GENDER-RELATED DIFFERENCES OF MALAYSIAN STUDENTS IN THEIR SOLUTION PROCESSES OF SOLVING MATHEMATICAL PROBLEMS

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Abstract: This study examined the gender differences of Malaysian students in their solution processes of solving routine and non routine mathematical problems. A total of 289 sixth grade Chinese and 341 sixth grade Malay students participated in the study. The Chinese sample consisted of 144 female and 145 male students, and the Malay sample consisted of 165 female and 176 male students. A set of 31 routine items, and 5 non routine problems was developed. Results of the study showed that: (1) There is no significant gender differences on solving routine problems for both Malay and Chinese samples. (1) none of routine items revealed DIF. (3) There is no significant gender differences on solving non routine problems for both Malay and Chinese samples. (4) There is no significant gender differences on the strategies of solving non routine problems for both Malay and Chinese samples. A qualitative analysis of student responses to routine and non routine problems showed that male and female students exhibit similar errors and similar solution strategies of solving routine and non routine problems.

Keywords: Execution, Integration, Nonroutine problems, Planning, Routine problems, Translation

INTRODUCTION

Current education reform in mathematics education reform emphasize the importance of thinking, understanding, reasoning, and problem solving in students' learning (e.g., [22, 23, 24, 25]). Such reform effort in mathematics curriculum and instruction requires examination of male and female students' thinking, reasoning, and problem solving rather than merely computation and symbol manipulation.

Mathematical problem solving is a complex cognitive ability. Mathematical literature described mathematics problem solving as several separate activities such as solving word problems, creating patterns, interpreting figures, and proving the theorey [33]. A problem solver is a someone who receives information and a goal without an immediate means to achieve the goal [27]. In order to achieve the goal, the mathematical problem solver must develop a base of mathematics knowledge and organize it, create an algorithm and generalize it to a specific set of applications, and use heuristics [33].

Two distinct types of thoughts: spatial inductive and verbal-logical deductive are both believed to be important to mathematical problem solving [1, 30]. During the process, students might apply a number of general strategies such as a solution rubric, a logical mathematical reasoning, a trial-and-error approach and an outright guess to derive answers on mathematical problem solving tests [9].

Mayer [19] has proposed four main component processes in mathematical problem solving: translating, integrating, planning, and executing. Royer and Garofoli [28] classified them into two stages: representation of a problem and solving the problem. Similarly, Montague [21] defined mathematical problem solving as a process involving two stages: problem representation and problem execution.

Translating involves constructing a mental representation of each statement in the problem.

Integrating involves constructing a mental representation of the situation described in the problem. Planning involves devising a plan for how to solve the problem. Executing involves carrying out the plan, including computations. The first two processes, translation and integration, are involved in problem representation. Planning is a natural product of problem representation. Students frequently correctly devise and carry out computational plans based on an incorrect representation of the problem.

In the problem solving literature it is customary to distinguish between representation and solution. Representation occurs when a problem solver seeks to understand the problem and solution occurs when a problem solver actually carries out actions needed to solve the problem [21].

NCTM [22, 24] proposes that problem-solving must be the focus and that mathematics should be organized around problem-solving, such as: a method of inquiry, application using problem solving approaches to investigate and understand mathematical content, and building new mathematical knowledge through problem-solving. NCTM believes that centering mathematics instruction on problem-solving helps students to learn key concepts and skills within motivating contexts.

It is argued that when students learn mathematics from problem situations, mathematical knowledge can be easily recalled by them. Using problem situations in the classroom also provides students opportunities to experience the power and usefulness of mathematics in the world around them and provides a consistent context for learning mathematics.

Problem situations can establish a need to know, and foster the motivation for concept development [22]. Therefore, students should be placed into classroom problem-solving situations from the very earliest stages of mathematics learning. Thus, problem solving is a major method for mathematics knowledge acquisition rather than merely applying the new learned mathematics knowledge to solve problems. NCTM advocates that learning is led by the search to answer questions: first at an intuitive, empirical level, then by generalizing, and finally by proving.

Researchers have identified a variety of types of mathematical problems, such as word and time-consuming problems, and word and calculation problems [21]. The consideration of these problems is more related to the length of time and the language needed for solving a problem than to the use of creativity in solving it. Another typology for mathematical problems is 'routine' and ‘non-routine’ problems [20]. For example, word problems are likely to be non-routine for students used to solving calculation problems.

Routine problem solving stresses the use of sets of prescribed procedures to solve problems. Gradually, students are asked to solve more complex problems that involve multiple steps and include irrelevant data. Commencing with the concrete level, students are asked to develop their own story problem situations and demonstrate the solution process with manipulative and/or pictures and later with symbols. Such problems are later presented to the class for solution One-step, two-step, or multiple-step routine problems can be easily assessed with paper and pencil tests typically focusing on the algorithms being used [20].

However, an increased need for employees with abilities in nonroutine problem solving has occurred in today’s workplace. Nonroutine problem solving stresses the use of heuristics and often requires little to no use of algorithms. Heuristics are procedures or strategies that do not guarantee a solution to a problem but provide a more highly probable method for discovering the solution to a problem.

OPEN-ENDED PROBLEMS

Presenting students with Open-ended problems is a very important characteristic of NCTM problem-solving. NCTM [22] defines "open-ended problems" as: Situations that allow students to experience problems with "messy" numbers or too much or not enough information or that have multiple solutions, each with different consequences.

Much has been said about the importance of open-ended mathematical problems [26]. However, this title comprises numerous problems that differ from one another in character. Their importance lies first and foremost in the fact that they break the stereotype that every problem has one correct solution. They also enable students to simultaneously work on the same problem on various levels: some will be satisfied with a single solution, others will find several, and yet others will systematically find all the possible solutions. However, the primary importance of problems of this kind lies in the fact that they can be used to learn various problem-solving strategies.

