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Motivation in the Learning of Mathematics

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Abstract

This study focuses on students' motivation in solving mathematical problems. Objectives of the study are to (i) identify students' level of effort, self efficacy and worry in solving mathematical problems based on gender, current cumulative grade point average (CGPA) and year of study; (ii) students' level of motivation in solving mathematical problems based on gender, current cumulative grade point average (CGPA) and year of study; and (iii) establish relationship between levels of motivation and students' mathematics achievement. The subscales used in the measurement of motivation are effort, self-efficacy, and worry. Data was gathered through a descriptive survey using questionnaires. Overall, students' motivations was found to be high and majority of the respondents were in the high level for effort but were only moderate for self efficacy. Significant difference was established in overall motivation scores between the female and male respondents, but not for the subscales effort, self-efficacy and worry. Respondents with higher CGPA obtained higher overall scores for motivation. Significant positive correlations were established between effort, self-efficacy, and overall motivation with students' overall academic achievement. Likewise, significant positive correlations were established between effort, self-efficacy, worry, and overall motivation with students' average mathematics achievement.

Keywords: Motivation, mathematical problem solving, self-efficacy, effort, worry.

1. Introduction

Motivation refers to "a student's willingness, need, desire and compulsion to participate in, and be successful in the learning process" (Bomia et al., 1997, p. 1). Middleton and Spanias (1999) viewed motivation as reasons individuals have for behaving in a given situation. A more comprehensive definition was provided by Ames (1992) who stated that motivation exists as part of one's goal structures, one's beliefs about what is important and it determines whether or not one will engage in a given pursuit. Skinner and Belmont (1991) explained that students who are motivated to engage in school "select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest" (p. 3).

According to Middleton and Spanias (1999), research indicates that success in mathematics is a powerful influence on the motivation to achieve. As indicated by Dickinson and Butt (1989), students

will find a task more enjoyable when they have moderately high probability of success as compared to one with a lower chance of success.

Motivation contributes to the ability to solve problems. Based on several problem solving models, O'Neil & Schacter (1997) developed the CRESST model of problem solving that incorporates four elements; content understanding, problem solving strategies, metacognition and motivation. In their model, motivation comprises of three components; self efficacy, effort and worry. Several researches showed that high worry is associated with low cognitive performance (Hembree, 1988, 1990; Pajares & Urdan, 1996; Seipp, 1991). On the other hand, studies such as Wigfield and Meece (1988) showed that there is no relationship between worry and achievement. Although worry can trigger negative effects on learning, depending on the degree of worry, it could also contribute to positive antecedent to high achievement. It may trigger positive outcomes, in terms that it will drive students to work harder if their worries drive as a challenge to exhibit better performance.

Effort is synonym to motivation. An individual who shows greater effort is considered to be motivated, whilst one who is motivated will also show greater effort. In Miller, Behrens, Greene, and Newman's study (1993) findings with respect to self-regulation and academic achievement, they confirmed that self-regulated learning comprised of several components, such as cognitive strategies and effort. Bandura (1993) and Schunk (1984) posited that effort is directly influenced by self-efficacy and directly affecting skill or performance.

Bandura (1994) defines self-efficacy as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Similar to Bandura's definition, Garcia et al. (1991) defined self-efficacy as self-appraisal of one's ability to accomplish a task and one's confidence in possessing the skills needed to perform that task. Several researches (Malpass, O'Neil and Hocevar, 1999; Mone, Baker & Jefferies, 1995; Wolf & Smith, 1995) have shown that self-efficacy has a high positive correlation with test performance outcomes.

Self efficacy is a continuous process throughout life. According to Bandura (1992), the growth of self-efficacy does not end during youth, but continues to evolve throughout life as people acquire new skills, experiences, and understanding. Bandura (1994) characterizes individual with a strong sense of self-efficacy as one who (i) view challenging problems as tasks to be mastered, (ii) develop deeper interest in the activities in which they participate, (iii) form a stronger sense of commitment to their interests and activities, and (iv) recover quickly from setbacks and disappointments. Bandura added that people with a weak sense of self-efficacy (i) avoids challenging tasks, (ii) believes that difficult tasks and situations are beyond their capabilities, (iii) focuses on personal failings and negative outcomes, and (iv) quickly loses confidence in personal abilities. Bandura (1993) posited that "self-efficacy beliefs contribute to motivation in several ways: They determine the goals people set for themselves, how much effort they expend, how long they persevere in the face of difficulties, and their resilience to failures" (p. 131).

