Mathematical Theory and Modeling
ISSN 2224-5804 (Paper) ISSN 2225-0522 (Online)
Vol.5, No.10, 2015

A Logistic Regression Model of Students' Academic Performance in University of Maiduguri, Maiduguri, Nigeria

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Abstract

A Logistic regression model was used to investigate the factors that influence student's performance in MTH101 (Element of Calculus) course. The data used were the grades of the (200-400) level students in MTH101 course which was collected from the department's examination record and also by questionnaire administered to the students. The data analysis shows that the factors that significantly influence academic performance in MTH101 course are G.P.A (student's academic Performance), course challenge (student's attitude related to the course) and concept in the course relate to real world experience (student's motivation). It was therefore recommended that intervention strategies to bring about improvement in the course should be focused on how to enhance academic performance, change course related attitudinal problems and provide sufficient motivation.

Key Words: ACADEMIC PERFORMANCE, LOGISTIC REGRESSION, AT RISK STUDENTS, ODDS RATIO, LEARNING IMPROVEMENT STRATEGY, COUNSELING, ATTITUDINAL PROBLEMS AND MOTIVATION.

1. Introduction

Elements of Calculus (MTH101) is a compulsory first year course for all students in the science faculty of the university of Maiduguri. The course is an essential basis for many advance courses in Mathematics and other disciplines in the sciences.Over the years, there have been recorded consistent poor performance in this course, by students in all the departments in the faculty. Studies have shown that poor performance in calculus is not restricted to Nigeria but to Colleges and Universities of other countries, for example, United States of America (Ferrini – Mundy & Graham 1991). Also there are other subjects for which poor performance of students are noted and have been therefore subject of research studies. Examples of such studies are found in (Edward *et al.* 1996), (Iduseri & Edokpa 2011), (Lauren *et al.* 2008) and (Mamta & Sandra 2014).

Consequently, there must be some inhibiting factors militating against students' performance. The interest of this paper is therefore focused on identifying such factors among the students in the Mathematics and Statistics department of the University in order to provide basis for improvement intervention strategy on course delivery.

2. Logistic Regression Model

There are several studies on factors that inhibit students' performance in courses at the undergraduate level. Some of the factors identified are high school grades (Russel & Julie2006) and (Edge & Friendberg 1984), belief and attitudes (Kloosterman & Stage 1992) and (Kloosterman *et al* 1996), motivation (Lowis & Castley 2008) and Socio-economic (Akanle 2007). The approach of studying these factors are based on either Logistic regression method (Aromolaran *et al.* 2013), (Omar *et al.* 2002), (Angela *et al.* 2013) and (Adejumo 2012) or Discriminant analysis (Blazenka & Dijana 2009), (Erimafa *et al*. 2009), (Fagoyinbo *et al*. 2013) and (Humeral *et al*. 2015). Here we adopt the logistic regression approach because of its advantages.

Logistic regression analysis extends the techniques of multiple regression to research situations in which the outcome variable is categorical. Applications abound in the fields of medicine (Sharareh *et al*. 2010), social sciences (Chuang 1997) and education (Aromolaran *et al*. 2013).

Its salient feature is that there is a binary response of interest and the predictor variables are used to model the probability of that response. Here the binary response variable, Y, is:

- Grades **D – F**, coded as **0**; regarded as students at risk of being successful in MTH101 course and
- Grades **A – C**, coded as **1**; regarded as students not at risk of being successful in MTH101 course.

The predictor variables are the factors being investigated, for possible influence on the response variable.

The model equation in logit form is given by

$$Log\left[\frac{p(x)}{1-p(x)}\right] = \alpha + \beta_1 X_1 + \beta_2 X_2 + ...\beta_k X_k \quad (2.1)$$

where X_i, i=1,…,k are the factors being investigated and

P(x) = P(Y=1/X=x)

$$= \frac{1}{1+e^{\sum_{i=1}^{k}\beta_i X_i}} \quad (2.2)$$

where the vector, X =(x_1, x_2,...x_k)

Hence the odds ratio is

$$\Pi(x) = \frac{p(x)}{1-p(x)} \quad (2.3)$$

3. Research Design

The research instrument used is the questionnaire method coupled with extraction of information from the respective student's record in the department of Mathematics and Statistics of the University. The questionnaire consisted of 41 questions making up the predictor variable investigated. It is conveniently grouped into nine subsections. Details of the questionnaire are provided in the appendix.

