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Impact of Students' Mathematical Beliefs and Self-regulated Learning on Mathematics Ability of University Students

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Abstract:

This present study was conducted to investigate the effect of mathematical beliefs and self-regulated learning strategies on mathematics achievement of university undergraduate students using binary logistic regression model. Sample was consisted of eighty-six undergraduate students who completed a self-reported questionnaire related to students' beliefs on three dimensions viz-a-viz beliefs about mathematics, beliefs about importance mathematics and beliefs one's ability in mathematics. This study indicated positive relationships among students' mathematical beliefs, self-regulated learning and mathematics low and high ability outcomes. In addition, overall binary logistic regression equation which assessed the joint contribution of one aspect of beliefs and self-regulated learning variables was significant. In addition 8.1% of the variance in mathematics ability can be explained by beliefs and self-regulated learning variables. The findings of current study indicate that further research should be initiated to examine the influence of beliefs on the mathematics ability, although achievement in academic performance can be attributed to a complex and dynamic interaction between cognitive and motivational variables.

Key words: mathematical beliefs, self-regulated learning, mathematics ability, binary logistic regression model, reliability coefficients, survey data.

Introduction

Educators admit that the students' beliefs and learning strategies have great impact on students' academic achievement. Previous studies proved that educators and parents long have been cursed by the problem of students' low achievement in schools. The proficient and experienced teachers are aware that many students complete academic courses without understanding the basic concepts, self-regulations and skills that teachers intend for them to learn. In many countries like Australia, USA, and UK, professional guidelines have been developed over the last two decades to strengthen mathematics and science curriculum standards (National Research Council. 1996; National Council for Teachers of Mathematics. 2000). These reforms are based on a solid foundation of research on student learning to achieve ever lasting success. According to Haigh and Rehfeld (1995) almost all these attempts have been based upon the postulation that integration increases student achievement in mathematics and science.

Mathematics is a fundamental science subject, which taught all over the world as an individuals' building foundation from pre schooling age. Mathematics is the only subject which is known either by literate as well as illiterate. Stage (2001) posed that a mathematics is a barrier to success in college and university for many students. It is noticed as a difficult subject to master due to its figurative and abstract nature. Stage (2001) argued, "A student who is futile in mastering mathematics skills loses opportunities to enroll in a broad range of college courses, thus limiting career choice."

The immature beliefs and inappropriate self-regulations have strong impact on students' critical thinking, problem-solving performance, and their approach to learning through innovative skills and engagement with mathematics (Schoenfeld 1983). At the same time, successful problem solving in mathematics requires students to be able to select and use task-appropriate cognitive strategies for understanding, representing, and solving problems (Schoenfeld 1983). Numerous researchers (Dahl et al. 2005) mentioned that students' beliefs about the nature of knowledge and learning influence the strategies they use for several purposes such as learning, developing the confidence ability, humanizing the critical and creative thinking, improving the problem solving methods and more diversify the self-regulated learning, which in turn, affects their academic achievement in mathematics (Hofer 1999). Examined that the students' beliefs and self-regulation strategies influence the students' mathematics achievement.

Objectives

The specific objectives of the present study are:

1. To explore the extent of each construct to predict the mathematics ability of undergraduate students in university Putra Malaysia.

2. To investigate the relationships among the subconstructs of two students' mathematical beliefs, and Self-Regulated Learning strategies.

3. To check the reliability coefficients of the sub-scales used in two main construct i.e. students' mathematical beliefs and Self-Regulated Learning strategies.

Significance of the study

The rapid changing economic and technological conditions of daily life require individuals to solve a wide range of problems, they have never seen before. In such challenging tasks, people must acquire life-long learning skills and abilities to reach their goals. The fortitude of the present study is to check how the application of relatively simple students' mathematical beliefs and self-regulated learning in mathematics affects an undergraduate students' ability in mathematics. Several studies have analyzed the effects of students' mathematical beliefs and critical thinking on mathematics achievement and self-regulated strategies on motivation, the present study is intended to augment the body of research related to students' beliefs about mathematics and self-regulated learning and their effects on student's ability in mathematics achievement.