Malpass, O'Neil and Hocevar (1999) conducted a study to investigate the effects of gender, self-efficacy, learning goal orientation, self-regulation, and worry on high-stakes mathematics (i.e., an Advanced Placement calculus exam) achievement in a sample of mathematically gifted, primarily Asian American, high school students using a structural equation modeling framework. Their analyses showed that self-efficacy is positively related to math achievement, is moderately and positively related to self-regulation, and is highly and negatively related to worry, and that learning goal orientation (or intrinsic value) is positively related to self-regulation and worry but is not related to self-efficacy or high-stakes mathematics achievement. The findings further stated that young men were less worried and had higher self-efficacy for math than young women and self-regulation was negatively related to worry, but surprisingly, was not related to high-stakes mathematics achievement.

Teachers especially in Malaysia tend to be overly focused on academic achievement and in guiding students to achieve excellent grades. In a country where centralized examination is practiced, the tendency to pay lesser attention to motivating students in the teaching and learning process is a common practice. Drill and practice becomes the main class activity during the few months before the

examination commence. The practice is also apparent in higher education. Thus, this study seeks to identify students' level of effort, self efficacy, worry and motivation and to establish relationship between motivation and mathematics achievement.

2. Objectives of the Study

The study seeks to determine:

(i) Students' level of effort, self efficacy and worry in solving mathematical problems based on gender, current cumulative grade point average (CGPA) and year of study;
(ii) Students' level of motivation in solving mathematical problems based on gender, current cumulative grade point average (CGPA) and year of study; and
(iii) Relationship between levels of motivation and students' mathematics achievement.

3. Research Method

Questionnaires were used to solicit information on students' motivation in mathematical problem solving through a descriptive survey. Cohen, Manion and Morrison (2000) indicated that survey is suitable for research that intends to "gather data at a particular point in time with the intention of describing the nature of existing conditions, or identifying standards against which existing conditions can be compared, or determining the relationships that exist between specific events" (p. 169). A descriptive survey typically seeks to ascertain respondents' perspectives or experiences on a specified subject in a predetermined structured manner.

3.1. Instrumentation

Subjects were required to respond to the measurement used by O'Neil and Schacter's (1997) to measure motivation. The elements in measuring motivation are effort, self-efficacy, and worry. The questionnaire consists of nine items to measure effort, eight items for self-efficacy and five items for worry. The Cronbach's Alpha analysis showed that the reliability for the motivation questionnaire was high (r = .844).

To provide a better understanding of each of the three specific components of motivation, a description of the component and a sample item for each of the component are provided below:

Component	Description	Sample Item
Effort	Some define effort as the "total work done to achieve a particular end". Effort is usually associated with motivation. If a student is more motivated to learn or to complete an assignment, they will more likely put in more effort to complete the task at hand. Personal interest is often associated with effort. For instance, if a student finds a topic particularly relevant, they will be more likely to be more motivated to learn about it, and hence, the amount of effort used will be increased (http://wik.ed.uiuc.edu/index.php/Effort).	I try my very best although I do not like the mathematical task that is given to me.
Self Efficacy	Bandura (1994) defines self-efficacy as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. He further added that self-efficacy beliefs determine how people feel, think, motivate themselves and behave. Such beliefs produce these diverse effects through four major processes. They include cognitive, motivational, affective and selection processes.	I believe that I will get excellent grade in the mathematics courses that I enroll in.
Worry	Worry refers to negative self-talk that often distracts the mind from focusing on the problem at hand (http://en.wikipedia.org)	Anxiety causes me to be more focused on my mathematics lesson.

3.2. Sample

The subjects of the survey were selected among final year students majoring in mathematics education from four universities in Malaysia, namely Universiti Putra Malaysia, Universiti Kebangsaan Malaysia, Universiti Malaya and Universiti Malaysia Sabah. Final year students were chosen because they would have undertaken a substantial number of mathematics courses by then to enable them to indicate their motivation towards mathematical learning. The questionnaire was self administered and data from 195 final year students were collected, of which 31 are males and 164 are female. The ratio is common in most education faculties in Malaysia. There is also a striking imbalance between males and females in some other faculties, favoring the females.

4. Findings

In this section, findings are presented based on the objectives of the research. The following subsections provide analysis of students' level of effort, self efficacy, worry and motivation in solving mathematical problems. Next, comparison of students' level of effort, self efficacy, worry and motivation based on gender, current cumulative grade point average (CGPA), and year of study is discussed. Lastly, relationship between levels of motivation with students' overall academic achievement is discussed.

4.1. Students' Level of Effort, Self Efficacy, Worry and Motivation in Solving Mathematical Problems

The respondents' overall motivation scores (n = 195) is 82.96 (SD = 9.82). An equal interval division for all three categories was also applied for scores in the survey to measure motivation. The range for summative score that a respondent obtains in the motivation survey is between 22 and 110. The level of motivation is categorized as low for scores 22 to 51, moderate for scores 52 to 81 and high for scores 82 to 111. Thus, the respondents' overall score in motivation is high (mean = 82.96, SD = 9.82). It was also found that majority of the respondents were in the high level for effort (73.8%). However, majority of the respondents were at a moderate level for self efficacy (48.2%) and worry (69.7%).