The questionnaire was tested for content validity and test-re-test reliability before administering it to students. The target population consists of 200 – 400 level students of Mathematics and Statistics department of the University of Maiduguri, Maiduguri, Nigeria. A random sample of 60 and 103 students from the target population of 140 were administered the questionnaire for the pilot and main survey respectively. The main study sample size of 103 was derived using the sample table guide for sample size decisions provided by (Krejcie & Morgan 1970). The response rate is 100% because concerted efforts were made to retrieve the questionnaire from students.

4. The Data

The data used were derived from the departmental examination record office and the questionnaire administered to students using appropriate numerical codes. The grades of the students in MTH101 course, which is the binary dependent variable, is coded as mentioned earlier. The questionnaire covered largely the forty-one independent variables that were investigated.

The choice of response to a question could be categorical, multiple choice, or alternative choice answers provided on a likert scale. The coding for the likert scale is done as follows:

Strongly agree is coded 4, agree 3, disagree 2, strongly disagree 1 and undecided 0.

All other types of choice of response were coded in a serial sequence. The coded form of the response to the questionnaire by the 103 students in the study constitute the data for analysis.

5. Demographic Features of the Data

A bar and pie chart was used to display some of the demographic variables, which are Gender, Age, Place of Residence, Home Background and Parent's Financial Status. These are shown in figures 1 to 6 respectively. Categorization of grades of the respondents in MTH101 course is shown in figure 6. All the charts were obtained using Microsoft Excel.

6. Method of Data Analysis

The data were analysed using statistical package for social sciences (SPSS). A stepwise Logististic Regression method was performed. The parameters were obtained by maximum likelihood method. The Neglerke R^2, Chi – Square Test, Hosmer- Lemeshow test and Percentage Accuracy in Classification(P.A.C) were used to assess the model fit. The wald statistic, likelihood ratio test and odds ratio with 95% Confidence Interval (C.I) were used to assess the significance of the individual coefficient.
Discriminant analysis was also performed on the data. Here the students falling respectively under the codes 0 and 1 of the independent variable formed the two groups for the Discriminant analysis. A Discriminant analysis was performed primarily as a confirmatory analysis. This is because of the advantages (Joseph *et al*. 2010) of the logistic regression over the Discriminant analysis. These are:

i. Logistic regression does not require any specific assumption on the distributional form of the independent variable.
ii. Heteroscadacity does not come to play as it does in Discriminant analysis and
iii. Discriminant analysis relies strictly on meeting the assumptions of multivariate normality and equal variance-convariance matrices across groups – assumptions that are not met in many situations.
iv. Logistic regression is much more robust when these assumptions are not met.

7. Discussion of Results

From the demographic features of the data in figures 1 to 5 below, the proportion of female respondents is smaller than that of males. This is because few females are enrolled in the mathematics department. Most of the respondents are off – campus students.

The value of the R^2 in table 1 indicate that 44.4% of the variability in the log odds ratio is explained by the independent variables. The result of the Hosmer – Lemeshow goddness – of – fit test in table 2 indicate that the logistic model is a good fit to the data. In table 3, the model correctly classifies 71% of all the cases. This again confirms that the model is a good fit.

The results in table 4 show that only three variables were identified to have significant regression coefficient β. They are G.P.A, Course Challenge and Concept of Course relate to the real world. Hence, they are the only variables that contributed significantly to the predictive ability of the model. Column seven of Table 4 gives the values of the corresponding estimated odds ratios, that is, e^{β}. The estimates range from 2.45 to 2.96. The highest value, 2.96 obtains for the variable course challenge while those for G.P.A and Concept in Class are each approximately 2.5. These estimates are quite high and indicate that with high G.P.A., positive attitude towards the course and believe that the concept in the course relates to the real world experience, students not at risk of being successful in the course have higher odds ratio than those at risk.

