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Effects of Students' Beliefs on Mathematics and Achievement of University Students: Regression Analysis Approach

Velo Suthar and Rohani Ahmad Tarmizi
Institute for Mathematics Research, University Putra Malaysia,
43400 UPM, Serdang, Selangor Darul Ehsan, Malaysia

Abstract: Problem statement: At present, after almost more than 20-decades, Malaysia can boast of a solid national philosophy of education, despite tremendous struggles and hopes. The professional learning opportunities are necessary to enhance, support and sustain students' mathematics achievement. **Approach:** Empirical evidence had shown that students' belief in mathematics is crucial in meeting career aspiration. In addition mathematical beliefs are closely correlated to their mathematics achievement among university students. **Results:** The literature exposed that a few studies had been done on university undergraduates. The present study involves a sample of eighty-six university undergraduate students, who had completed a self-reported questionnaire related to student mathematical beliefs on three dimensions, viz-a-viz beliefs about mathematics, beliefs about importance of mathematics and beliefs on one's ability in mathematics. The reliability index, using the Cronbach's alpha was 0.86, indicating a high level of internal consistency. Records of achievement (GPA) were obtained from the academic division, University Putra Malaysia. Based on these records, students were classified into the minor and major mathematics group. The authors examined students' mathematical beliefs based on a three dimensional logistic regression model estimation technique, appropriate for a survey design study. **Conclusion/Recommendations:** The results illustrated and identified significant relationships between student beliefs about importance of mathematics and beliefs on one's ability in mathematics with mathematics achievement. In addition, the Hosmer and Lemeshow test was non-significant with a chi-square of 8.46, $p = 0.3$, which indicated that there is a good model fit as the data did not significantly deviate from the model. The overall model, 77.9% of the sample was classified correctly.

Key words: Mathematics achievement, mathematical beliefs, logistic regression analysis, likelihood method-of-estimation

INTRODUCTION

The swift competition and progress in a globally changing economic and technological environment have been one of the driving forces for enhancing educational accountability in many countries (Martin *et al*., 1998). It is absolutely necessary for a nation to improve its standards of teaching, research and practice in science, mathematics, technology and engineering. As a consequence, professional and business guidelines have been developed over the last two decades to strengthen mathematics and science curriculum standards. The Malaysian government had announced a new education policy to strengthen the education standards in science and technology to compete with advanced countries and vowed to stand in the list of developed countries in 2020 (Mahathir, 1991). For example in the United States, national organizations produced documents to advocate curriculum articulation between mathematics and science education (National Council for Teachers of Mathematics, 2000; National Research Council, 1996). Meanwhile, educators in the United Kingdom adopted interdisciplinary approaches in the development of its national curriculum (Nixon, 1991). The Curriculum Council of Western Australia (1998) also recommended teaching methods across traditional subject boundaries (Venville *et al*., 1998).

Malaysia has successfully democratized higher education to produce sufficient graduates to meet its manpower requirements during its phenomenal economic growth over the last three decades. Higher education in the public universities is heavily subsidized by the government. In 2007, there were

Corresponding Author: Velo Suthar, Institute for mathematics Research, University Putra Malaysia, 43400 UPM, Serdang, Selangor Darul Ehsan, Malaysia

9,422,002 students in 20 public universities, 32 private universities and university colleges, 4 branch campuses of international universities, 21 polytechnics, 37 public community colleges and 485 private colleges (Ministry of Higher Education, 2007). The four international universities with branch campuses in Malaysia are University of Nottingham, Monash University, Swinburne University of Technology and Curtin University of Technology.

The Malaysian government is attempting to increase the number of graduates especially in the fields of science, technology and innovation to become knowledge workers to sustain the nation and to achieve the title of a developed nation by the year 2020 (Sam *et al*., 2009). These fields inevitably require students to be adept in Mathematics. Various efforts such as the 60: 40 ratio in the teaching of Science and Mathematics policies had been put in place. Various research has been undertaken to investigate trends in mathematics achievement and the factors influencing mathematics learning and performance (Ma and Klinger, 2000; Pape *et al*., 2003; AlKhateeb, 2001; Mullis *et al*., 2004; House and Telese, 2008). Ma and Klinger (2000) considered the factors influencing mathematics achievement, which included students' gender, age, ethnicity, their family socioeconomic status and school characteristics in their study. In Papanastasiou (2000), the effects of school, students' attitudes and beliefs in mathematics learning on students' performance were explored. Mathematics beliefs and self-concept were also investigated by House and Telese (2008) and Wang (2007) while AlKhateeb (2001) examined gender differences in mathematics achievement among high school students.

