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Variables Associated With Mathematics Achievement Of Primary Five Pupils In Singapore Schools

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Abstract

This study is concerned with an investigation into the correlation of a number of independent variables with the dependent variable of mathematics achievement of Primary Five pupils in Singapore schools. For the group of psychological factors (attitude towards mathematics, interest in mathematics, memory), two questionnaires and one digit-span test were used with 200 pupils. There were four paper-and-pencil tests developed for the other group of mathematical factors (logical thinking ability, language, mathematical concept, computational skills). Instruments were reliability tested and validated by the test-retest method, factor analysis method, KR20 and the Cronbach Alpha methods. Multiple correlational analysis was used to determine the results. Results showed mathematical concept with the highest correlation for all the three groups of high, medium and low achievers. The correlations were both positive and significant. Stepwise regressional analysis also indicated that the group of mathematical factors contributed a higher variance to mathematics achievement than the group of psychological factors.

Introduction

A five-year analysis of the Primary School Leaving Examination (PSLE) results (Ministry of Education, 1992), which is a national examination, reveals that students fared poorly in Mathematics when compared to the other examination subjects of English, Chinese, Malay, Tamil and Science. The percentage of passes in Mathematics is the lowest in relation to the percentage of passes in other subjects.

The 1988 to 1992 PSLE Mathematics results ranged from 77.5% to 78.3% of passes. This, compared to English which ranged from 90.6% to 94.3%, Science 89.5% to 93.5%, Chinese 98.5% to 98.7%, Malay 98.1% to 99.4% and Tamil 98.5% to 98.7%, is evidently much lower in terms of percentage of passes for the subject. This is a cause for concern not only to teachers teaching Mathematics but also to educationists.

Many researchers have studied the relationship between a number of variables and students' achievement. Hansen (1944) classified the variables into various groupings, such as arithmetic factors, mental factors and reading factors. Prowsri & Jearakul (1986) grouped them into home background factors, personal factors and intermediate factors. Fong & Chew (1988) grouped them as mathematical factors and reading and comprehension factors.

The present study examined seven independent variables as predictors for students' mathematical achievement. They are classified under two categorical factors, i.e. the psychological and the mathematical factors. Three independent variables of the psychological factors understudied are memory, interest and attitude towards mathematics. The other five mathematical factors are mathematical language, mathematical concept, logical thinking ability and computational skills. The main aim of the study is to determine the factors contributable to pupils' success in mathematics achievement at the Primary Level.

Review of Literature

This section reviews previous studies on different aspects of the psychological and mathematical factors. The psychological factors considered are attitude towards mathematics, interest in mathematics and memory. The mathematical factors considered are logical thinking ability, computational skills, mathematical language, mathematical concept and mathematical achievement.

Psychological Factors

(i) Attitude towards Mathematics

Aiken (1985) maintains that attitude indicates a person's negative or positive response to certain objects, situations, institutions, concepts or other persons. However, Warren & Jahoda (1973) regard attitude as psychological or mental characteristics.

Positive relationships are found between attitude and mathematics achievement by Bassham, Murphy & Murphy, 1964; Capps & Cox, 1969; Duckworth & Entwistle, 1974; and Prowsri & Jearakul, 1986. However there are research studies which had findings

contradicting the above studies (Neale, 1969; Postlethwaite in Callahan & Glennon, 1975).

(ii) Interest in Mathematics

Aiken (1985) distinguishes interest from attitude. Interest in mathematics refers to the willingness of students to spend time on the subject, which may take the form of reading more about it or participating in mathematical activities. Attitude on the other hand, refers to an expressed liking or dislike of the subject.

The area of research to correlate mathematics achievement and pupils' interest in mathematics is few. Sjoberg (1984) developed a model which explains the relationship between achievement and the interest variable. Research by Prowsri & Jearakul (1986) found that interest in mathematics contributed only 4.2% variance to the prediction of mathematics achievement.

(iii) Memory

Memory involves the retention and retrieval of materials and activities. It is also believed that memory is associated with intelligence. The more intelligent subjects are able to remember more and with greater speed than less intelligent subjects (Howe, 1983; Eysenck, 1977).

Few studies have included memory as one of the variables to be investigated in relation to achievement. Hansen's (1944) study found a high correlation between the dependent variables of delayed memory span, immediate memory span, memory and the criterion variable of achievement in problem solving ($p<0.01$). Another study by Hope & Owens (1987) found that in a mathematical setting, children's poor performance in computing with fractions is associated with their inability to recall basic number facts.