The confidence interval for each of the odds ratio estimates does not include one. That is, as the value of each predictor variable can take increases, so does the odds ratio.

8. Conclusion

A logistic model was fitted to data on some variables provided by questionnaire administered on 103 students in MTH101 class. From the Neglerke R^2, 44.4% variation in the log odds ratio was explained by fitting the independent variables. The unexplained variation is 55.6%; this is quite high, implying that there are other important independent variables which are not included in the regression model. Consequently, a research for these variables could be focused perhaps in the direction of questions probing deeply into the socioeconomic background of the students. The Hosmer Lemeshow test shows that the model is a good fit. The model also correctly classifies 70.8% of the overall cases; this is also an indication that the model is a good fit. Only three variables made significant contribution to the predictive ability of the model. The highlights of the logistic regression results were also confirmed by applying Discriminant analysis to the data. However the logistic regression method of analysis is the preferred choice. The fitted model in logit form is given by

$$\log \frac{P(X)}{1-P(X)} = -8.369 + 0.926X_1 + 1.026X_2 + 0.896X_3 \qquad (7.1)$$

where

$$p(x) = \frac{e^{(-8.369 + 0.926X_1 + 1.026X_2 + 0.896X_3)}}{1 + e^{(-8.369 + 0.926X_1 + 1.026X_2 + 0.896X_3)}}$$

and

X_1 = G.P.A
X_2= Course Challenge
X_3 = Concept of the course relate to real world experience.

The odds ratio for these three variables are quiet high, implying that for each of these variables not at risk students are more likely to succeed in MTH101 course than those at risk.
Hence, these three variables affect the status of the at risk students in MTH101 course. The variable G.P.A is on academic performance while the variables course challenge and concept of course relate to real world experience come under the sub grouping of the variables with titles, student's attitude and student's motivation respectively. Consequently, this clearly indicates that any intervention strategy that could lead to the improvement of performance of the students at risk of being successful in MTH101 course could be focused on student's academic performance, attitude related to the course and motivation.

9. Recommendations

Based on the results, the following recommendations are proposed.

i. Those at risk students having a negative attitude towards the course because they believe calculus is difficult, can be helped by counseling at the start of their University career. This counseling can be done by either the course instructor or 100 level co-ordinator.

ii. Those at risk students who believe that calculus is not related to the real world experience can be helped by an intervention early in their University career. Interventions from counselors, support groups and the course lecturer could motivate these students as to changing their attitude towards the course. This intervention could be based on telling them the importance of calculus and its application to the real world experiences. Another intervention strategy could be by encouraging the use of progressive teaching techniques in the course. This will help the students better understand the fundamentals of the complex concept that are often presented in the course.

iii. Students who are at risk of receiving low grades in this course can reliably be identified. Identification of potential low performing students can happen both in the classroom and at the administrative level. Classroom techniques to identify low performing students include using clear grading strategies, helping students be aware of their grades early and often throughout the semester, the issuance of formal continuous assessment reports, the use of formative assessment, and the implementation of proactive counseling by peers, instructors, and/or administrators to make students aware of the potential implications of their grade status, and to offer them advice and assistance on improving their grades.

iv. The results showed that there are other important independent variables not identified but could be accommodated in the model. This could form the basis for further investigation. Expanded questions on the socioeconomic status of the students are suggested as one of the areas that could be further investigated.

v. This model could be modified for use in other similar courses where students are having learning difficulties.

Acknowledgement

The authors wish to thank Dr. Ahmed Abdulkadir of the Department of Mathematical Sciences of the Abubakar Tafawa Balewa University, Bauchi, Nigeria and the referees for their valuable comments during the preparation of the manuscript of this paper.