Research was performed by Sam *et al*. (2009) on TIMSS data demonstrated that the eighth grade students from Singapore (Singapore, used to be a part of Sultanate of Johor, Malaysia 1965) were ranked first in mathematics among participating 41 countries while its neighbored, Malaysia was ranked 16th and 10th in 1999 and 2003 respectively (Mullis *et al*., 2000; 2004). Is it something about its students, teachers and/or school system that lead to Singapore's superiority over Malaysia in as far as mathematics performance is concerned? Thus it is the main interest of this study to investigate the possible weakness and flaw in Malaysian education system, including the students, teachers, schools and other characteristics of the students in hope of helping Malaysia improve its performance in Mathematics globally.

Importance of mathematics: Everything in the universe has been recognized by its worth and value. A diversity of independent major study areas and disciplines are offered at interest of higher education. The importance of having a solid background in mathematics and quantitative analysis as prerequisites for admission into university and college areas of study is well recognized. Students' achievements in mathematics in high school have a significant effect on their performance in college (Ismail and Awang, 2008). Mathematical and quantitative competencies are also linked to better chances of employability, higher wages and higher on-the-job productivity once employed (Geary and Hamson, 2000). Thus, mathematics learning and students' performance in mathematics receive considerable attention from educators, teachers and parents. It is therefore important to identify and recognize the factors that could influence students' mathematics achievement in order to help them improve and make substantial academic progress.

Recently, in Malaysia, the growing awareness of the importance of mathematics competency in secondary school for tertiary education and future careers has led to high expectations from both the teachers and parents for students to do well in mathematics examinations. Mathematics as a subject is taught in every tuition centre across all levels of schooling outside of the school hours, with a growing number of parents who appointing teachers to provide personal tutoring for their children at home (Ismail and Awang, 2008). There is also a concern about the issue of disparity in mathematics achievement between the different subgroups of the population, as well as ways of improving students' overall performance and narrowing students' achievement gaps. It is the purpose of this study to examine the differences in students' achievement in University mathematics across a variety of characteristics pertaining to the students' beliefs about mathematics, cognitive and self-regulated learning strategies, demographic factors, including gender, the education of parents and impact of self study outside of school hours.

MATERIALS AND METHDOS

A descriptive survey research was conducted using a set of questionnaire to collect data from the university undergraduate students. In the first part of the questionnaire was soliciting demographic information whilst the second part comprise of 48 items with 5-points likert scale questions (1 is strongly disagree to 5 is strongly agree) measuring mathematical beliefs and Self-Regulated Learning (SRL). In the materials and methods assessed the use of Self-Regulated Learning strategies (SRL) adapted from the Self-Regulated Learning Questionnaire (SRLQ) (Pintrich *et al*., 1993;

Pintrich and De Groot, 1990) and students' beliefs in mathematics item were adapted from Vallerand *et al.* (1992). The SRLQ was developed Pintrich *et al*. (1991) and Kaya (2007) by to assess self-regulation and the use of learning strategies by students. In the previous study, 81 Likert-type items of the Turkish version of the MSLQ (Hendricks *et al*., 2000) were used and it was scored on a 7-point Likert scale.

Additionally, closed (multiple choice) and open ended questions were part of the questionnaire for assessing critical and mathematical problem solving ability of the students. The open ended questions were adopted from Costa and McCrae (1991) and Farley (1991) type T measure. The questionnaire was administered to the university undergraduate students during their lecture sessions. Survey responses were tabulated and reported in the form of frequencies and percentages as suggested by Fraenkel and Wallen (1994).