4.2. Level of Effort, Self Efficacy, Worry and Motivation Based on Gender

Table 1 displays the scores on the motivation survey. The female respondents showed significantly higher scores (mean = 83.63, SD = 10.20) in overall score for the motivation survey as compared to the male respondents (mean = 79.39, SD = 6.59). Likewise, the female respondents obtained higher scores in all three components of motivation; effort (m = 36.21, SD = 5.33), self-efficacy (m = 30.00, SD = 5.18) and worry (m = 17.43, SD = 2.42). Significant difference was established in overall motivation scores between the female and male respondents ($t = -2.23$, $df = 193$, $p < .05$), favouring the females, but not for the subscales effort, self-efficacy and worry.

Table 1: T-Test of Motivation Scores Based on Gender

		N	Mean	SD	t	df	Sig
Motivation - effort	Male	31	34.32	3.727	-1.887	193	.061
	Female	164	36.21	5.333			
Motivation – self-efficacy	Male	31	28.52	3.20	-1.532	193	.127
	Female	164	30.00	5.18			
Motivation -worry	Male	31	16.55	2.14	-1.882	193	.061
	Female	164	17.43	2.42			
Total Motivation	Male	31	79.39	6.59	-2.23	193	.027*
	Female	164	83.63	10.20			

*Indicates significance at the 0.05 level.

4.3. Level of Effort, Self Efficacy, Worry and Motivation Based on Current Cumulative Grade Point Average (CGPA)

The respondents' overall motivation scores were also analyzed based on their current cumulative grade point average (CGPA). CGPA is categorized as above 3.5, between 3.00 and 3.49 and below 3.00. Table 2 below shows the distribution based on CGPA categories. It seems that respondents with higher CGPA obtained higher scores in the survey. In terms of effort, respondents in the 3.50 and above category scored the highest (mean = 36.61, SD = 5.59). The same pattern is displayed for self efficacy, the 3.50 and above category scored the highest (mean = 30.49, SD = 4.69). For the scale used for measurement of worry, higher score shows a positive contribution of worry on motivation. For this components, the 3.00 - 3.49 group (mean = 17.79, SD = 2.38) outperformed the above 3.50 group (mean = 17.17, SD = 2.70). However, the above 3.00 – 3.49 group exceeded the rest of the categories in overall motivation score (mean = 84.41, SD = 10.00).

Table 2: Level of Motivation by CGPA Category

Construct	Category of CGPA	N	Mean	Standard Deviation
Effort	Below 3.00	51	35.09	4.73
	3.00 - 3.49	96	36.15	5.27
	3.50 and above	41	36.61	5.59
	Total	188	35.96	5.21
Self-efficacy	Below 3.00	51	28.09	3.81
	3.00 - 3.49	96	30.47	5.47
	3.50 and above	41	30.49	4.69
	Total	188	29.83	4.99
Worry	Below 3.00	51	16.59	2.03
	3.00 - 3.49	96	17.79	2.38
	3.50 and above	41	17.17	2.70
	Total	188	17.33	2.41
Total motivation	Below 3.00	51	79.78	8.40
	3.00 - 3.49	96	84.41	10.00
	3.50 and above	41	84.27	10.75
	Total	188	83.12	9.93

Analysis of variance (ANOVA) conducted established significant differences between scores in the motivation survey for the three CGPA categories ($F(2, 185) = 4.09$, $p < 0.05$) (Table 3). Respondents with higher CGPA obtained higher overall scores for motivation. Scheffe's test conducted showed that respondents in the below 3.00 category showed significantly different scores ($p < .05$) as compared to the other 3.00 – 3.40 category. However, respondents in the 3.00 to 3.49 category did not show significant differences to respondents in the above 3.50 category in their scores in the motivation survey.

Table 3: ANOVA of Overall Motivation Scores by CGPA Categories

		Sum of Squares	Df	Mean Square	F	Sig.
Overall Motivation Scores	Between Groups	780.35	2	390.18	4.09	.018
	Within Groups	17653.83	185	95.43		
	Total	**18434.18**	**187**			

*Indicates significance at the 0.05 level.

4.4. Level of Effort, Self Efficacy, Worry and Motivation Based on Year of Study

The findings above concentrate on the final year students only. However, efforts were also made to collect data from students who are not in the final year. The number of respondents for Year 1 and 3 are relatively small since the universities involved in the study experienced a great decline in students' enrollment for the mathematics education program. First year students scored higher than the other

groups in effort, self-efficacy, worry and overall motivation. As mentioned above, worry as measured in the questionnaire refers to the influence of worry, in the positive sense, towards motivation. Year 4 students scored slightly higher than the Year 3 group in both effort and self-efficacy and in overall motivation score (Table 4).