GENDER DIFFERENCES IN MATHEMATIC

Gender differences in mathematics have been a popular but complex issue in educational research [7, 15]. The Hyde et al. [14] meta-analysis of 100 studies suggested that gender differences in mathematics performance were small but gender differences in mathematical problem solving with lower performance of women existed in high school and in college.

Based on these findings, we may assume that females and males have different patterns of mathematical problem solving. Since many mathematical problems on standardized tests are multi-step and require some systematic approach, students could arrive at a correct solution by choosing and combining a set of appropriate strategies. Strategy flexibility is important for successful performance on standardized tests such as the SAT-M [9].

Some research studies have reported gender differences in strategy use among elementary school students [3, 4, 5, 8, 13]. Carr and Davis [4] found that girls and boys showed different preferences for strategy use to achieve the solution. Fennema et al. [8] suggested girls tended to use more concrete strategies and boys tended to use more abstract strategies and that elementary school boys tended to be more flexible in employing strategies on extension problems than elementary school girls. Their study also found girls chose to use more standard algorithms than boys at the end of Grade 3. However, there were no gender differences in the group whose members had used invented algorithms in the earlier grades.

Gender differences were evident in successful patterns and in strategy use on conventional and unconventional problems. Female students were more likely than male students to correctly solve conventional problems (by) using algorithmic strategies; male students were more likely than female students to correctly solve unconventional problems (by) using logical estimation and insight [9].

Previous studies used, almost exclusively, multiple choice tests to examine the gender differences in solving routine word problems. How male and female students differ in solving more complex mathematical problems is less investigated. Due to the use of multiple choice items the gender differences in most of the previous studies were examined and reported only quantitatively, as differences in mean scores or percent correct and incorrect rather than providing an analysis of the differences in solution processes. It is useful to know the performance differences in terms of mean scores, but such simple comparisons of status using mean scores lose comparative insights about male and female students' mathematical thinking [13].

Hough [13] examined the gender differences of U.S. and Chinese students in their solution processes of solving routine and nonroutine mathematical problems. Results of the study showed that overall there were statistically significant gender differences (favoring males) on both routine and nonroutine problem solving for the U.S. sample, but not for the Chinese sample. However, examinations of students' component processes for solving routine problems revealed that significant gender differences only exist for the execution component for the U.S. sample.

Information about how students approach the solution of a given problem is more important than whether or not they are able to recognize the correct solution. The purpose of this study was to explore the gender differences of Malay and Chinese students in their solution processes of solving routine and nonroutine mathematical problems.

Examination of gender-related performance differences on both routine and nonroutine mathematical problem solving not only allows for investigating whether the gender differences in routine problem solving differ from those in nonroutine problem solving, but also allows for investigating gender differences in thinking and reasoning as they solve these problems [13].

The significance of this study is related to the importance of problem solving in the current mathematics education reform and the goal of achieving equal educational outcomes in student learning of mathematics [22, 24]. Since mathematics is no longer just a prerequisite subject for prospective scientists and engineers but is a fundamental aspect of literacy for the twenty-first century [18, 22], male and female students should have equal opportunity to learn mathematics, have equal treatment within classrooms, and achieve equal mathematics educational outcomes [7]. The present study aimed at exploring gender related differences of Malaysian students in their solution processes of solving routine and nonroutine problems.

RESEARCH QUESTIONS

The present study sought answers to the following questions

(1) Are there significant gender-related differences of Malaysian students in their solution processes in solving routine mathematical problems? (2) Are there significant gender-related differences of Malaysian students in their solution processes in solving non-routine mathematical problems? (3) Are gender differences of routine and nonroutine problems linked to content areas within mathematics?

METHOD

Subjects

In total, 289 sixth grade Chinese and 341 sixth grade Malay students participated in the study. The Chinese sample consisted of 144 female and 145 male students, and the Malay sample consisted of 165 female and 176 male students.

INSTRUMENTS

Routine problems

A test for analyzing cognitive components in solving word problems was developed. In this test, four cognitive components involved in solving routine problems were classified and analyzed: translation, integration, planning, and execution. The test comprised of 31 multiple choice items: 5 items for the translation component, 5 items for the integration component, 5 items for the planning component, and 16 items for the execution component. The execution component involved students' computation skills in order to cover different operations (addition, subtraction, multiplication, and division) on different types of numbers (whole numbers, decimals, and fractions). Items for translation, integration, and planning components were adapted from student's text book.

The test was tried out on a sample of 144 students- males and females, to make sure that the items of the test are clear and are understood by those being tested, and to find out the psychometric properties of the test. Accordingly, the item analysis revealed levels of difficulty from .27 to .92. Besides, it revealed that the detractors were reversal to the item discriminate. Data about validity of the scale were collected through three methods: Internal consistency, item analysis, content validity.

The Cronbach's alpha coefficients calculated for the Execution, Translation, Integration, and Planning subscales were .85, .71, .70, and .73, respectively, and it was calculated to be 0.89 for the entire scale. The scale correlation coefficients ranged between .36 and .46 on execution component, between .37 and .57 on translation component, between .39 and .46 on integration component, and between .38 and .60 on planning component. It is generally agreed that correlations in the range of .35 to .65 are useful and statistically significant beyond the1%level, whereas correlations less than .25 are not useful and statistically non significant [2]. Thus, the results show that the alpha coefficients for all subscales were significantly high, suggesting that the internal reliability index of the four constructs and the entire scale is adequate.

The test booklet was administered within one class period during the second semester of the school year 2009/ 2010. Students had 50 minutes to complete the booklet. Students had no trouble finishing all items within the time limit. Appendix A shows test items for component processes of solving routine problems.

Nonroutine problems

A test consisting of five open-ended problems was developed to examine gender differences in nonroutine mathematical problem solving. These five open-ended problems involved a variety of important content areas, such as a whole numbers, pattern recognition, money, estimation, and functions.

The test was tried out on a sample of 144 students- males and females, to find out the psychometric properties of the test. Accordingly, the item analysis revealed levels of difficulty from 0.20 to 0.62 and levels of discriminate ability from o.26 to o.49. Data about validity of the scale were collected through item analysis, and Logical judgment. In order to collect data about the reliability of the test, Cronbach alpha method was used (alpha= .96).