The subjects of the study were the undergraduate students (male and female) enrolled during the semester of 2009 in University Putra Malaysia. Upon obtaining permission, arrangements for dates and times was made to administer the instruments. They (students) were also reminded that their specific responses would not be shared with their course instructors and would not affect their course grades. The students asked to respond to the items appropriately and honestly.

The reliability coefficients of the subscales were checked in this study. Mathematics achievement test (the second part of the questionnaire about critical thinking and problem solving) was used to determine the students' mathematics achievement and to assess the students' degree of attainment of the course objectives. Several logistic regressions were performed through SPSS to assess prediction of membership in majoring or non-majoring mathematics undergraduate students of University Putra Malaysia. Besides, Logistic regression model was applied to explore the extent of demographic and educational factors, which affect the university students' achievement in mathematics and as well as to ensure the accuracy and predictive validity of logistic regression model.

RESULTS AND DISCUSSION

Table 1 presents the descriptive statistics for the age variable measured in years of undergraduate students of University in the present study. The average age of respondents was 22.44 years and standard deviation of .644, while minimum and maximum ages of respondents were 20 years and 23 years respectively and its standard error was .069. The average age estimate coincides with the age estimates of 39 students (45%) in that sample were so-called "traditional" undergraduates with online learning was slightly difference with 3 range (ages 18-24); calculated by Artino and Stephens (2009) and Briley (2007) who reported that the average ages were 21.95 years and standard deviation of 4.62, respectively.

The frequencies and percentages of gender of respondent, the sample included 62 females (72.1%) and 24 males (27.9%). Monthly expenditure in Malaysian Ringgit (RM) of the respondents were illustrated in detail with 44 students (51.2%) expenses were RM1-300, 33 students (38.4%) expenses were RM301-600, 7 students (8.1%) expenses were RM600-900 and 2 students (2.3%) were RM 901 and above. There were four ethnic groups found in a sample of 86 students in the study. These races/ethnicities comprises of Malay, Chinese, Indian and International are 59 students (68.6%), 23 students (26.7%), 3 students (3.5%) and one student (1.2%), respectively. The sample of respondents consists of both major and non-major mathematics; there were 46 students (53.5%) from major mathematics and 40 students (46.5%) from non-major mathematics. The respondents were further classified in number of semesters; there were 60 students (69.8%) of 6th semester and 40 students (30.25%) of 8th semester. The self-study hours (measured intervals of 2 h) of the respondents indicated that 39 students (45.3%) studied to 0-2 and 3-4 h and only 8 students (9.3%) reported studying around 5-6 h daily.

Further, a descriptive statistic confirms that parents' education of the respondents were mostly from the primary and secondary education level. A major portion of the parents' only completed high school education, followed by bachelors with 71 fathers of respondents (82.6%) and 13 fathers of respondents (15.1%), respectively and only one (1.2%) with a Masters degree and other. There was no big difference between father and mother education levels. Similarly for mothers, a major portion high school education, followed by bachelor with 78 mothers of respondents (90.7%) and mothers of respondents (8.1%), respectively and only one (1.2%) in other. Additionally, items measuring three constructs, these are students' beliefs about mathematics, Beliefs about mathematics importance and Beliefs ones ability in mathematics presented with their descriptive statistics (means and standard deviation) as revealed in Table 2.

Table 1: Descriptive statistics of age variable of respondents

	N	Minimum statistic	Maximum statistic	Mean Statistic	Std. error	SD
Age of respondent	86	20	23	22.44	0.069	0.644
Valid N (listwise)	86					

Table 2: Descriptive statistics of 15 items were used in three constructs these measures students' beliefs of major and minor mathematical groups