Table 4: Level of Motivation by Year of Study

Construct	Category by Year of Study	N	Mean	Standard Deviation
Effort	Year 1	38	36.37	5.59
	Year 3	22	34.36	6.18
	Year 4	195	35.91	5.15
	Total	255	35.85	5.31
Self-efficacy	Year 1	38	30.05	6.26
	Year 3	22	28.50	5.25
	Year 4	195	29.76	4.94
	Total	255	29.70	5.18
Worry	Year 1	38	18.37	2.28
	Year 3	22	17.36	1.56
	Year 4	195	17.29	2.40
	Total	255	17.45	2.35
Total motivation	Year 1	38	84.79	12.01
	Year 3	22	80.23	10.46
	Year 4	195	82.96	9.82
	Total	255	82.99	10.24

4.5. Relationships between Levels of Motivation with Students' Overall Academic Achievement

Current cumulative grade point (CGPA) is used as a reflection of respondents' overall academic achievement. Thus, Pearson correlation analysis was conducted to establish correlation between scores in the survey with current CGPA. Significant positive correlations are established between effort (.151, $p < .01$), self-efficacy (.180, $p < .01$), and overall motivation (.202, $p < .01$) with students' overall academic achievement (Table 5)

Table 5: Correlations between Components of Motivation and Overall Motivation with Students' Current CGPA

Components of Motivation	Correlation Index
Effort	.151*
Self-efficacy	.180*
Worry	.132
Overall Motivation	.202**

** correlation is significant at the level 0.01 (2-tailed)

Students' average grade in mathematics courses undertaken at the university level was used to indicate their mathematics achievement. Grade A was assigned score of 5, B is 4, C is 3, D is 2 and F is 1. Thus the non-parametric Spearman correlation analysis was used to establish relationship between scores in the survey with mathematics achievement in the university. Significant positive correlations are established between effort (.241, $p < .01$), self-efficacy (.253 $p < .01$), worry (.227 $p < .05$), and overall motivation (.308, $p < .01$) with students' average mathematics achievement (Table 6)

Table 6: Correlations between Components of Motivation and Overall Motivation with Students' Average Mathematics Achievement

Components of Motivation	Correlation Index
Effort	.241**
Self-efficacy	.253**
Worry	.227*
Overall Motivation	.308**

** correlation is significant at the level 0.01 (2-tailed)

5. Summary and Concluding Remarks

Overall, students' motivations was found to be high and majority of the respondents were in the high level for effort but were only moderate for self efficacy. Significant difference was established in overall motivation scores between the female and male respondents, favouring the females, but not for the subscales effort, self-efficacy and worry. In other words, female students have higher level of effort and self-efficacy and have lesser worry in the learning of mathematics. This contradicts findings of earlier study conducted by Malpass, O'Neil and Hocevar (1999) that showed young men were less worried and had higher self-efficacy for math than young women. However, the pattern is normal in Malaysia where girls outperformed boys in academic achievement. These findings are coherent with other findings established by Md.Yunus et al. (2006, 2008).

Respondents with higher CGPA obtained higher overall scores for motivation. Significant positive correlations were established between effort, self-efficacy, and overall motivation with students' overall academic achievement. Likewise, significant positive correlations were established between effort, self-efficacy, worry, and overall motivation with students' average mathematics achievement. The findings support findings of Middleton and Spanias' (1999) study which concluded that success in mathematics is a powerful influence on the motivation to achieve. However, this study cannot establish whether high level of motivation is the result of high achievement or whether high achievement is the result of high level of motivation. This findings also confirms conclusive findings from previous researches (Malpass, O'Neil and Hocevar, 1999; Mone, Baker & Jefferies, 1995; Wolf & Smith, 1995) that self-efficacy has a high positive correlation with test performance outcomes. Consequently, effort is directly influenced by self-efficacy and directly affecting skill or performance (Bandura, 1993 & Schunk, 1984).

Gage and Berliner provided 15 (1992, pp. 367 – 378) motivational techniques that can be applied to calssroom or similar settings. Among the techniques are begin the lesson by giving students reasons to be motivated, tell students exacly what you want to accomplish, have students set short term goals, use spoken and written praise, use tests and grades judiciously, capitalize on the arousal of suspense, discovery, curiousity, exploration, control and fantasy, occasionally do the unexpected, whet the appetite, use familiar materials for examples, use unique and unexpected contexts when applying concepts and principles, make students use what they have previopusly learned, use simulation and games, minimize the attractiveness of competing motivational system and minimize any unpleasant consequences of student involvement. These techniques could easily be applied or integrated in a mthematics classroom. Thus, teachers need to reserve part of the class time to conduct activities that would develop enthusiasm in mathematics, thus enhancing students' motivation in learning mathematics. Special attention must also be given to the male students so as to rediuce the gap in achievement between the male and female students.

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