The test booklet was administered within one class period during the second semester of the school year 2009/ 2010. Students had 40 minutes to complete the test. Appendix B shows the set of five open-ended problems.

Data analysis of routine problems

Each student's response to items measuring component processes of solving routine problems was coded correct or incorrect. Item analysis was conducted to determine patterns of errors in incorrect responses. If a student's omitted an item, the student's response on the item was coded as incorrect (i.e., 1 for correct, and 0 for incorrect). To explore gender related differences in the processes of solving routine problems. *t*-test and differential item functioning (DIF) were used.

Psychometricians define DIF more precisely as a situation where individuals who have the same ability, but are members of different subgroups, do not have the same probability of a correct response to an item [11].

The M-H method works by first dividing subgroups into the reference group and the focal group. The focal group is of primary interest in the analysis and is compared to the reference group after being matched on θ [31]. The total test score usually serves as the θ estimate, and the performance of the reference and focal groups is compared at unit intervals of θ weighted by the number of examinees at each level [29]. From this comparison, an odds-ratio estimator can be calculated, and a χ^2 test of significance can be carried out to assess the presence of DIF.

To assess the degree of DIF present, the odds-ratio estimator can be transformed onto the ETS "delta metric" (Δ; [6]). The Δ statistic represents the difference in item difficulty for the reference and focal groups after the total score has been taken into account [29].

In the present study, the M-H technique was implemented. First, subgroup members were matched based on their total scores for the test scale. Then, the χ^2's *p* value, as well as the M-H odds-ratio estimator were examined to assess the degree of DIF present. Positive values of Δ favored females, and negative Δ values favored males. More specifically, there are three possible degrees of DIF: (a) negligible DIF, where χ^2 is nonsignificant or the absolute value of Δ is less than 1.0; (b) intermediate DIF, where χ^2 is significant and Δ is between 1.0 and 1.49 in absolute value; and (c) large DIF, where χ^2 is significant and the absolute value of Δ is 1.5 or larger [6].

Data analysis of nonroutine problems

Students' responses to open-ended, nonroutine problems were coded and analyzed according to two analysis schemes: quantitative holistic and qualitative analytic analysis. In the quantitative analysis, each student response was assigned a numerical score (0 to 4). In general, to receive a score of 4, a student's explanation or solution process had to show a correct and complete understanding of the problem. At the score level 3, students' explanations or solution processes needed to be correct and complete, except for a minor error, omission, or ambiguity. To receive a score of 2, the explanation or solution process showed some understanding of the problem but was otherwise incomplete. If a student's explanation showed a limited understanding of the problem, it was scored as 1. If a student's answer and explanation showed no understanding of the problem, the response received a score of 0. If a student omitted an open-ended problem, the student response was scored as 0 for the problem [13].

To explore a gender related differences in solving nonroutine problems, *t*-test was used. A qualitative analysis of each response to the open-ended problems focused on four critical cognitive aspects: solution strategies, mathematical errors, mathematical justifications, and modes of representation [13]. Based on these four aspects, a specific qualitative coding scheme for each problem was developed. For each of the open-ended items, the researcher performed all classifications of the responses and the strategies. To explore a gender related difference in the strategies of solving nonroutine problems, *z*-test was used.

RESULTS

The results are reported in two separate sections. The first section provides the overall results of the gender differences for the two samples on routine problems. The second section presents results for open-ended, nonroutine problems.

Results of routine problems

Table 1 shows the mean scores of Malay students on each of the component processes of solving routine problems, and the results of *t*-test for the equity of means on each component of routine problems. Mean scores for male and female students were very close on almost every component. Results indicated that there is no significant difference between male and female performance in: execution (t (339)=- 1.67, p>.05); translation (t (339)= - 1.34, p>.05); integration (t (339)= - 0.60, p>.05); planning (t (339)= - 1.54, p>.05).

Component	Gender	Mean	Standard deviation	*t*-value	*p*-value
Execution	Male	13.03	4.04	-1.67	0.10
	Female	13.71	3.44		
Translation	Male	3.43	1.76	-1.34	0.18
	Female	3.68	1.65		
Integrating	Male	2.96	1.45	-0.60	0.55
	Female	3.04	1.28		
Planning	Male	3.51	1.74	-1.54	0.12
	Female	3.79	1.62		
Over all	Male	22.93	8.30	-1.54	0.13
	Female	24.22	7.21		

Note: the possible score for the translation component is 5; the possible score for the integration component is 5; the possible score for the planning component is 5; and the possible score for the execution component is 16.

Table 1: Summary results of t-test for equity of means on each components of solving routine problems for male and female Malay students

Component	Gender	Mean	Standard deviation	*t*-value	*p*-value
Execution	Male	14.50	2.31	-0.63	.53
	Female	14.67	2.05		
Planning	Male	3.58	1.52	-1.42	.22
	Female	3.79	1.35		
Integrating	Male	3.44	1.60	-0.68	.50
	Female	3.67	1.61		
Translation	Male	3.69	1.52	-1.24	.22
	Female	3.70	1.44		
Over all	Male	25.22	5.94	-1.07	.29
	Female	25.94	5.42		

Note: the possible score for the translation component is 5; the possible score for the integration component is 5; the possible score for the planning component is 5; and the possible score for the execution component is 16.

Table 2: Summary results of t-test for equity of means on each components of solving routine problems for male and female Chinese students.

Table 2 shows the mean scores of Chinese students on each of the component processes of solving routine problems, and the results of *t*-test for the equity of means on each component of routine problems. Mean scores for male and female students were very close on almost every component. Results indicated that there is no significant difference between male and female performance in: execution (t (287) = -0.63, p>.05); translation (t (287)= - 1.42, p>.05); integration (t (287)= - 0.68, p>.05); planning (t (287)= - 1.24, p>.05).