Materials and Methods

Research Design

The present research is a descriptive in nature and involves questionnaire that consists of two scales: Mathematical Beliefs, and Self-regulated Learning Strategies. The subscales for the mathematical beliefs are: beliefs about mathematics, beliefs about importance of mathematics and beliefs on one's ability in mathematics (Vallerand et al. 1992 and Kaya 2007); while the subscales for the self-regulated learning strategies are: rehearsal, elaboration, organization, meta-cognitive self-regulation, time and study environment management, effort regulation, and help-seeking (Pintrich et al. 1991). 5-points likert scale questions (1 is strongly disagree to 5 is strongly agree), as well as various closed and open ended questions for the above mentioned two constructs were used in the questionnaire. Mathematical beliefs and self-regulated learning were independent variables, while students' ability in mathematics achievement was the dependent variable. In this study, some items of the scales were slightly adjusted (and/or revised) to ensure applicability to all students.

Research Sample

The sample for the present study was the undergraduate students (male and female) enrolled during the second semester of 2008/2009 in University Putar Malaysia. Students were assured that their specific responses would not be shared with their course instructors and would not be affected their course grades. The self-regulated learning questionnaire (SRLQ) developed by Pintrich et al (1991) and revised by Kaya (2007), was used to assess the impact of students' mathematical beliefs and self-regulated learning strategies on achievement of school students.

Data Collection

The students' record of mathematics achievement in terms of Grade Point Average (GPA) of four courses of the previous semester was obtained from the academic division of University Putra, Malaysia. Students were classified into two groups' i.e. high and low ability. High ability was identified if the student's average score was above the median value while for low ability the student's average score was below or equal to the median value of mathematics achievement. For analyze the survey data of this study the Statistical Package for Social Sciences (SPSS) was used. The internal consistency coefficient of the scale was used as 0.86.

Logistic Regression Model

The binary logistic regression model was used, the probability of an event occurring is directly estimated. Because the logistic regression is produced a nonlinear model, the equations used to describe the outcomes are slightly more complex than those for multiple regression. The outcome variable, $\hat{Y}_i$, is the probability of (an event occurring) or having one outcome or another based on a non-linear function of the best linear combination of predictors; with two outcomes. The logistic regression model can be written as:

$$\hat{Y}_i\left(\Pr ob(event)\right) = \frac{e^Z}{1+e^Z}$$

Or equivalently,

$$Pr\,ob(\,event\,) = \frac{1}{1+e^{-Z}}$$

where $\hat{Y}_i$ is the estimated probability that the *ith* case (i=1,2,……,n) is in one of the two categories, *e* is the base of the natural logarithms, approximately 2.71828 and *Z* is the usual linear regression equation.

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_P X_P$$

with constant β_0, coefficients β_j, and predictors X_j, for p predictors (*j=1,2,3,…..,p)*

Assessing goodness of fit of the model using likelihood method

It means to asses that how well the fitted model fits not only the sample of data from which it is derived, but also the population from which the sample data were selected. The probability of the observed outcomes, given the parameter estimates, is known as the likelihood which is a small number less than 1The log-likelihood, for a candidate model, is calculated as:

$$\text{Log-likelihood} = \sum_{i=1}^{n}\left[Y_i \ln\left(\hat{Y}_i\right) + \left(1-Y_i\right)\ln\left(1-\hat{Y}_i\right)\right]$$

Where, $Y_{i's}$ are actual outcomes and $\hat{Y}_{i's}$ are the predicted probabilities of events occurring. A good model is one that results in a high likelihood of the observed results.

Results

Table 1 divulges the reliability coefficient of cronabachs' alpha (α) of the students' mathematical beliefs and learning strategies scales was calculated as 0.81 which is marginally higher than acceptable. Only scale 10 ("Help seeking") was not reliable while the reaming were found moderately to highly reliable.

Table 2 shows the frequencies and percentages of Gender of respondent, the sample included 62 females (72.1%) and 24 males (27.9%). There were four ethnical groups found in a sample of 86 students in the study. These races/ ethnicities comprises of Malay, Chinese, Indian, and others are 59 students (68.6% age), 23 students (26.7% age), 3 students (3.5% age) and one student (1.2% age), respectively. The sample of respondents consists on both major and non-major mathematics; there were 46 students (53.5%) from major mathematics and 40 students (46.5%) from non-major mathematics.