Mathematical Factors

(iv) Logical Thinking Ability

Inhelder and Piaget (1958) describe logical thinking as a combination of various operations: combinatorial, proportional,

coordination of two systems and the relativity of motion or acceleration, notion of probability and correlation.

A reliable test for logical thinking was developed by Tobin and Capie (1984) based on Lawson's identification of five reasoning modes; identifying and controlling variables, combinatorial reasoning, probabilistic reasoning, correlational reasoning and proportional reasoning. It was found that these modes were reliable in discriminating students with good logical thinking ability from those with poor logical thinking ability.

Positive correlation between logical thinking ability and students' achievement was found in numerous studies (Suppes & Binford, 1965; Tobin & Capie, 1984; Prowsri & Jearakul, 1986).

(v) Computational Skills

Hamrick and Mckillip (1978) emphasise that computational skills are important because they help children to understand mathematical concepts better. They also help pupils to recognise generalisations.

Numerous studies have reported positive significance of computational skills with mathematics achievement (Chase, 1960; Caldwell & Goldin, 1979; Ballew & Cunningham, 1982; Muth, 1984; Fong & Chew, 1988).

(vi) Mathematical Language

Shuard and Rothery (1984) explain that there are mainly three categories of mathematical text. The first contains words which have the same meaning in both mathematical English and ordinary English. The second has words which have a meaning only in mathematical English, for example, 'hypotenuse' and 'parallelogram'. The last involves words which occur in both ordinary English and mathematical English but possess a different meaning in mathematical English from their meaning in ordinary English, for example words such as 'means' and 'significant'.

There were research studies which found a weak correlation between reading ability and mathematics achievement (Hansen, 1944; Chase, 1960; Balow, 1964; Exezidis, 1983).

However, there were also findings which found positive relationships between reading ability and mathematics achievement (Cuevas, 1984; Muth, 1984; Fong & Chew, 1988).

(vii) Mathematical Concept

'Concept' is a "guiding force" and a dynamic process for scanning perceptual data in the light of past experience. (Wallace, 1965).

There were studies which reported positive correlations between concept and mathematics achievement (Chase, 1960; Guay & McDaniel, 1977; Caldwell & Goldin, 1979; Exezidis, 1983; Liu, 1983).

Research studies have found that mathematical concepts are major contributors to successful problem solving (Bourke, 1985; Muth, 1984; Babbitt, 1986).

(viii) Mathematics Achievement

Aiken (1985) defined an achievement test as one which assesses the knowledge of some school subjects. What a person has attained in the past is usually quite a good indicator of his future ability. Cronbach (1984), on the other hand, described it as one which can establish whether a student has a command of the material which teachers have taught.

Conceptual Model for Research

From the literature reviewed, a research model was conceptualised which related the independent variables to be investigated with the dependent variable of mathematics achievement. The relationship between two groups of independent variables (mathematical factors and psychological factors) and a dependent variable of mathematics achievement was also examined (Figure. 1).