With respect to DIF analysis, several items were found to contain DIF in the comparisons made. There were two comparisons: Malay males versus Malay females, and Chinese males versus Chinese females.

Tables 3 shows the group means, Δ, and χ^2 statistic obtained in the Malay males versus Malay females comparison (i.e., The summary results of the M-H method to identify Differential Item Functioning on the mathematics routine problems for each of the thirty-one items). According to the ETS criteria, none of the thirty one items reveals DIF.

Tables 4 shows the group means, Δ, and χ^2 statistic obtained in the Chinese males versus Chinese females comparison (i.e., The summary results of the M-H method to identify Differential Item Functioning on the mathematics routine problems for each of the thirty-one items). According to the ETS criteria, none of the thirty one item reveals DIF.

Item analysis for both Malay and Chinese samples on each component of solving routine problems (execution, translating, integrating, and planning) indicated that: for both Malay and Chinese samples students did not have a mean difference on each solution processes of solving routine problem. In fact, on each of these items, Malay and Chinese male and female students had a similar success rate, and similar mathematical errors.

Results of non routine problems

Table 5 shows the mean scores for Malay students on each of nonroutine problems and the results of t-test for equity of males and females means on each nonroutine problem. Females and males mean scores on each nonroutine problem were convergent. The findings of t-test indicate that there is no significant difference between males and females performance on each of nonroutine problems (for money problems: t (339)= 0.61, p>0.05; for pattern problem: t (339)= - 0.20, p> .05; for the whole numbers problem: t (339) = 0.19, p>0.05; for estimation problem: t (339) = 0.57, p> .05; and for function problem: t (339) = 0.03, p> .05).

Table 6 shows the mean scores for Chinese students on each nonroutine problem, and the results of t-test for equity of means on each of nonroutine problems. Females and males mean scores on each nonroutine problem were convergent. The findings of t-test indicate that there is no significant difference between males and Females performance on each of nonroutine problems (for money problems: t (287) = 0.63, p> .05; for pattern problem: t (287) = - 1.90, p> .05; for the whole numbers problem: t (287) = -0.04, p> .05; for estimation problem: t (287) = - 0.86, p> .05; and for function problem: t (287) = 0.24, p> .05).

	Group mean				
Item	**Male**	**Female**	**Δ**	**χ^2**	***P*. value**
1.	.14	.30	.29	3.26	.02
2.	.29	.53	.18	2.40	.12
3.	.42	.56	.27	5.73	.02
4.	.45	.65	-.22	2.63	.10
5.	.24	.32	-.73	29.75	.00
6.	.76	.83	-.02	0.01	.92
7.	.50	.64	.42	13.14	.00
8.	.37	.48	-.44	13.16	.00
9.	.35	.51	-.17	1.69	.19
10.	.24	.32	-.73	29.75	.00
11.	.91	.93	-.14	0.42	.52
12.	.45	.65	-.22	2.63	.10
13.	.29	.48	-.18	1.35	.25
14.	.73	.82	-.06	0.13	.72
15.	.25	.21	-.88	45.57	.00
16.	.82	.88	-.10	0.31	.58
17.	.04	.06	-.41	2.52	.11
18.	.30	.43	-.19	2.21	.14
19.	.16	.22	-.53	13.43	.00
20.	.24	.32	-.73	29.75	.00
21.	.42	.42	-.30	5.34	.02
22.	.16	.13	-.96	31.39	.00
23.	.42	.42	-.30	5.34	.02
24.	.42	.42	-.30	5.34	.02
25.	.44	.91	-.43	15.61	.00
26.	.42	.42	-.30	5.34	.02
27.	.19	.26	.95	52.10	.00
28.	.42	.42	-.30	5.34	.02
29.	.78	.76	-.41	9.06	.00
30.	.57	.65	.85	49.11	.00
31.	.44	.91	-.43	15.61	.00

Table 3: Summary result of the M-H analysis: Malay males versus Malay females

Item	Group mean		Δ	χ^2	*P*. value
	Male	Female			
1.	.34	.40	.30	4.82	.03
2.	.35	.41	.30	4.82	.03
3.	.50	.57	.43	33.08	.00
4.	.70	.78	.72	29.43	.00
5.	.61	.55	-.89	75.81	.00
6.	.71	.77	.72	29.43	.00
7.	.70	.72	-.21	2.62	.11
8.	.70	.78	.72	29.43	.00
9.	.41	.40	-.84	37.30	.00
10.	.48	.50	-.22	3.29	.07
11.	.26	.78	-.42	7.59	.01
12.	.62	.71	.84	42.63	.00
13.	.75	.81	.51	10.05	.00
14.	.67	.82	.21	1.47	.22
15.	.38	.44	.40	6.76	.01
16.	.75	.81	.51	10.05	.00
17.	.27	.36	.82	44.69	.00
18.	.70	.78	.72	29.43	.00
19.	.52	.60	.53	20.88	.00
20.	.45	.54	.42	11.11	.00
21.	.70	.78	.72	29.43	.00
22.	.49	.48	-.91	41.76	.00
23.	.85	.89	.66	15.05	.00
24.	.57	.61	-.07	0.28	.60
25.	.50	.50	-.49	17.55	.00
26.	.53	.57	-.02	0.03	.87
27.	.63	.73	-.30	5.33	.02
28.	.18	.58	.78	28.13	.00
29.	.43	.53	-.67	28.67	.00
30.	.67	.82	.21	1.47	.22
31.	.14	.30	.29	3.26	.07

Table 4: Summary result of the M-H analysis: Chinese males versus Chinese females

Problem	Gender	Mean	Standard deviation	*t*-value	*p*-value
Money	Male	2.90	1.41	.61	.54
	Female	2.80	1.53		
Pattern	Male	2.95	1.50	-.20	.84
	Female	2.99	1.53		
Whole numbers	Male	2.77	1.70	.19	.85
	Female	2.74	1.63		
Estimation	Male	2.78	1.52	.57	.57
	Female	2.68	1.70		
Function	Male	2.92	1.45	.03	.97
	Female	2.92	1.45		
Over all	Male	14.33	6.53	.27	.79
	Female	14.13	7.12		

Note: The possible score for each of the nonroutine problem is 4

Table 5: Summary results of t-test for equity of means on solving nonroutine problems for male and female Malay students.