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Appendix

i. Bio Data

1. What is your age?
   1) 18 or younger
   2) 19 – 20
   3) 21 - 22
   4) 23 - 25
   5) 26 – 29
   6) 30 or older
2. What is your gender?
   1) Female
   2) Male
3. Place of residence?
   1) Hostel
   2) Off campus
4. What is your Jamb Score?
   1) 0 – 149
   2) 150 – 199
   3) 200 and above
5. What is your O'level (i.e either WAEC or NECO or NABTEB) grade in Mathematics?
   1) A
   2) B
   3) C
   4) D
   5) E
   6) F
6. Career choice?
   1) Imposed by Parents/School
   2) Chosen by me
7. What is your GPA in 100 level?
   1) Below 1.5
   2) 1.5 – 1.9
   3) 2.0 – 2.4
   4) 2.5 – 2.9
   5) 3.0 – 3.4
   6) 3.5 – 5.0

ii. Parental Background

8. What is your Parents education status?
   1) Educated above secondary school
   2) Educated below secondary school
   3) Not educated
9. What is your parent's financial status?
   1) Rich
   2) Average
   3) Poor
10. Home background?
    1) Broken home (parents divorced)
    2) Broken home (parents apart)
    3) Parents deceased (either or both)
    4) Parents living together

iii. Parent's Motivation

11. .During your Primary/Secondary School days, what is your parent's level of interest in what you have learnt in school?
    1) Very interested
    2) Interested
    3) Not interested
12. After your school hours when you were in Primary/Secondary school, how encouraging were your parents?
    1) The organize extra lessons for me and the compel me to have reading hours every day
    2) They organize extra lessons for me
    3) The compel me to have reading hours every day
    4) Indifferent

To What extent do you agree or disagree with the following statements in questions 13 - 23?

iv. Conditions of the Lecture Hall

Question Number	Questions	STRONGLY AGREE	AGREE	Disagree	Strongly Disagree	Undicided
13.	The lighting and ventilation of the MAT 101 classrooms during lectures are sufficient					
14.	The lecture hall is always over populated during MAT 101 classes					

v. Course Delivery

Question number	Questions	Strongly agree	Agree	Disagree	Strongly Disagree	Undecided
15.	The time dedicated to each topic within the course (MAT 101) is sufficient and meets the requirements of the syllabus					
16.	The lecturer doesn't miss lectures and he comes to class early					
17.	The lecturer makes good use of the examples chosen					
18.	The lecturer is able to motivate the class					
19.	The lecturer is able to awaken the interest of the students for the Course					
20.	The lecturer creates a friendly atmosphere which encourages Participation					
21.	The lecturer recommends textbooks for reading					
22.	The recommended reading list is useful for understanding the Course					
23.	The lecturer is willing at all times to deal with students' queries					

vi. Students Attitude related to the course

24. How challenging was this MTH 101 class for you?
    1) Difficult
    2) Somewhat challenging
    3) Not very challenging
    4) Easy
25. How will your level of success in this class affect your academic, career or personal goals?
    1) It definitely will not affect my goals at all
    2) It probably will not affect my goals
    3) It probably will affect my goals
    4) It definitely will affect my goals
26. How has taking this course (MTH 101) affected your interest in Mathematics in general?
    1) As a result of this course, I am now less interested in Mathematics in general
    2) Taking this course has not affected my interest in Mathematics in general
    3) As a result of this course, I am now more interested in Mathematics in general
27. Success in this course (MTH 101) mainly requires
    1) Memorizing facts, methods, and/or equations
    2) Analyzing theories, concepts, or ideas
    3) Synthesizing new information or ideas
    4) Making judgments about the value of ideas
    5) Applying learned ideas in practical situation
    6) Offering my opinion, expressing my feelings or belief

vii. Student's Attitude related to the School

28. Why did you come to University of Maiduguri?
    1) Social or physical environment of Flagstaff
    2) Social or physical environment on campus
    3) Reputation of academic programs
    4) Convenience
    5) Fianancial incentive (relative low cost of tuition, scholarship, etc)
    6) Other
29. How satisfied are you with your overall experience at University of Maiduguri?
    1) Very dissatisfied
    2) Slightly dissatisfied
    3) Generally satisfied
    4) Very satisfied