Table 1: The coefficient-alpha (α) reliability of the subscales

S. No.	Item Description	Alpha (α)	Items
1	Beliefs About Mathematics	0.69	5
2	Beliefs about Importance of Math	0.78	5
3	Beliefs on One's Ability in Math	0.73	5
4	Rehearsal	0.71	4
5	Elaboration	0.68	5
6	Organization	0.63	4
7	Meta-cognitive Self-regulation	0.71	5
8	Time and Study Environment	0.65	5
9	Effort Regulation	0.76	4
10	Help Seeking	0.43	4

The table also depicts different levels of parents' education at School, Bachelor, Master and others levels. A major portion (80-90%) of both the parents (father & mother) falls in school followed by bachelor (8-15%), master and other (1.2%) respectively. The educational level of both the parents (father & mother) was almost same.

Partial correlation

After examining the multicolinearity among the variables, the correlation matrix among each of the five significant scales is exhibited in Table 3. Help seeking scale is not significantly correlated with two scales (beliefs about mathematics as well as beliefs on one's ability in mathematics), but highly correlated with organization scale at 0.01 level of significance. However, all other predictor variables are significantly correlated to each other. On the other hand all the significant correlation coefficients are smaller than .8 and as a general rule of thumb the problem of multicolinearity is not a severe concern in the data.

Assessing the goodness-of-fit of the model

To check the model validity and efficiency of estimation, the likelihood ratio test was used which involves formulation and testifying of a statistical hypothesis. This test is used to determine whether the predictor variables in the model are significantly associated to the response variable. Under the null hypothesis, H_0: $\beta_1=\beta_2=\ldots=\beta_{10}$, the statistic G follows a chi-square distribution with 10 degrees of freedom and measure how well the independent variables affect the outcomes or response variable. In the study G=29.698 with p=0.001 were calculated and represented in Table 4 which indicates that null hypothesis is rejected and conclude that at least one and perhaps most of the coefficients are different from zero.

Table 2: Frequency of demographic characteristics of respondents (undergraduate students)

Variable	Frequency	Percent	Cumulative Percent
Gender of Respondent			
Female	62	72.1	72.1
Male	24	27.9	100.0
Age in Years			
20	1	1.2	1.2
21	4	4.7	5.8
22	37	43.0	48.8
23	44	51.2	100.0
Race/ Ethnicity			
Malay	59	68.6	68.6
Chinese	23	26.7	95.3
Indian	3	3.5	98.8
Others	1	1.2	100.0
Mathematics Subject			
Major	46	53.5	53.5
Non-Major	40	46.5	100.0
Fathers' Education			
School	71	82.6	82.6
Bachelor	13	15.1	97.7
Master	1	1.2	98.8
Other	1	1.2	100.0
Mothers' Education			
School	78	90.7	90.7
Bachelor	7	8.1	98.8
Other	1	1.2	100.0

Coefficients of partial correlation and model Chi-Square

The degree of precision of the model-predicted values is also assessed with the help of the Hosmer-Lemeshow goodness-of-fit test (Archer et al, 2007), is given by

$$\hat{C} = \sum_{k=1}^{g} \frac{\left(o_k - n'_k \bar{\pi}_k\right)^2}{n'_k \bar{\pi}_k \left(1 - \bar{\pi}_k\right)}$$

where, g denotes the number of groups, n_k' is the number of observations in the k^{th} group, o_k is the sum of the positive response for the k^{th} group and $\bar{\pi}_k$ is the average of the ordered $\hat{\pi}$ for k^{th}

Table 3: Pearson Correlation Significance (2-tailed)

	BaM	BIM	BoAM	Organization	Help Seeking
BaM	1	.532(**)	.696(**)	.323(**)	.114
		.000	.000	.002	.296
BIM		1	.426(**)	.420(**)	.253(*)
			.000	.000	.019
BoAM			1	.347(**)	.143
				.001	.190
Organization				1	.336(**)
					.001
Help Seeking					1

BaM = beliefs about mathematics, BIM = beliefs about importance of mathematics,
BoAM = beliefs of one's ability in mathematics. **Correlation is significant at the 0.01 level (2-tailed) and *Correlation is significant at the 0.05 level (2-tailed) group.

As presented in Table 4, Hosmer-Lemeshow chi-square statistics was calculated as 6.63 with p-value 0.58. The large p-value suggests that there is no difference between the observed and the predicted values of the response variable, implying that the model estimates fit the data at an acceptable level.