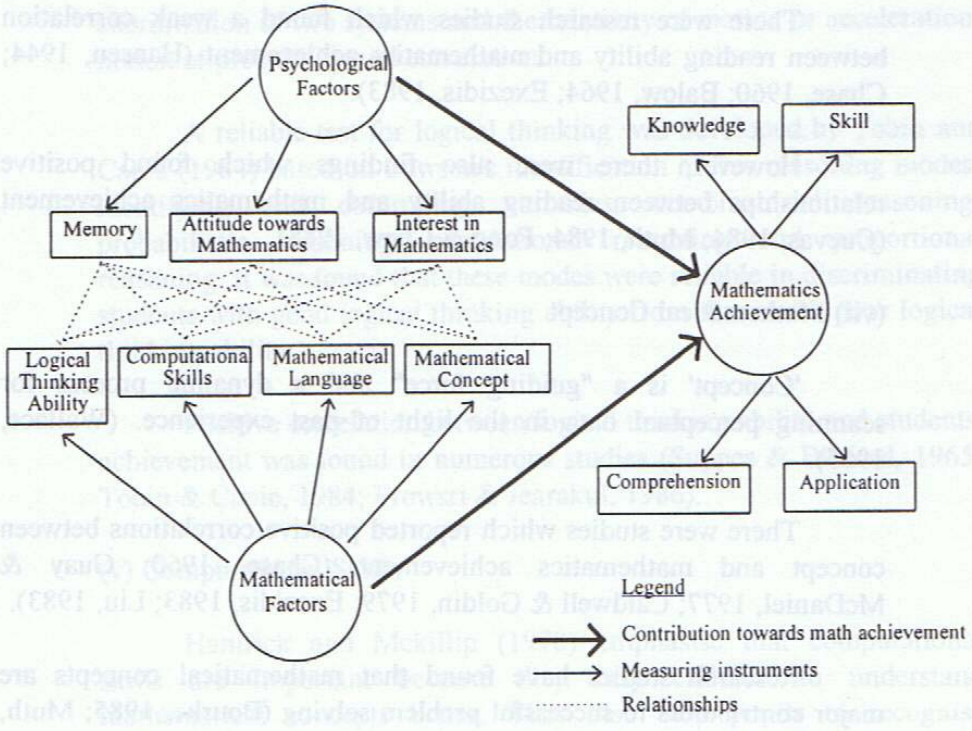


Figure 1. Conceptual Model for Research

Instrumentation

Instruments for interest in mathematics and attitude towards mathematics were in the form of questionnaires. The questionnaire for attitude towards mathematics consisted of 12 items whilst the questionnaire for interest in mathematics consisted of 7 items. The other variables were investigated through paper-and-pencil tests. Memory was tested through the use of the digit-span test, which consisted of four trials by the students. The digits for each trial ranged from three to nine.

Mathematical language was investigated through a paper-and-pencil test of 9 items. The test for mathematical concept consisted of 11 items, the test of logical thinking ability consisted of 9 items and the test for computational skills consisted of 9 items.

The dependent variable of mathematics achievement was also investigated through a paper-and-pencil test. This test consisted of 37 items.

Seventeen were multiple-choice items whilst 20 were open-ended problem-solving questions. Through this test, pupils were grouped into high, medium and low achievers. Their results were confirmed by comparing their performance with their school test results in mathematics.

Population and Sample

The sample consisted of 200 Primary Five pupils randomly selected from four primary schools in Singapore. The four primary schools were chosen as they were all neighbourhood schools. The selected schools received children from the neighbourhood where the schools were situated. The sampling approach attempts to tap children of varied academic abilities from these schools.

From the four schools, using a mathematics achievement test and the schools' assessment as criterion, a total of 120 high achievers, 285 medium and 177 low achievers were identified. The final sample consisted of 50 low achievers, 100 medium achievers and 50 high achievers. They were randomly selected using the random numbers table.

Collection of Data

The questionnaires which were designed for inquiring interest in mathematics and attitude towards mathematics were reliability validated using the Cronbach Alpha programme after factor analysis of all the items. For the digit-span test, correlational analysis was used on the two tests, digit-forward and digit-backward span tests, conducted on the same group of pupils. The items for the other paper-and-pencil (e.g. computational and concept) tests were factor analysed. Then the items were tested for their reliability using the KR20.

Analysis of Result

The relationships between the independent variables and the dependent variable were analysed by means of multiple correlations (see Table 1 on page 9). Multiple regression techniques were also employed to ascertain the contribution of the independent variables as predictors of mathematics achievement. The final method of analysing the data of the study was by

stepwise regression. This procedure was used to determine the most consistent and powerful psychological and mathematical predictors of mathematics achievement (see Tables 2, 3 and 4 on page 9 and page 10).

In Table 1 on page 9, it can be deduced that mathematical concept (0.75) and mathematical language (0.71) yielded the highest correlation among the seven independent variables. It is noticed that all the mathematical variables rank higher in correlation with mathematics achievement than the psychological variables.

Of the psychological variables, attitude towards mathematics contributed the highest variance (13.79%) as compared to memory (0.53%) and interest in mathematics (0.49%) (see Table 2 on page 9). The findings confirm that there is an obvious relationship between pupils' achievement and attitude.

When the psychological variables were compared to the mathematical variables, the mathematical variables contributed a higher variance. As shown in Table 3 on page 10, mathematical concept contributed a variance of 56% out of a total of 67%, mathematical language 9.6%, computational skills 0.93% and logical thinking ability 0.74%. Memory was generally found to be statistically non-significant with mathematics achievement (see Table 4 on page 10). In this study, computational skills and mathematical language contributed 10.5% of the variance in the prediction of mathematics achievement.

Only contribution of variance by one mathematical factor, that of mathematical concept to mathematics achievement may be said to be stable. This is evidenced by its contribution of variance for all the three groups of high (22.58%), medium (33.02%) and low (39.13%) achievers. The strength and direction of the relationships of the other variables varied in consistency amongst the three groups. It can therefore, be said that the direction of relationship amongst the other independent variables were inconsistent. This seemed to confirm researchers' findings that there are high correlations and variances between mathematical concept and mathematics achievement (Chase, 1960; Liu, 1983). Based on the findings, the final model of relationships among the variables is shown in Figure 2 on page 11.