Problem	Gender	Mean	Standard deviation	*t*-value	*p*-value
Money	Male	3.10	1.19	0.63	.52
	Female	3.01	1.23		
Pattern	Male	2.90	1.49	-1.90	.06
	Female	3.20	1.15		
Whole number	Male	3.08	1.39	-0.04	.91
	Female	3.08	1.35		
Estimation	Male	2.96	1.49	-0.86	.39
	Female	3.10	1.36		
Function	Male	3.17	1.28	0.24	.81
	Female	3.14	1.26		
Over all	Male	15.22	6.05	-0.48	.64
	Female	15.24	5.48		

Note: The possible score for each of the nonroutine problem is 4

Table 6: Summary results of t-test for equity of means on solving nonroutine problems for male and female Chinese students

Students' responses to each of the nonroutine problems were analyzed to provide further information about gender-related differences in strategies of solving these problems.

Table 7 shows the descriptions of each solution strategy and percentages of male and female students in each strategy for the money problem. This problem assessed students' numerical ability. Three strategies were used by both samples. For the Malay sample, 30% of males and 35% of females used strategy 1, whereas 40% of males and 46% of females used strategy 2.

Results of *z*-test indicates that: there are no significant differences between males and females in solution strategies of solving the money problem. For the Chinese sample, the common strategy of solving the money problem was the strategy 2 (70% of males and 72% of females). Results of *z*-test indicates that: there are no significant differences between males and females in solution strategies of solving the money problem.

Strategy	Discription	Malay			Chinese		
		Male percentage	Female Percentage	*Z*-value	Male percentage	Female percentage	*Z*-value
1	Students divided 276000 by 50, and multiplied the result by 5 (276000/50×5=27600). Students compared between 27600 and 25000 to make a decision..	30	35	-0,83	5	9	-1.00
2	Students multiplied 276000 by 5, and divided the result by 50 (276000×5/50=27600). Students compared between 27600 and 25000 to make a decision.	40	46	-0.86	70	72	-0.40
3	Students multiplied 276000 by 5, and multiplied 25000 by 50 (276000×5=1380000, 25000×50=1250000). Students compared between 1380000 and 1250000 to make a decision.				10	8	0.50
4	Strategies cannot be identified.	30	39	0.17	15	11	0.80

Table 7: The Descriptions of Each Solution Strategy, Percentages of Male and Female Students in Each Strategy for the Money Problem, and Results of z-test.

Table 8 shows the descriptions of each solution strategy and percentages of male and female students in each strategy for the pattern problem. For the Malay sample, about 85% of the male and female students had clear indications of using one of the solution strategies. For the Chinese sample, about 97% of the male and female students had clear indications of using one of the solution strategies. As

Table 9 shows the descriptions of each solution strategy and percentages of male and female students in each strategy for the Whole Number Problem. With respect to the uses of solution strategies, there are many similarities between male and female students for both samples. For the Malay sample, about 75% of the male and female students had clear indications of using one of the solution strategies. For the Chinese sample, about 97% of the male and

was shown in Table 8, for both Chinese and Malay samples, the percentage distributions of the female and male students who employed each of the solution strategies were very similar. Results of *z*-test indicate that there are no significant differences between males and females in solution strategies of solving the Patterns problem for both Chinese and Malay samples.

female students had clear indications of using one of the solution strategies. As was shown in Table 8, for both samples, the percentage distributions of the female and male students who employed each of the solution strategies were very similar. Results of *z*-test indicates that: there are no significant differences between males and females in solution strategies of solving the Whole number problem for both Chinese and Malay samples.

Strategy	Description	Malay			Chinese		
		Male percentage	**Female percentage**	***Z*-value**	**Male percentage**	**Female percentage**	***Z*-value**
1	Students focused on the total number of the dots in each figure to describe how to get the next figure (3, 6, 9, 12, 15, 18, 22, 25).	39	35	0.57	40	38	0.29
2	Students found that the number of dots in the first row of a figure was equal to the number of each figure. The number of dots on the second row was one more than the first row, and so on.	10	13	-0.75	20	25	-0.83
3	Students realized that, from figure to figure, each row has one more dot that the corresponding row in the previous figure, from the sixth figure, to get the seventh figure.	36	41	-0.71	37	35	0.29
4	Strategies cannot be identified.	15	11	1.00	3	2	0.50

Table 8: The Descriptions of Each Solution Strategy, Percentages of Male and Female Students in Each Strategy for the Pattern Problem, and Results of z-test.

Table 10 shows the descriptions of the Estimation strategies and the percentages of female and male students for *Estimation Problem.* For both Malay and Chinese samples, the percentages of the female and male students who employed each of the estimation strategies were nearly the same. This means that both female and male students tended to use similar kinds of estimation strategies. For the Malay sample, about 80% of the male and female students had clear indications of using one of the solution strategies. For the Chinese sample, about 90% of the male and female students had clear indications of using one of the solution strategies. Strategy 1 was the most frequently used strategy for both male and female students. Results of *z*-test indicate that there are no significant differences between males and females in solution strategies of solving the Estimation problem for both Chinese and Malay samples.

Table 11 shows the descriptions of each solution strategy and percentages of male and female students in each strategy for the Function Problem. For the Malay sample, about 72% of the male and female students had clear indications of using one of the solution strategies. For the Chinese sample, about 90% of the male and female students had clear indications of using one of the solution strategies. As shown in Table 11, for both Malay and Chinese samples, the percentage distributions of the female and male students who employed each of the solution strategies were very similar. Results of *z*-test indicate that there are no significant differences between males and females in solution strategies of solving the Function problem for both Chinese and Malay samples.