Table 4: Summary Measures of goodness-of-fit of the model

-2Log likelihood	Cox & Snell R^2	Nagelkerke R^2	Model Chi-square	df	p-value	H-L Chi-square	df	p-value
89.337	0.292	0.390	29.698	10	0.001	6.63	8	0.58

Among the various measures that have been proposed to test the significance of the fitted model one was known as Cox & Snell $R^2 = 1 - \left\{\frac{L_0}{L_1}\right\}^{2/n}$ (Maddala 1983; Cox and Snell 1989, Hilbe 2009). An alternative form proposed by Nagelkerke (1991) as $\overline{R}^2 = \frac{R^2}{\max R^2}$. Also the maximum possible value of R^2 is $\max R^2 = 1 - \{L_0\}^{2/n}$=0.75. The value of R^2=0.292 and

$\overline{R}^2 = 0.390$ (Table 4) indicates that these models fit the data at an acceptable level.

Interpretation of the Regression Coefficients

Table 5 shows coefficients β_n, their standard errors, Wald statistic, associated p-values, odds ratio i.e. exp(β). Wald statistic is given by

$$W = \frac{\hat{\beta}_i^{\,2}}{\left[s.e\left(\hat{\beta}_i\right)\right]^2}$$

Table 5: Estimates of the Logistic Regression Model

Variables	β	S.E	Wald	df	p-value	Odds ratio Exp(β)
Race	-	-	3.768	3	.288	-
Race (1)	1.326	.709	3.498	1	.061	3.768
Race (2)	-.711	1.626	.191	1	.662	.491
Race (3)	.253	.125	4.100	1	.043	1.287
Gender	-1.296	.648	3.994	1	.046	.274
BaM	.291	.168	3.064	1	.080	1.747
BIM	.179	.141	1.620	1	.203	1.197
BoAM	.351	.174	4.076	1	.043	1.420
Elaboration	1.757	.612	1.480	1	.016	2.490
Organization	1.250	.588	4.515	1	.034	3.490
Help Seeking	-1.597	.574	7.742	1	.005	.203
Constant	-4.685	3.203	2.140	1	.143	.009

*BaM = beliefs about mathematics, BIM = beliefs about importance of mathematics,
BoAM = beliefs of one's ability in mathematics, Gender (0 = female, 1= male) of the students

The Wald statistics agrees reasonably well with 7 different predictors and have significant contribution to foretell the response variable.

Classification of cases

Correct Classification Rate (CCR) is also used to assess the worth of the fitted model. Fitted probabilities can be calculated for each observation from the fitted logit. We may assign 1 for the fitted probability if an observation is greater than or equal to 0.5 and if less than 0.5 we may classify it as 0. Then decide what proportion of misclassified observations is classified correctly. The logistic model is working well when correct classification is indicating a high proportion of misclassification is correctly classified. While, a low proportion of correct classification is signifying poor performance of misclassification of observed values. Table 6 displayed the predicted CCR which is 69.8 percent. Based on this measure, we may also conclude that the model performance is good.

Table 6: Correct Classification Rate as a Predictive Ability of the model

Observed Ability	Predicted Ability	
	Low (0)	High (1)
Low (0)	27	14
High (1)	12	33
Overall Percentage	69.8	

Discussion

The binary multiple logistic regression model is restricted in assumption by the ratio of 1:10 between the number of variables and observations (Hosmer and Lemeshow 2000; Agresti 2002). Eight explanatory variables (3 from each mathematical beliefs and self-regulated learning strategies) were considered for estimation of coefficients in present pilot study survey data. The remaining two are demographic variables (e.g.; race and gender are both categorical variables) of respondents depicts in Table 5.

The estimated coefficient for the beliefs about mathematics scale, the fitted coefficient is 0.291with corresponding odds ratio 1.747 indicates the change in the log-odds of achievement in mathematics, when student change the from reference category low ability (0) to the high ability (1). The result indicates that the achievement in mathematics significantly increase by 75% for change from low ability to high ability in the strength of agreement on belief about mathematics. Likewise, for the beliefs about importance of mathematics scale is 0.179 with corresponding odds ratio 1.197 indicates that those students who have strong belief about importance of mathematics are 1.2 times as likely achieve in mathematics in the study population. Unfortunately, the results is in actual direction but non significant.

