STUDENT LEVEL FACTORS THAT INFLUENCE THE MATHEMATICS ACHIEVEMENT OF AUSTRALIAN STUDENTS: A PATH ANALYSIS WITH COMPARISONS OVER TIME ®

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Abstract

Over the past 30 years IEA has conducted three international studies of mathematics at the 13-year-old level. In the three studies, in addition to mathematics achievement tests, students were required to respond to an attitude questionnaire concerning their attitudes towards mathematics, the learning of mathematics and school learning and a general information questionnaire about themselves and their mathematics schoolwork. Australia is one of the countries which participated in all the three IEA studies. In this paper path analysis techniques are employed to examine student level factors that influence mathematics achievement of the 1994 Year 8 Australian students (Third IEA Mathematics Study) by using the PLSPATH 3.01 computer program. Conclusions are drawn about the student level factors that influence the mathematics achievement of the 1994 Year 8 Australian students and comparisons are made with the student level factors influencing mathematics achievement at the 13-year-old level in 1964 and 1978.

Factors influencing Mathematics Achievement

Previous research studies in Australia have indicated that there are substantial differences between students in their achievement levels in school mathematics, and have identified some of the student level factors that influence mathematics achievement. Keeves (1972), Dungan and Thurlow (1989) and Milne (1992) have argued that students' attitudes towards mathematics were among the student level factors influencing mathematics achievement in Australian schools. Furthermore, these researchers contend that students who express more positive attitudes towards mathematics are likely to achieve at a higher level in mathematics than those students who express less positive attitudes towards mathematics.

Another student level factor that was found to influence the mathematics achievement of Australian students was home background. Keeves (1968, 1972), Rosier (1980) and Ainley et al. (1990) have reported that socioeconomic status of the family influenced the student's school performance. That is, students from higher socioeconomic status homes were likely to perform at a higher level than students from lower socioeconomic status homes.

Keeves (1968, 1972, 1976), Rosier (1980), Bourke (1984, 1986) and Leach and Tunnecliffe (1984) reported that the time allowed and the opportunity given to students to learn mathematics were both factors that influenced the achievement of Australian students in school mathematics.

Research findings (Newman, 1976, 1979, 1983; Morris, 1978; Turner, 1980; Dawe, 1983; Ellerton and Clements, 1990) have found that language is one of the factors that influences achievement in school mathematics.

However, it has been argued by Ellerton and Clements (1989, 1991) that among all school subjects, the least affected subject by linguistic and cultural considerations is mathematics. It can be considered to be a culture-free subject (Ellerton and Clements, 1989, 1991).

The findings of research in Australia have suggested that all students whose first language was not the medium of instruction were educationally disadvantaged. Nevertheless, students who were competent both in their first language and in English which was the medium of instruction had some advantage in learning mathematics over those students who were competent in only one of these languages. Both groups had a clear advantage over students who had lower levels of competence in both languages (Dawe, 1983; Clarkson, 1991, 1992, 1993). Therefore, the level of competence which students had in each language was a vital factor which needed to be considered (Clarkson, 1992).

Causal models of student level factors influencing mathematics achievement of students at the lower secondary school level are required to examine the network of hypothesised interrelationships between variables that are considered important as a result of a theoretical framework and previous research findings. The present study investigates the type and size of interrelationships between specific latent variables and their effects on mathematics achievement and whether these relationships are consistent over time. If the same variables indicated relatively stable effects over time in Australia, they could be taken as evidence for the generality of the model and the coherence of the theoretical framework under investigation. Thus the purpose of this study is to develop a theoretical model of student level factors influencing the mathematics achievements of lower secondary school students in Australia and to examine these hypothesised interrelationships between variables.

Strategy of Analysis

From the findings of previous research a model of student level factors influencing mathematics achievement at the the Year 8 level was developed and PLSPATH (Sellin, 1990) was chosen as an appropriate multivariate technique to examine the hypothesised model. The first part of this paper discusses the results obtained when the hypothesised model was tested by employing PLSPATH in the analysis of data from the Third IEA Mathematics Study. The second part of the paper compares the student level factors that influence the mathematics achievement of students on different occasions.

Data collection

Table 1 shows the Target Populations of the three international studies conducted in Australia under the auspices of the International Association for the Evaluation of Educational Achievement (IEA). In the First IEA Mathematics Study (FIMS), conducted in 1964, two groups of students participated, 13-year-old students in Years 7, 8 and 9 and students in Year 8 of schooling. The total number of students taking part was 4320 (see Table 1).

In the first study only government schools in New South Wales (NSW), Victoria (VIC), Queensland (QLD), Western Australia (WA) and Tasmania (TAS) participated. In the Second IEA Mathematics Study (SIMS), which was administered in 1978, nongovernment schools and the Australian Capital Territory (ACT) and South Australia (SA) were also involved as well as those states that participated in FIMS. Thus in SIMS government and nongovernment school students in six states and one territory were involved. The total number of participants was 5120 students (see Table 1).