Strategy	Description	Malay			Chinese		
		Male percentage	Female percentage	*Z*-value	Male percentage	Female percentage	*Z*-value
1	Students added 621 to 518, and divided by 12 (621+518/12=94 cartons).	70	65	-.071	90	83	1.40
2	Students divided 621 by 12(621/12=51 cartons), and divided 518 by 12 (518/12=43 cartons). Students added 51 to 43 (51+43=94 cartons).	7	12	-1.00	8	13	-0.50
3	Strategies cannot be identified.	23	22	0.17	2	3	-0.50

Table 9: The Descriptions of Each Solution Strategy and Percentages of Male and Female Students in Each Strategy for the Whole Number Problem

Strategy	Description	Malay			Chinese		
		Male percentage	Female percentage	*Z*-value	Male percentage	Female percentage	*Z*-value
1	(Counting): Students counted the completely shaded squares and partially shaded squared and combined them to get the 12(621/12=51 cartons), and div estimate.	70	74	-0.80	72	80	-1.60
2	(Reforming): Students reformed the polygon into a rectangle with approximated the same area, and used the area of the rectangle as an estimate for the area of the polygon.	18	15	0.60	22	15	1.40
3	Strategies cannot be identified.	12	11	0.25	8	5	0.60

Table 10: Descriptions of the Estimation Strategies and the Percentages of Female and Male Students

Strategy	Description	Malay			Chinese		
		Male percentage	Female percentage	*Z*-value	Male percentage	Female percentage	*Z*-value
1	Every poster needs 10 minutes each, so 6 posters need 60 minutes (6×10=60).	50	52	-0.29	70	76	-1.20
2	Students found the answer by drawing a graph.	22	21	0.50	19	14	1.00
3	Strategies cannot be identified.	28	27	0.17	11	10	0.25

Table 11: The Descriptions of Each Solution Strategy and Percentages of Male and Female Students in Each Strategy for the Function Problem.

DISCUSSION

The present study examined the gender-related differences of Malay and Chinese students in their solution processes of solving routine and non routine mathematical problems. Results of the study showed that overall there were no significant gender differences on both routine and non routine problem solving for the Malay sample, and for the Chinese sample. Results from *t*-test and DIF analysis of students' component processes (translation, integration, planning, and execution) of solving routine problems revealed that for the Malay and Chinese samples there were no significant gender difference on the execution, translation, integration, and planning components. This finding seems to be consistent with the findings from previous studies. In fact, previous studies reported that in general, male students were not more successful than female students on computation tasks [10, 14, 17]. The findings from the present study seem to be inconsistent with the findings from the previous studies [13] indicating that there is gender related difference in Execution.

Results of t-test and *z*-test showed that overall there were no significant gender differences on both solving non routine problems and strategies used. The findings from the present study seem to be inconsistent with the findings from several meta-analyses (e.g., [13, 14, 32]), which have revealed that male students usually score higher than female students on tasks requiring mathematical thinking and problem solving.

How can we explain the finding that there were no gender differences for the Chinese and Malay samples on both routine and non routine problem solving? In Malaysian society, women and men tend to have equal opportunities for jobs and equal salaries. Thus, the finding that there was no gender difference in solving routine and non routine problems for the Malaysian samples may be explained by the fact that Malaysian students are raised in relatively more uniform educational and social conditions. In addition, the mathematics curriculum of sixth grade concentrates on teaching problem solving ability.

Hanna et al. [12] investigated the gender differences in mathematical performance among 15 countries based on the data of the Second International Mathematics Study (SIMS). Their analysis shows that gender differences in mathematical performance vary from country to country. Lummis and Stevenson [16] reported that the gender differences vary from one type of task to another. Gender differences are inconsistent from country to country.

One of the contributions of this study was the use of both routine and non routine problems to examine male and female students' thinking and reasoning involved in solving these problems. Reporting mean scores is one way to portray the gender differences in mathematics. However, the mean scores may conceal some aspects of students' performance. In addition to differences in mean scores, this study also provided a more detailed description of male and female students' solution processes of solving routine and non routine problems. Furthermore, the present study investigated a gender related DIF of the processes of solving routine problems. Results of DIF analysis indicated that the test was free from gender bias.

The results from the present study may suggest that we can focus on problem-solving processes to not only foster students' learning and understanding of mathematics, but also eliminate gender differences in mathematics. Future studies are needed to examine the actual impact of teaching problem-solving processes on gender-related differences in mathematics [13], and to examine gender differences of high school students in their solution processes of solving mathematical problems.

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Appendix A

University of Malaya

Faculty of Education

Department of Educational psychology and counseling

Name of school:

………………………………………………………………………………………….……….

…………….

Student name:……………………………………………………………………………………………

…….…………………

Gander: ☐ Male ☐ Female

Ethnicity: ☐ Malay ☐ chine's ☐ Indian

Instructions

- Fill the above data (information).
- The test comprised of 30 Multiple - Choice items.
- Use your pencil.
- The time is 40 minutes.
- Read the item carefully, and select the correct answer on the answer paper as follows:

Example:

23+15=

a) 38
b) 28
c) 48
d) 42

●	○	○	○
A	B	C	d

1.	$\begin{array}{r} 9200637 \\ -\ \underline{1992582} \end{array}$ a)8792155 b)7208155 c)8208155 d)7208055
2.	223146 × 5= a)1115730 b)1115720 c)1116700 d)1115740
3.	480200 ÷ 8 = a)80025 b)6025 c)600025 d)60025
4.	124 + 2 × 84 = a)10584 b)20832 c)292 d)210
5.	$4\frac{2}{7} - 2\frac{9}{14} =$ a)$2\frac{7}{14}$ b)$2\frac{5}{14}$ c)$1\frac{9}{14}$ d)$2\frac{9}{14}$
6.	$6 \div \frac{2}{3} =$ a)9 b)3 c)6 d)2