The variable beliefs on one's ability in mathematics has the estimated coefficient 0.351 with corresponding odds ratio1.420 which indicates the achievement in mathematics significantly 1.4 times as likely among the students having strong agreement regarding belief one's ability in mathematics as others.

The estimated coefficient for the variable organization is 1.250 with corresponding odds ratio 3.490 indicates the change in the log-odds of achievement in mathematics. The figure suggests that achievement in mathematics is significantly 3.5 times as likely to prevail among the students having strong agreement regarding the organization as others. The coefficient for the variable help seeking is -1.597 with corresponding odds ratio 0.203. It suggests that the students having strong agreement regarding help seeking are likely to significant by 80% decrease in achievement in mathematics when the change of low ability to the high ability.

The estimated coefficient corresponding to the variable race (1) is 1.326 and an odd ratio is 3.768 indicates the change in the log-odds of achievement of mathematics of Chinese students in comparison with Malay students. The result suggests that the achievement in mathematics among the Chinese students is significantly 3.8 times better than the Malay students. Indian students have lower achievement in mathematics but not statistically significant and other students have 1.3 times better achievement in mathematics than reference group at 0.05 percent level of significance.

Finally, the estimated coefficient for the variable gender is -1.296 and its corresponding odds ratio 0.491 indicates that the change in the log-odds of achievement in mathematics among male as compared to the female students. Simply the result suggests that the achievement in mathematics is significantly 51% goes down among the male student than female students in the study population. More clearly, achievement in mathematics significantly decreases 51% among male students than female students.

BIBLIOGRAPHY:

Agresti, A., 2002. *Categorical Data Analysis*. 2nd Ed. New Jersey: John Wiley and Son.

Archer, J.K., S. Lemeshow and D.W. Hosmer. 2007. "Goodness-of-fit tests for logistic regression models when data are collected using a complex sampling design." *Comput. Statist. Data Anal.* 51: 4450-4464.

Cox, D.R. and E.J. Snell. 1989. *The Analysis of Binary Data*. 2nd edition. London: Chapman and Hall.

Dahl, T.I., M. Bals and A.L. Turi. 2005. "Are students' beliefs about knowledge and learning associated with their reported use of learning strategies?" *Br. J. Educ. Psychol.* 75*:* 257-273.

Haigh, W. and D. Rehfeld, 1995. "Integration of secondary mathematics and science methods courses: A model." *School Sci. Math.* 95: 240-247.

Hilbe, J.M. 2009. *Logistic Regression Models. Chapman and Hall*. New York: CRC Press.

Hofer, B.K. 1999. "Instructional context in the college mathematics classroom: Epistemological beliefs and student motivation." *J. Staff Prog.* Organizational Dev. 16: 73-82.

Hosmer, D.W. and S. Lemeshow. 2000. *Applied logistic regression*. 2nd Ed. John Wiley & Sons, Inc.

Kaya, S. 2007. *The influences of student views related to mathematics and self-regulated learning on achievement of algebra I students*. Unpublished Doctoral Thesis, Ohio State University.

Maddala, G.S. 1983. *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press.

National Council of Teachers of Mathematics. 2000. *Principles and Standards of School Mathematics*. National Council of Teachers of Mathematics, Reston, VA.

National Research Council. 1996. *National science education standards*. Washington, DC: National Academy Press.

Pintrich, P.R., D.A.F. Smith, T. Garcia and W.J. McKeachie. 1991. *A manual for the use of the motivate strategies for learning questionnaire (MSLQ).*

Schoenfeld, A.H. 1983. "Beyond the purely cognitive: Beliefs system, social cognitions and metacognitions as driving forces in intellectual performance." *Cognitive Sci.* 7: 329-363.

Stage, S.A. 2001. "Program evaluation using hierarchical linear modeling with curriculum-based measurement reading probes." *School Psychol. Quart.* 16: 91-112.

Vallerand, R.J., L.G. Pelletier, M.R. Blais, N.M. Brière, C.B. Senécal and E.F. Vallieres. 1992. "The academic motivation scale: A measure of intrinsic, extrinsic and a motivation in education." *Educ. Psychol. Measur.* 52: 1003-1017.