Table 1: Correlation Coefficients of the Seven Independent Variables with the Dependent Variable of Mathematics Achievement

Independent Variables	Mathematics Achievement (Dependent Variable)
Mathematical Concept	0.75 (p<0.0001)
Mathematical Language	0.71 (p<0.0001)
Logical-Thinking Ability	0.53 (p<0.0001)
Computational Skills	0.56 (p<0.0001)
Attitude Towards Maths.	0.37 (p<0.0001)
Memory	0.11 (p<0.1069)
Interest in Mathematics	0.10 (p<0.1412)

Table 2: Summary of Stepwise Multiple Regression Analysis Showing the Contribution of the Psychological Variables to Mathematics Achievement

Independent Variables (in the order entered into regression)	B Values					Percentage of Explained Variances Added
	Step 1	Step 2	Step 3	R^2	R^2 Added	
Attitude	0.62	0.60	0.66	0.138	–	13.79
Memory	–	0.25	0.25	0.143	0.005	0.53
Interest	–	–	0.16	0.148	0.049	0.49

Legend: *Memory* *Memory*
Attitude *Attitude Towards Mathematics*
Interest *Interest in Mathematics*

Table 3: Summary of Stepwise Multiple Regression Analysis Showing the Contribution of the Mathematical Variables to Mathematical Achievement

Independent Variables (in the order entered into regression)	B Values				R^2	R^2 Added	Percentage of Explained Variances Added
	Step 1	Step 2	Step 3	Step 4			
Con	3.08	2.03	1.83	1.66	0.56	–	56.00
Lang	–	2.04	1.89	1.75	0.65	0.096	9.57
Compute	–	–	0.89	0.82	0.66	0.009	0.93
Lt	–	–	–	0.62	0.67	0.007	0.74

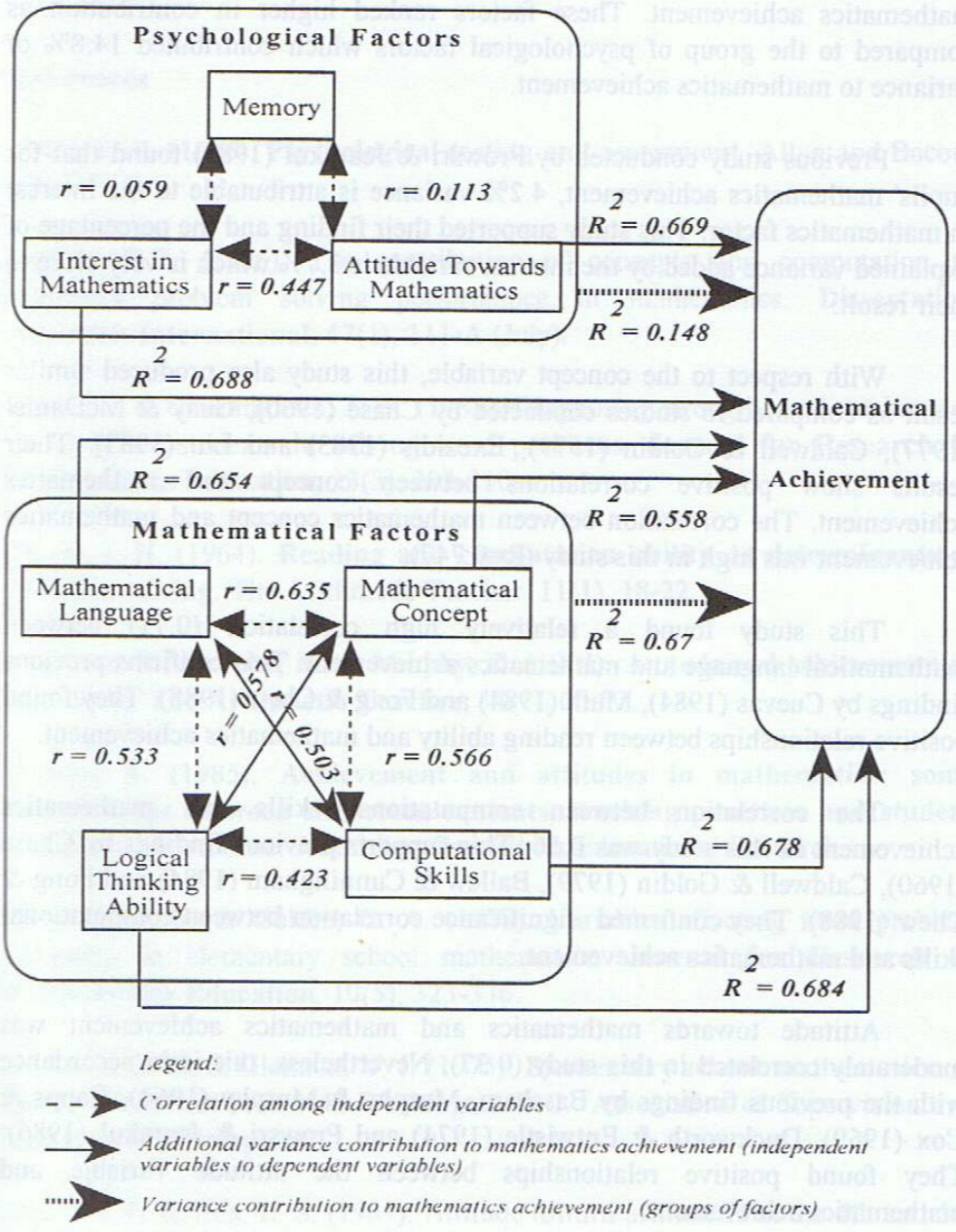
Legend: *Con Mathematical Concept* *Compute Computational Skills*
Lang Mathematical Language *Lt Logical Thinking Ability*