7.	$64 \times 1\frac{1}{8} =$ a)8 b)72 c)9 d)36
8.	$5\% \times 20 =$ a)1 b)2 c)5 d)10
9.	1.5 + 9 + 0.3= a)2.7 b)10.8 c)12.6 d)16.2
10.	5.3 – 4.6 = a)0.3 b)0.7 c)1.3 d)1.7
11.	3572 ÷ 46 = a)77 b)77 r 30 c)78 d)78 r 30
12.	$\begin{array}{r} 38.15 \\ -\underline{\ \ 9.43} \end{array} =$ a)28.72 b)29.72 c)31.32 d)38.72
13.	828000 ÷ 3600 = a)23 b)230 c)2300 d)23000

14. $13.08 \div 12 =$

a)1.09
b)1.9
c)10.9
d)19

15. $\begin{array}{r} 0.034 \\ \times \underline{\ \ 17\ \ } = \end{array}$

a)0.00578
b)0.0578
c)0.578
d)5.78

16. $\frac{3}{4} - \frac{1}{6} =$

a) $\frac{2}{24}$

b) $\frac{2}{6}$

c) $\frac{7}{12}$

d) $\frac{2}{2}$

17. $\frac{3}{5} \times \frac{1}{9} =$

a) $\frac{3}{45}$

b) $\frac{3}{14}$

c) $\frac{2}{4}$

d) $\frac{27}{5}$

18. $6 \times \frac{4}{7} =$

a) $\frac{4}{42}$

b) $\frac{24}{42}$

	c) $\frac{24}{7}$ d) $6\ \frac{4}{7}$
19.	**Which sentence is correct?** Ahmad has 5 more marbles than Ali. a) Ahmad's marbles = 5+ Ali's marbles. b) Ahmad's marbles + 5 = Ali's marbles. c) Ahmad's marbles 5+ Ali's marbles=5. d) Ahmad's marbles = 5.
20.	**Which numbers are needed to solve this problem?** Nadia had RM3 for lunch. She bought a sandwich for RM0.95, an apple for RM 0.20, and milk for RM 0.45. How much money did she spend? a) 3, 0.95, 0.20, 0.45 b) 0.95, 0.20, 0.45 c) 0.95, 0.45 d) 3
21.	**Which operations should you carry out to solve this problem?** Twelve candies come in each bag at the store. You buy 3 bags on Monday, 2 bags on Wednesday, and 1 bag on Friday. How many candies do you have? a) add, then multiply b) add, then divide c) add only d) divide only
22.	**Which operations should you carry out to solve this problem?** A group of 140 boys were selected to take part in the opening ceremony of a music festival. Three groups of girls with 42 girl in each group joined the boys. What was the total number of children taking part in the ceremony? a) multiply only b) multiply , then add c) add only d) multiply, then divide
23.	**Which operations should you carry out to solve this problem?** If 5 children shared $\frac{5}{8}$ of a pizza, what is the fraction of the pizza each child gets? a) add only b) multiply only c) divide only d) divide , then subtract

24. **Which operations should you carry out to solve this problem?**
A total of 782 424 cartons of lime juice will be packed into boxes. Each box holds 36 cartons. If there are 21 750 boxes, how many boxes will not be used?
a) multiply, then divide
b) multiply, then subtract
c) divide , then subtract
d) divide , then add

25. **Which numbers are needed to solve this problem?**
Maria has 5 friends; she used $1\frac{1}{2}$ slab to bake 3 small cakes. What was the fraction of butter used for each cake?
a) $5,\ 1\frac{1}{2}$
b) $5,\ 1\frac{1}{2}$, 3
c) $3,\ 1\frac{1}{2}$
d) 5, 3

26. **Which numbers are needed to solve this problem?**
Delima Travel and Tours collected RM 451 550 from the sales of tour packages to asian countries. They also sold 45 travel packages worth RM 325 each to Middle East. How much did the company sold to Middle East.

a) 45, 325
b) 45, 325, 451550
c) 451550, 325
d) 451550, 45

27. A group of 140 boys were selected to take part in the opening of a music festival. Three groups of girls with 42 girls in each group joined the boys. What was the total number of children taking part in the ceremony?

a) $140 + 42$
b) 140×42
c) $140 + 42 \times 3$
d) $42 + 140 \times 3$

28. 20 groups of girls were chosen to take part in the closing ceremony. A total of 126 boys, grouped in nines, were also chosen to take part. There were more girls groups than boys group. What was the difference between the number of the girls and the boys groups?

a) $20 – 126 \div 9$
b) $126 – 20 \times 9$
c) $126 + 126 \div 9$
d) $20 + 126 + 9$

29. A train travels 120 km an hour. How far in km does the train travel in $\frac{3}{4}$ hour?

a) $120 \div \frac{3}{4}$

b) $1\ 20 \times \frac{3}{4}$

c) $120 \times \frac{1}{4}$

d) $120 \div \frac{1}{4}$

30. Puan Hamimah visited Japan which lasted for 12 weeks. Then, she visited Korea for 9 weeks. She spent $\frac{2}{3}$ of the total duration to do research. How long in weeks did she spend to do the research?

a) $12 \times \frac{2}{3} + 9$

b) $9 \times \frac{2}{3} + 12$

c) $\frac{2}{3} \times (12+ 9)$

d) $\frac{1}{3} \times (12+ 3)$

31. **Which numbers are needed to solve this problem?**
The table shows three models of cars sold by a company. Calculate the cost in RM of: 6 units of models A cars and 9 units of models B cars?

Price of cars
Models A – RM45 000
Models B – RM60 000
Models C – RM60 000

a. 6, 9, 45 000
b. 6, 45 000
c. 9, 60 000
d. 9, 6, 45 000, 60 000

Appendix B

University of Malaya

Faculty of Education

Department of Educational psychology and counseling

Name of school:

……………………………………………………………………………………………..………
…………….

Student
name:…………………………………………………………………………………………
………..……………….

