Problem solving heuristics programme (M.H.P) and its impact in enhancing pupils’ performance in solving of non-routine problems at Jurong Primary School

Tan Sunny
Jurong Primary School

Abstract

M.H.P, the problem solving heuristics programme developed by Sunny Tan, was implemented in Jurong Primary School in 2006 to “enable pupils to develop their ability to expedite the processes of discovering and identifying heuristics and apply them in mathematical problem solving.” M.H.P stands for Maths Heuristics Programme designed for the high and middle ability (HAMA) upper primary pupils. M.H.P curriculum focuses on problem solving skills based on Polya (1988)’s four stages of problem solving namely understanding, planning, executing and reflecting. The planning phase is further broken down into pupils learning all the full range of problem solving heuristics as mandated by the curriculum. Pupils are also exposed to a “wide range of situations from routine mathematical problems to problems in unfamiliar contexts and open-ended investigations (MOE,2000.P5)” as listed in the syllabus.

This paper examines the pupil’s performance in doing non-routine problem sums. A study was carried out on two groups of 65 pupils selected from Primary Six cohort. It aimed to compare pupils under the M.H.P programme against those who did the sums through traditional approach where the focus on problem solving, range of heuristics and type of problems were somewhat limited. The researcher will discuss the results that were collated to find out if there was a significant difference in the performance between these two groups of pupils.

Introduction

“Mathematical problem solving” (MPS) is at the centre of the framework of the mathematics curriculum in Singapore (Ministry of Education, 2000). The Section C of PSLE paper consists of long open-ended questions which contribute to about 55% of the marks and the nature of these questions is usually problem-solving type. There are two types of mathematical problems, routine and non-routine. Routine problems can be easily solved by the 4 operations, which are addition, subtraction, multiplication and division. However, to solve challenging and non-routine problems, pupils require the four operations and special strategies known as problem solving heuristics.

The mathematics syllabuses, developed by Curriculum Planning and Developing Division (CPDD) have identified eleven heuristics that are applicable to mathematical problem solving at primary level.

1. Use of Diagram / Model
2. Act It Out
3. Before & After Concept
4. Make a Systemic List
5. Look for Pattern
6. Work Backwards
7. Guess & Check
8. Simplify the Problem
9. Make supposition
10. Restate the problem in another way
11. Solve part of the problem

Though problem-solving heuristics are listed in the syllabus, the use of these heuristics is not fully reflected in the textbooks (Fan & Zhu 2000) and according to Lee & Fan (2002), “it is by no means clear how heuristics should be incorporated into teaching and when.” (p.5) Moreover, not all the eleven heuristics that can be used to solve problems are explicitly taught by teachers.

Anecdotal evidence has suggested that the range of heuristics taught by the teachers was limited and the types of questions were confined to those found in the textbooks, mainly closed routine. The use of diagram/model heuristics is most widely taught in schools. If they face problems with the model approach, they are then equipped with a few common heuristics like Guess and Check, Listing and Working Backwards to help them tide over their difficulties.

This research was embarked to ascertain whether pupils whom had been under the M.H.P programme and explicitly trained in all the eleven problem solving heuristics will enhance their performance in the solving of non-routine problem sums.

Area of Focus

To investigate if pupils who had been under the M.H.P programme are more effective than those who did their sums through traditional approach in enhancing pupils’ performance in the solving of non-routine problem sums.

To test the null hypothesis:

\[ H_0: \text{There is no significant difference in the mean scores achieved in the non-routine problems test between the experimental and control groups} \]

Against

\[ H_1: \text{There is a significant difference in the mean scores achieved in the non-routine problems test between the experimental and control groups.} \]

This is a two-sided test.

Method

Sample

The subjects comprise of 65 pupils selected from Primary Six cohort to form the experimental group (G2). They were separated from their classes and were explicitly trained in problem solving heuristics by Mr. Sunny Tan.

The next group of 65 pupils was selected from the rest of the P6 cohort to make up the control group (G1). The pupils in the control group were retained intact in their classes. Both groups are homogeneous in their abilities and have about 50% males and 50% females. They also have a good mix of Malay, Chinese and Indian children.
Design
The Semester Assessment One 2006 scores in Mathematics were used as a pre-test score. This was compared against the performance in three post-test, 10-item problem sum test on solving non-routine problems and Semester Assessment Two 2006 scores.

In addition to this, a t-test was done to compare their scores in the SA1 to ascertain the equivalence or the homogeneous ability of the two groups. The basic design of the project was as follows:

Table 1: Equivalent groups pre-and-post-test design

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Action</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>O1</td>
<td>-</td>
<td>O4</td>
</tr>
<tr>
<td>G2</td>
<td>O1</td>
<td>✓</td>
<td>O4</td>
</tr>
</tbody>
</table>

Procedure
The SA1 2006 Mathematics scores were used as a pre-test score to determine pupils’ present standing in terms of solving non-routine problems. I had actually intended to only collate pupils’ scores in the non-routine problem sums items in this test but the answer scripts had already been returned to the pupils.