	Minor mathematics group			Major mathematics group		
Items' description	Mean statistic	S. error	SD	Mean statistic	S. error	SD
Items for students' beliefs about math	4.31	0.076	0.479	4.40	0.070	0.474
Mathematics is a considered one of the interesting subjects.	4.15	0.137	0.864	4.33	0.132	0.896
Good mathematics teachers spark my interest in math.	4.58	0.107	0.675	4.63	0.084	0.572
I get inspiration on completion of complex math problems.	3.80	0.144	0.911	3.98	0.114	0.774
Mathematics is a challenging subject.	4.60	0.086	0.545	4.74	0.079	0.535
I enjoy learning by different ways in math class work and assignment.	4.40	0.093	0.591	4.30	0.098	0.662
Items for beliefs about importance of math	4.55	0.083	0.516	4.37	0.079	0.537
Math is key of scientific learning	4.65	0.092	0.580	4.54	0.074	0.504
I study math because I know how useful it is.	4.58	0.118	0.747	4.24	0.133	0.899
Knowing math will help me earn a living.	4.54	0.096	0.600	4.20	0.130	0.885
Math is a worthwhile and necessary subject.	4.43	0.123	0.781	4.46	0.092	0.622
Math will not be important to me in my life's work.	4.63	0.111	0.705	4.39	0.114	0.774
Items for beliefs ones' ability in mathematics	3.59	0.098	0.617	3.93	0.080	0.542
I have the ability in math than in my ability in other science subjects.	3.63	0.159	1.005	4.13	0.141	0.957
I can cope with new situation because I have a good background in mathematics.	3.45	0.134	0.846	3.87	0.106	0.718
I get flustered if I am presented with a problem different from the problems worked in class.	3.10	0.123	0.778	3.41	0.115	0.777
I do not feel that I can use the knowledge gained in math courses I have taken so far.	3.73	0.148	0.933	3.96	0.135	0.918
No matter how hard I try, I feel I just cannot understand my math.	4.03	0.150	0.947	4.26	0.095	0.648

Table 3: Correlations of students' beliefs about mathematics and demographic variables

	1	2	3	4	5	6	7	8	9	10
Sex of respondent	1	0.219(*)	0.003	-0.001	0.013	-0.295(**)	-0.202	-0.201	-0.042	-0.095
		0.043	0.978	0.991	0.905	0.006	0.062	0.064	0.706	0.382
Age of respondent		1.000	0.174	-0.213(*)	-0.237(*)	-0.290(**)	-0.201	-0.267(*)	-0.036	-0.230(*)
			0.108	0.049	0.028	0.007	0.064	0.013	0.742	0.033
Race/ethnicity of respondent			1.000	0.011	-0.033	-0.073	0.076	0.148	-0.132	0.454(**)
				0.918	0.763	0.506	0.487	0.173	0.227	0.000
Fathers' education				1.000	0.656(**)	0.159	0.050	0.099	-0.049	0.155
					0.000	0.144	0.647	0.363	0.655	0.155
Mothers' Education					1.000	0.113	0.229(*)	0.184	0.015	0.149
						0.300	0.034	0.089	0.892	0.172
Hours of daily study						1.000	0.288(**)	0.248(*)	0.295(**)	0.165
							0.007	0.022	0.006	0.128
[1]Ave BaM							1.000	0.696(**)	0.534(**)	0.096
								0.000	0.000	0.381
[2]Avg.BoAM								1.000	0.431(**)	0.285(**)
									0.000	0.008
[3]Avg.BIM									1.000	-0.177
										0.104
Math as minor or major										1.000
# Cases (listwise)	86	86	86	86	86	86	86	86	86	86

*: Correlation is significant at the 0.05 level; **: Correlation is significant at the 0.01 level; [1]: Ave BaM is average beliefs about mathematics; [2]: Avg.BoAM is Beliefs about mathematics importance; [3]: Avg.BIM is Beliefs ability in mathematics

Table 4: Classification of cases

	Predicted		
	Math as minor or major subject		
Observed	Minor	Major	Correct (%)
Minor math	23	16	59.0
Major math	11	35	76.1
Overall percentage			68.2

*: The cut value is 0.500

Correlation coefficients between beliefs about mathematics and demographic variables were found significant at the 0.05 level (2-tailed) denoted by one stretch (*) and significant at the 0.01 level (2-tailed) denoted by two stretch (**) as in Table 3.

A logistic regression model was developed to predict the correct classification of the students between the major and non-major mathematics classes. The independent variables used for these analyses were obtained from the background questionnaires that were administered to the students. The questionnaires were identical for the both groups. The first model dealt with students' views about mathematics.