Gander: ☐ Male ☐ Female

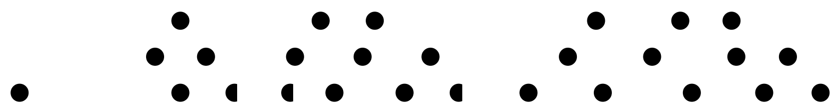
Ethnicity: ☐ Malay ☐ Chinese ☐ Indian ☐ Other

Instructions

- Fill the above data (information).
- The test comprised of 5 problems. Write your solving processes.
- Use your pencil.
- The time of the test is 30 minutes

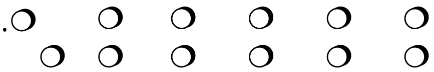
1. Five voluntary organizations raised RM 276000 each to help 50 families that were affected by an earthquake. Will each family be able to get a minimum of RM 25000? Explain your answer.

2. Look at the pattern below



1. 2. 3.

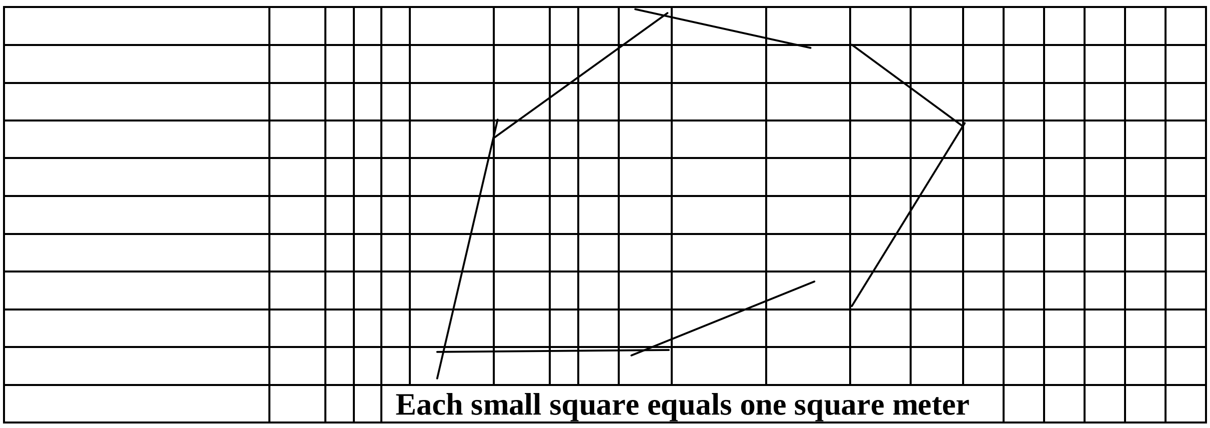
A. Draw the fifth figure.
B. Draw the seventh figure.
C. Describe how you knew what the seventh figure would look like.

3. 

Ahmad and Rama are coloring eggs and putting th them into the eggs cartons. Rama colored 621 eggs and ad Ahmad colored 518 eggs. (There are 12 eggs in a carton).

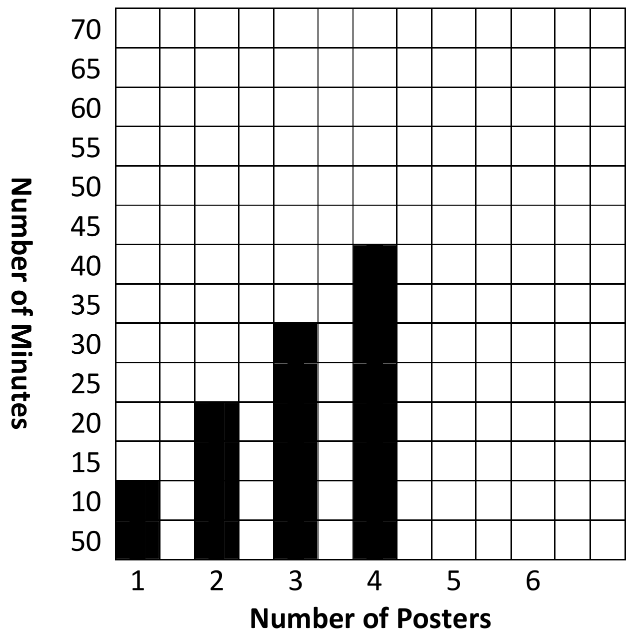
How many cartons will they need to hold all the eggs? Explain how you got your answer.

4. a. Estimate the area inside the polygon.



b. Explain how you found your estimate. You may use the above drawing in your explanation.

5. The graph below shows how many minutes it takes to make different numbers of posters.



If this continues, how many minutes will it take to make 6 posters? Explain your answer

Scoring Rubrics for nonroutine problems

Scoring Rubric (problem 1):

4 correct answer with an explanation.

3 correct answer without explanation.

2 incorrect answer with explanation.

1 student try to answer.

0 no solution.

Scoring Rubric (problem 2):

4 correct answer with an explanation (finding the rule).

3 correct answer without an explanation.

2 students drew the two figures.

1 students drew one figure only.

0 no solution

Scoring Rubric (problem 3):

4 Correct answer (94 cartons) with an explanation.

3 Correct answer (94 cartons) without an explanation.

2 incorrect answer with an explanation.

1 An attempt is made to count eggs (perhaps even successfully), but there is no.

evidence of an attempt to divide eggs into cartons.

0 Trace evidence of work but without clear connection to problem situation.

Scoring Rubric (problem 4):

4. Accurate estimate an estimate between 54 and 56.

3. Acceptable estimate an estimate between 50 and 53 or between 57 and 59.

2. Poor estimate An estimate between 47 and 49 or between 60 and 62.

1. Unreasonable or no estimate without estimate without estimate or an estimate that is outside the ranges of good, acceptable, or poor estimates.

0. No solution.

Scoring Rubric (problem 5) :

4 correct answer with an explanation (verbally and graphically)

3 correct answer without explanation (graphically only)

2 correct answer without explanation.

1 student try to solve the problem graphically.

0 no solution.