Table 4: Summary of Stepwise Multiple Regression Analysis Showing the Contribution of the Six Independent Variables to Mathematics Achievement

Independent Variables (in the order entered into regression)	B Values						R^2	R^2 Added	Percentage of Explained Variances Added
	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6			
Con	3.08	2.03	1.96	1.76	1.62	1.62	0.558	–	55.81
Lang	–	2.04	1.90	1.76	1.64	1.60	0.654	0.096	9.57
Att	–	–	0.22	0.21	0.20	0.25	0.669	0.015	1.54
Compute	–	–	–	0.86	0.80	0.83	0.678	0.008	0.87
Lt	–	–	–	–	0.56	0.59	0.684	0.006	0.58
Int	–	–	–	–	–	-0.14	0.688	0.004	0.37

Legend: *Con Mathematical Concept* *Compute Computational Skills*
Lang Mathematical Language *Lt Logical Thinking Ability*
Att Attitude Towards Mathematics *Int Interest in Mathematics*

Figure 2: The Final Model of Relationships Among the Variables



Conclusion

The group of mathematical factors could be a source of possible explanation for the variations in mathematics achievement of Primary Five pupils. Mathematical factors contributed 67% of variance to predict mathematics achievement. These factors ranked higher in contribution as compared to the group of psychological factors which contributed 14.8% of variance to mathematics achievement.

Previous study conducted by Prowsri & Jearakul (1983) found that for pupils' mathematics achievement, 4.2% variance is attributable to the interest in mathematics factor. This study supported their finding and the percentage of explained variance added by the interest variable is 3.7% which is very close to their result.

With respect to the concept variable, this study also produced similar result as compared to studies conducted by Chase (1960), Guay & McDaniel (1977), Caldwell & Goldin (1979), Exezidis (1983) and Liu (1983). Their results show positive correlations between concept and mathematics achievement. The correlation between mathematics concept and mathematics achievement was high in this study (R=0.747).

This study found a relatively high correlation (0.71) between mathematical language and mathematics achievement. This confirms previous findings by Cuevas (1984), Muth (1984) and Fong & Chew (1988). They found positive relationships between reading ability and mathematics achievement.

The correlation between computational skills and mathematics achievement in this study was 0.56. This supports previous findings by Chase (1960), Caldwell & Goldin (1979), Ballew & Cunningham (1984) and Fong & Chew (1988). They confirmed significance correlation between computational skills and mathematics achievement.

Attitude towards mathematics and mathematics achievement was moderately correlated in this study (0.37). Nevertheless, this is in accordance with the previous findings by Bassham, Murphy & Murphy (1964), Capps & Cox (1969), Duckworth & Entwistle (1974) and Prowsri & Jearakul (1986). They found positive relationships between the attitude variable and mathematics achievement.

One may conclude from this study that future research could include the experimentation with various strategies in the teaching of mathematical concepts. Control and experimental groups may be established to verify the treatment of mathematical concepts and assess each group's difference in mathematics achievement.

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