viii. Student Motivation

30. How do responsibilities outside of school affect your success at school?
    1) They don't ever affect my success at school
    2) They occasionally affect my success at school
    3) The often affect my success at school
    4) They always affect my success at school
31. What non-academic factor most influences your success in this MTH 101 class?
    1) Work and/or financial situation
    2) Family obligations
    3) Physical and/or emotional health
    4) Athletics
    5) Social and/or recreational activities
    6) Interest and/or motivation in this class or in school
32. How consistent are activities in this MTH 101 class with your original expectations of this class?
    1) The activities don't meet my expectations
    2) The activities are what I expected
    3) The activities exceed my expectations
33. How do things you learn in this MTH 101 course relate to the real world?
    1) Concepts in this course do not relate to the real world experiences
    2) Concepts in this course only slightly relate to real world experiences

3) Concepts in this course mostly relate to real world experiences
4) Concepts in this course relate very well to real world experiences

34. The resources necessary for success in this course (MTH 101) are:
    1) Not available
    2) Available,, but very difficult or inconvenient to use
    3) Available, but a bit difficult or inconvenient to use
    4) Readily available and easy to use
35. The primary motivation you are pursuing a University degree is to:
    1) Be financially successful
    2) Pursue a career I love
    3) Satisfy a personal interest or goal
    4) Follow the advice of a parent or guardian
    5) Interact socially with other students
    6) Other

ix. Student Academic Habit

36. How often do you come to lectures?
    1) Less than 50% of the lectures
    2) 51 – 74% of the lectures
    3) 75 – 94% of the lectures
    4) 95 – 100% of the lectures
37. How many hours per week do you devote to this course (MTH 101) beyond the time you spend in class (for example, reading, doing homework, and studying)?
    1) I don't spend any time on this course outside of lectures
    2) Less than one hour
    3) 1 – 3 hours
    4) 4 – 6 hours
    5) 7 – 10 hours
    6) More than 10 hours
38. Compared to your course mates, what is your level of in-class participation?
    1) My course mates, participate more than I do
    2) I participate about the same as my course mates
    3) I participate more than course mates
39. How academically prepared were you for this course (MTH 101) at the beginning of the semester/
    1) Not prepared
    2) Somewhat prepared, but lacking some important skills or knowledge
    3) Prepared
40. How do your regularly prepare for this course (MTH 101)?
    1) Reading the text or assigned readings
    2) Studying notes taken in class
    3) Doing homework
    4) Talking with course mates or friends
    5) Other
    6) I don't do anything to prepare
41. How often did you discuss ideas from lectures, or readings from this course (MTH 101) with people outside of class?
    1) Never
    2) 1 – 3 times per semester
    3) 6 – 10 times per semester
    4) More than 10 times per semester