Table 5: Logistic regression model on students' beliefs about mathematics variables

Variables	B	SE	Wald	DF	Sig.	Exp (B)
Beliefs about mathematics	3.434	1.783	3.711	1	0.054	30.993
Beliefs math importance	-4.262	1.874	5.174	1	0.023	0.014
Beliefs Ability in mathematics	1.352	0.666	4.119	1	0.042	3.864
Constant	-0.658	2.925	0.051	1	0.822	0.518

The logistic regression that was performed included a set of 3 independent variables that examined whether or not the two groups of students (major and minor mathematics undergraduate students) differed in students' beliefs about mathematics variables. The overall chi-square test for the logistic model was significant $\chi^2_{(3)}$ = 22.568 (p = 0.000) which indicated that there were differences between the two groups on the three students' beliefs about mathematics variables of interest viz-a-viz beliefs about mathematics, beliefs about mathematics importance and beliefs one's ability in mathematics.

In addition, the Hosmer and Lemeshow test was non-significant with a chi-square of 4.500, p = 0.809 which indicated that there was a good model fit, thus indicating that the data did not significantly deviate from the model. In terms of the variance that was explained by this set of variables, the Cox and Snell R^2 equaled 23.3%, while the Nagelkerke R^2 equaled 31.2%. Based on this model, 59% of the students were correctly classified in the minor mathematics group, while 76.1% of the students were correctly classified to be in the major mathematics group. So in the overall model, 68.2% of the sample was classified correctly Table 4. These overall results are better than shown by previous studies by Papanastasiou and Zembylas (2006). The major findings of this preliminary study indicated that there were significant differences between the two groups on their ''Beliefs about mathematics", "Beliefs about mathematics importance" and "Beliefs ones' ability in mathematics'' as depicted in Table 5. Further explanation when interpreting the b-values for this model, indicated that on a scale from 1-5, for each construct increase in the student's amount of beliefs about mathematics, their probability of being in the major mathematics group would increase by 30.99 times more. Hence beliefs about mathematics are statistically significant for classifying the students correctly in the two groups. On the same scale, for each unit increase for the variable of "Beliefs math importance", the students had a 98.5% decrease in their probability of being in the major mathematics group. This indicated that the students in the minor mathematics group considered mathematics to be less important than the major mathematics students. However, for each unit increase in the students' beliefs ability in mathematics, those students would increase their probabilities of being in the major mathematics group by 13.52%.

CONCLUSION

The main conclusion of the current study is that the mathematical beliefs of the students' majoring in mathematics in University Putra Malaysia are significantly different from the students who are minoring in mathematics. Thus mathematics majors had higher mathematical beliefs compared to the minors. The mathematical beliefs of the students do influence to a certain extent on majoring or minoring into mathematics. However, since this is not an experimental or longitudinal study, cause-effect relationships cannot be claimed (Papanastasiou and Zembylas, 2006). Therefore, no causal effects due to students' mathematical beliefs can be attributed to the students' choice of either to major or minor in mathematics. These findings also indicated that other background variables may be influential such as, these students' secondary or post-secondary schooling, or attendance to the developmental course(s) during secondary or post-secondary level.

A univariate logistic regression modeling was demonstrated in this study. Also, in the present study, maximum likelihood analysis of the differences of students' beliefs between major and minor mathematics showed that more mathematics majors than minors classified "student's beliefs about mathematics" as a knowledge and understanding priority. If mathematics and science educators were merely to follow the results of the statistical sophisticated logistic regression analysis from the present study to target groups for the promotion of sound knowledge, insight, cognizance and understanding. A program to increase the awareness and thoughtfulness of the importance of mathematics may have been developed for all Malaysian science students at secondary and post-secondary levels, before entering in tertiary education at college and University. The results of the present study from this model of the preliminary study are consistent with the work of Papanastasiou and Zembylas (2006). These results from the logistic regression modeling on students' beliefs about mathematics indicated that the university education system was efficient and differences on the students' mathematical beliefs between major and minor mathematics groups can be distinguished clearly.

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