The post-test item was SA2 2006 Mathematics scores and three 10-item problem sum test on non-routine problems which was administered over three forty-five minutes sessions after the problem solving heuristics had been introduced to the experimental group in modules prior to the test over a ten-week period. The test was administered to both the control and experimental groups at the same time. There was no attempt to give additional help to these pupils during the administration of the tests.

Measure
In order to validate the test scores, the present test scores were correlated against the SA1 scores for both the control and experimental groups. The correlation score was 0.686 and 0.453 for the control group and experimental groups respectively. The scatter plot graph for both groups are as follows:

![Graph 1: Experimental Group Present Scores vs. SA1 Scores](image-url)
In order to ascertain the reliability of the present test scores, the odd-even correlation coefficient score and the Cronbach’s alpha coefficient were computed. They yielded quite high scores of 0.768 and 0.870 respectively.

Analysis
A paired t-test was done:

a) To ascertain the equivalence of the two groups

b) To compare the test scores obtained by the control and experimental groups in the present tests. The aim was to show that pupils under the M.H.P programme do enhance their performance in solving non-routine problems for the experimental group.

Results and Discussion
The output for comparing the control and experiment groups’ SA1 scores shows:

<table>
<thead>
<tr>
<th></th>
<th>Size</th>
<th>Mean</th>
<th>St. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>65</td>
<td>54.5</td>
<td>14.7</td>
</tr>
<tr>
<td>G2</td>
<td>65</td>
<td>65.7</td>
<td>18.1</td>
</tr>
</tbody>
</table>

- Difference = mu (G1) - mu (G2)
  Estimate for difference: -11.1538
- 95% CI for difference: (-16.5959, -2.9618)
- T-Test of difference = 0 (vs. not =): T-Value = -2.57, P-Value = 0.007
- Both use Pooled St. Dev = 15.9004

It is seen that the experimental group (G2) did slightly better in the SA1 test with a mean of 65.7 as compared to 54.5 in the pre-test (SA1). This was significant with a p-value of 0.007
The output for comparing the control and experiment groups’ performance in the post-test is as follows:

**Table 3: Two Sample t-test for G1 vs. G2 Post-test Scores**

<table>
<thead>
<tr>
<th>Size</th>
<th>Mean</th>
<th>St. Dev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>65</td>
<td>51.1</td>
<td>2.45</td>
</tr>
<tr>
<td>G2</td>
<td>65</td>
<td>89.0</td>
<td>3.24</td>
</tr>
</tbody>
</table>

- Difference = \( \mu (G1) - \mu (G2) \)
- Estimate for difference: -37.8844
- 95% CI for difference: (-5.18743, -2.38946)
- T-Test of difference = 0 (vs. not =): T-Value = -5.41, P-Value = 0.001, DF = 64
- Both use Pooled St Dev = 2.8236

It was clearly seen that the experimental group (G2) outperformed the control group significantly with a mean of 89.0 as compared to 51.1. The t-test yielded a p-value of 0.001

**Conclusion**

Although it was seen that the experimental group did better than the control group in the SA1, we should not deem that they already have a head start and would surely do better than the pupils in the control group in the post-test. The pupils have been ingrained in their methods discovered from their own problem solving experience accumulated for the last six years. Pupils in the experimental group would actually have to overcome their initial inhibitions of having to use Polya (1988)’s approach and heuristics to solve non-routine problems.

The findings show that most pupils under the M.H.P programme were able to select appropriate heuristics to solve the problem and present their thinking process in a concise and clear manner within the time allocated. Pupils’ self esteem are increased when they experience the satisfaction, pleasure, fun and thrill of discovery with heuristics problem solving.

We can conclude that pupils under the M.H.P programme and explicitly trained in problem solving heuristics would do better than those who are did their sums through the traditional approach in solving of non-routine problem sums.

**Some Limitation of the Research**

a) We could have compared the pupils’ performance in non-routine items in the SA1 against the present test scores.

b) The teaching of the heuristics approach seems to be teaching mere algorithm for some pupils.

c) Some concerns for the secondary school teachers will be: ‘How to translate pupils from arithmetic to algebra?’

d) To what extent will non-routine problems be relevant to their daily lives?
Suggested Further Research Projects

Action research on specialized training in problem-solving heuristics and its impact on pupils’ performance in the solving non-routine problems involving:

1. Whole Numbers & Decimals
2. Fractions
3. Geometry
4. Ratio
5. Percentage
6. Rate & Speed
7. Measuration

Acknowledgement

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References