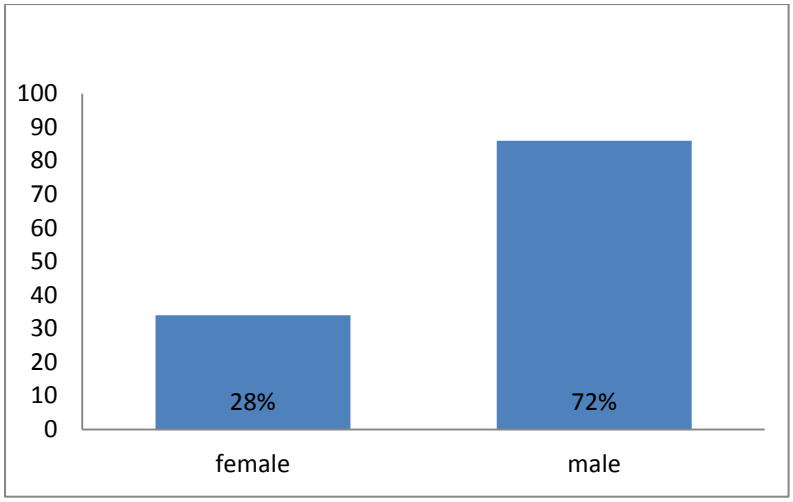

Figure 1 Gender of Respondents

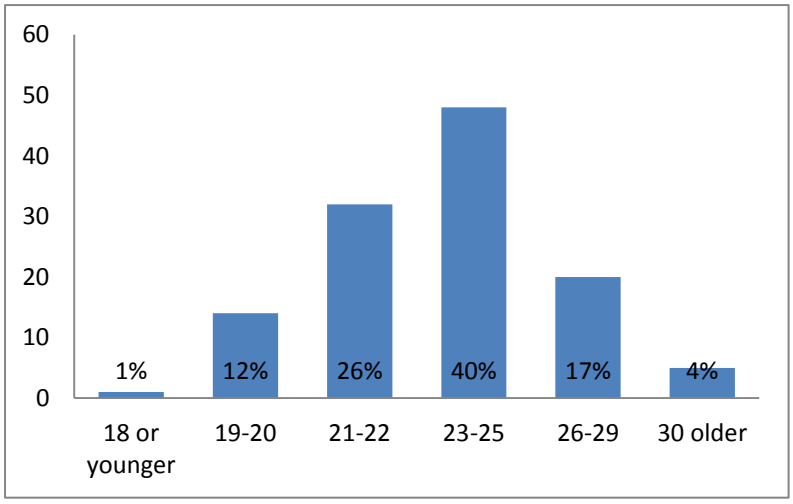

Figure 2 Age of Respondents

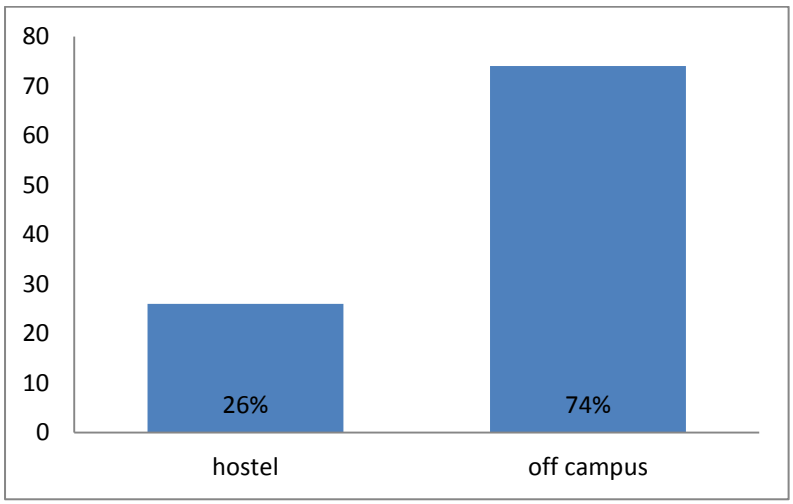

Figure 3 Residence of Respondents

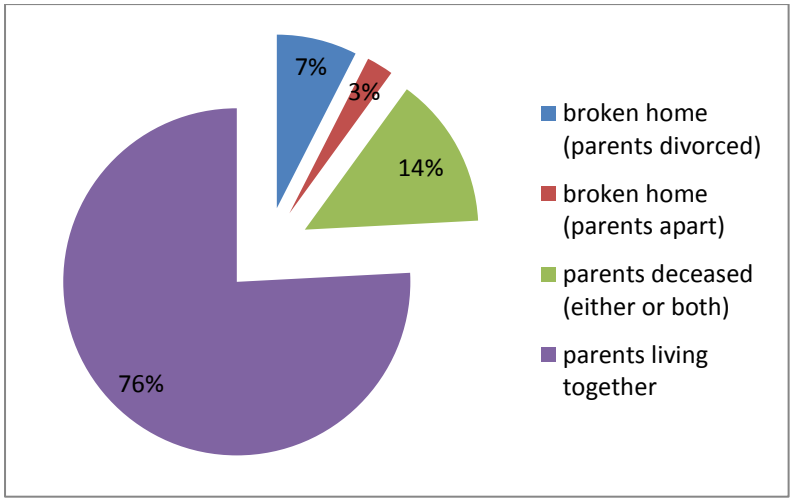

Figure 4 Home Background

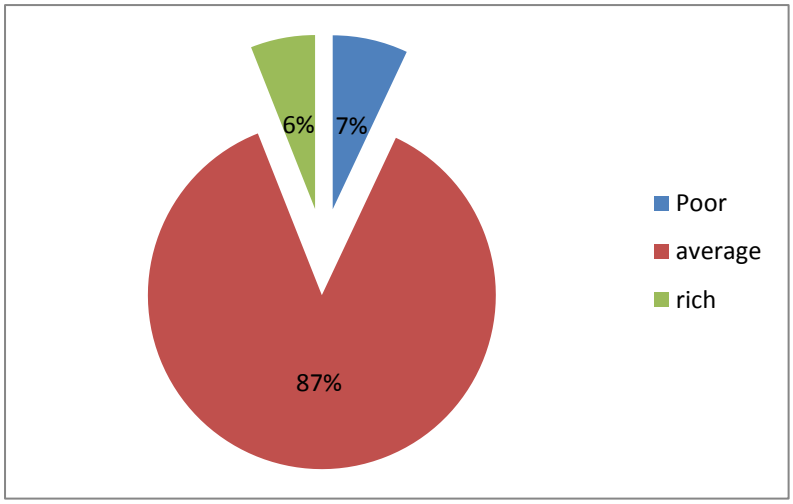

Figure 5 Parent's Financial Status

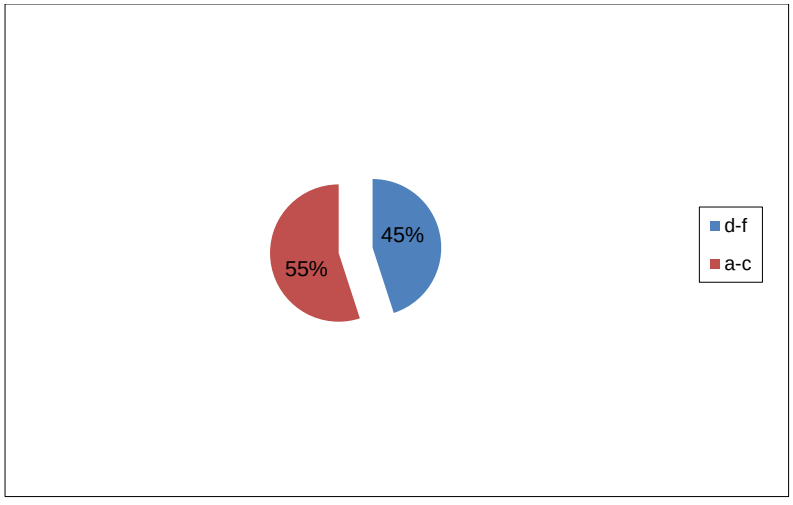

Figure 6 Categorization of Grades of Respondents in MTH101 Course

Table 1 Model R^2

-2 Log likelihood	Nagelkerke R Square
69.092	.444

Table 2 Hosmer and Lemeshow Test

Chi-square	df	Sig.
11.824	7	.106

Table 3 Classification Table

Observed		Predicted		
		Mat 101 grades		Percentage Correct
		d to f	a - c	
Mat 101 grades	d to f	29	17	63.0
	a – c	13	44	77.2
Overall Percentage				70.8

Table 4 Variables in the Equation

	β	S.E.	Wald	Df	Sig.	Exp(β)	95.0% C.I.for EXP(β)	
							Lower	Upper
G.P.A	.926	.280	10.965	1	.001	2.526	1.459	4.370
Course challenge	1.086	.419	6.717	1	.010	2.962	1.303	6.734
Concept in the class	.897	.379	5.591	1	.018	2.451	1.166	5.154
Constant	-8.369	2.195	14.536	1	.000	.000		

Table 5 Discriminant Analysis Ouput of the Significant Variables

		Wilks' Lambda							
						Exact F			
Step	Entered	Statistic	df1	df2	df3	Statistic	df1	df2	Sig.
1	GPA	.832	1	1	69.000	13.925	1	69.000	.000
2	Course Challenge	.733	2	1	69.000	12.395	2	68.000	.000
3	Concept in the class	.681	3	1	69.000	10.485	3	67.000	.000

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