value 0.068

Father's education level has a great impact ($P < 0.01$) on performance than the mother's level of education ($P < 0.05$). Mothers are less educated with compared to fathers in MEZ and hence fathers' education level creates expectations and

makes attitudes towards higher education since fathers know the significant impact of higher education.

Early preparation for examinations is advantageous for examination candidates in any level. Hence, this study aimed at analysing the significant impact of early preparation on mathematics performance at O/L examination which is a turning point of student life. According to the information illustrated in Table 6, there is a significant effect of well preparation on mathematics performance. The relationship is highly statistically significant ($P < 0.01$) under the results of chi squire test ($\chi^2 = 23.358$ with $df = 2$) given at the bottom part of the Table 6.

Table 6: Early preparation for examination and Mathematics performance

Performance of O/L Mathematics		*Preparation for examination*			*Total*
		Weak	*Moderate*	*High*	
Pass	Count	26	113	22	161
	Percentage	16.1%	70.2%	13.7%	100%
Fail	Count	7	86	46	139
	Percentage	5.0%	61.9%	33.1%	100%
Total	Count	33	199	68	300
	Percentage	11.0%	66.3%	22.7%	100%
Chi-Squared value		23.358			
P –Value		0.000			

Logistic regression analysis

The results of this analysis are illustrated in Table 7 and it reveals a significant relationship between three predictor variables and the outcome variable in the model. The Omnibus test indicates an overall significant model ($\chi_4^2 = 3.386$, $P < 0.01$). Moreover, the analysis demonstrated that all three variables were significantly related at 5 per cent level to the outcome variable, namely, low / high mathematical performance (see Table 7). In other wards, one familial variable and two educational background variables were predictive of differential mathematical performance.

Table 7: Results of the logistic regression analysis

Predictor Variable	*β*	*SE*	*Wald's* χ^2	*P*	*Exp(β)*	*95% CI for Exp(β)*	
						Lower	*Upper*
FEDU							
Primary	0.568	0.404	6.140	0.050**	1.765	0.800	3.897
O/L Pass	0.920	0.438	1.979	0.060*	2.509	1.063	5.925
A/L or Higher	1.202	0.581	4.403	0.036**	3.327	1.066	10.385
			4.284	0.038**			
PEX							
Moderate	0.623	0.479	11.340	0.003***	1.864	0.728	4.770
High	1.523	0.531	1.687	0.094*	4.585	1.619	12.987
			8.220	0.004***			
PT							
Yes	1.403	0.298	22.214	0.000***	4.068	2.270	7.290
Constant	-2.560	0.596	18.452	0.000***	0.077		

* indicates significance at 0.10 level

** indicates significance at 0.05 level

*** indicates significance at 0.01 level

The Cox and Snell R^2 and the Nagelkerke R^2 values were 0.15 and 0.20 respectively. Theses pseudo R^2 measures can be treated as "somewhat analogous to R^2 in linear regression" but never reaches its maximum limit of one. Additional support for model adequacy can be found by inspecting the results of Hosmer – Lemeshow inferential goodness – of – fit test. This test is based on all three predictor variables and yielded a chi square value of 1.415 with $p = 0.923$. This insignificant a result is further evidence of overall model fit *i.e.* Acceptance of the null hypothesis of no specification bias.

The overall effect of father education level is statistically significant at 5 per cent level while the sub levels i.e. primary, O/L pass and A/L or higher are statistically significant at 1 percent and 5 percent levels of significance respectively. Wald's χ^2 statistics are significant and confidence intervals of odds ratios for these categories were not included the number one indicating a crucial impact of father education on the performance of mathematics. The impact of each levels of father education is compared with the benchmark group i.e. no schooling category. Its impact is given by the constant term of the model and it is highly statistically significant ($P < 0.01$). When father's education level is primary their children excel in mathematics performance two-fold higher than whose father's has no schooling.

Further, if a father has completed his O/L there is three-fold higher ability to get success in mathematics for his child with compared to a father who has no schooling keeping other factors are constant.

There is a great influence of early preparing for examination for O/L level mathematics. The overall impact is highly statistically significant while sub levels of preparation is moderate and high is statistically significant under the levels of 10 per cent and 1 per cent respectively. The impact of early preparation is compared with the reference group i.e. weakly prepared students. When a student is well-prepared for the examination in advance his or her ability to get success in mathematics is five-fold higher with compared to a students who has no well preparation early.

It is a widespread norm and theoretical acceptance that acquisition of extra knowledge for any subject is matter of its success and it was confirmed by the results of this study. The participation for mathematics tuition classes is positively influence on the performance and it is highly statistically significant. A student who participates for tuition depicts four-fold higher success rate than a student who did not.

The variables gender, school support and mother's level of education did not significantly contribute to the performance in mathematics in this sample. Although, there was an association between gender and mathematical performance under the chi-square test results, logistic regression dropped this variable from the model. This does not mean that gender has not affected to performance, it says there is no significant impact. It had been reported that males often surpassed females in the performance in mathematics and findings of this study is not consistence across different western context (Rothman and Mcmillan, 2003). However, the results of the Australian studies published by Mullins et al. (2000) and Lokan et al. (2001) have not shown significant gender differences in relation to mathematical achievement. The current study complemented to the study of Sarojinee (1996) with regard to the gender as affective factor for mathematical achievements in grade 11.

Conclusions

The objective of this study was to quantify the relationship between the different factors that are considered responsible for the student's mathematics performance in O/L examination with providing a basis for further research regarding student performance.

This study focused only the Morawaka Education Zone in Matara district and hence, the results of this study may not be generalized to the country as a whole.

From this study based on sampled data, three factors were identified influencing the excellence performance of the students' mathematics success at O/L. Father's level of educations is positively contributes to the performance of mathematics at O/L examination. However, this variable cannot be controlled in social science researches. Giving opportunities to acquire extra knowledge for mathematics is an important for obtaining a higher level of achievement at O/L examination. Early training or early preparation for examination is a well accepted norm and it also is true for the mathematical success at O/L examination. Last two factors can be controlled and hence need more attention in decision making in education. As an example, school teaching activities solely based on covering the curricular within a specified period of time. But it should be included a way of giving special training in preparing for examinations in advance. This matter is relevant to the policy implications under the results of this study.

These results are localized, insufficient to infer on covariates affecting students' mathematical success at O/L for the country as whole. The study carried out can be better extended to sample more regions, include other variables that have not been considered. Models like log-linear can be utilized to assess the general relationship among variables and as an alternative model.

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