Table 1:- Target populations in FIMS, SIMS and TIMS

Target Population	Label	Size	Sampling Procedure	Primary Unit	Secondary Unit	Design Effect	Effective Sample Size
13-year-old_R	FIMSA	2917	SRS	School	Student	7.66	379.9
Grade 8_R	FIMSB	3081	SRS	School	Student	11.82	260.6
Total-G_R	FIMS	4320	SRS	School	Student	11.11	389.0
13-year-old, G&NG	SIMS	5120	PPS	School	Student	7.00	731.2
Grade 8, G&NG	TIMS	7392	PPS	School	Class	16.52	229.2

SRS = Simple-Random-Sample
PPS = Probability-proportional -to-size
R = Restricted to government schools in five states
G = The participant schools were only government schools

In the Third IEA Mathematics Study (TIMS), which was conducted in 1994, government and nongovernment school students in all states and territories including Northern Territory were involved. The total number of students tested in Australia was 7,392 (see Table 1).

In 1964 and 1978 the samples were age samples and included students from Years 7, 8 and 9 in all participating states and territory, while in TIMS the samples were grade samples drawn from Years 7 and 8 or Years 8 and 9. In ACT, NSW, VIC and TAS, Years 7 and 8 students were selected while in QLD, SA, WA and NT samples were drawn from Years 8 and 9.

Therefore, to make the most meaningful possible comparison of mathematics achievement over time by using the 1964, 1978 and 1994 data sets, the following steps were taken. The 1964 students were divided into two groups, 13-year-old students in one group and all Year 8 students including 13-year-old students at that year level as the second group, since in addition to an age sample a grade sample had also been drawn. It is important to observe that 13-year-old students in Year 8 were considered as members of both groups. In the first group, students were chosen for their age and in the second group for their year level. The 1978 students were chosen as an age sample and included students from both government or nongovernment schools.

Meanwhile, in TIMS the only common sample for all states and territories was Year 8 students. Thus only Year 8 students in all states and territories are considered as the TIMS data set in this study.

After excluding schools and the states and territories that did not participate in the 1964 study, two sub-populations of students were identified for comparison between occasions. The two groups were 13-year-old students in FIMSA and SIMS: all were 13-year-old students and were distributed across Years 7, 8 and 9 on both occasions. Hence, these two groups of 13-year-old students were considered to be comparable for the examination of changes in factors influencing achievement over time, between 1964 and 1978. Whereas for the comparison between FIMS and TIMS the other sub-populations consisted of 1964 and 1994 Year 8 students. Students in both groups were at the same year level, although there were differences in the ages between these groups which were tested on the two occasions. Hence, the comparisons in this study are between 13-year-old students in FIMSA and SIMS on the one hand, and FIMSB and TIMS Year 8 students on the other.

In all the three IEA Mathematics Studies students were requested to respond to the mathematics tests and questionnaires. Furthermore, general information about the students' background was collected from those students who participated in the studies using a Student Questionnaire. Three types of information were collected from the students. The first type of information was about themselves, such as their sex, race, age, whether they were born in Australia, how often they spoke English at home and the language their parents mostly spoke at home. The second type of information was about their schools and the learning of mathematics. This information included number of hours spent on different activities in a week, number of hours they gave to mathematics homework, number of hours they devoted to all homework, and about their liking of mathematics as well as their mathematics test results. The third type of information collected from the students was about their home background, such as their father's occupation and education, mother's occupation and education, number of brothers and sisters, number of books at home, father's and mother's country of birth, and languages most often used in their homes.

The purpose of the questionnaires was to obtain background information about each student in order to develop variables that would help to explain differences between students in their achievement in mathematics. Therefore, the three types of information which were collected from the students are considered in the following sections in order to examine which variables might explain differences between students in their mathematics achievement at the 13-year-old and Year 8 levels in Australian lower secondary schools.

Method

In this study the partial least squares path analysis procedure was employed to identify the student level factors that influenced mathematics achievement. Partial least square path (PLSPATH) analysis "is a general technique for estimating path models involving latent constructs indirectly observed by multiple indicators" (Sellin, 1992, p. 398). This procedure is useful in modelling educational and social systems. Thus PLSPATH analysis can be employed as a method of analysing path models which involve latent (indirectly observed) and manifest (directly observed) variables. The PLSPATH model includes an inner model which specifies the hypothesised relationships among the latent variables (LVs) and an outer model that specifies the relationships between the LVs and the manifest variables (MVs) which are their indicators (Sellin, 1992).

PLSPATH identifies the optimal linear relationships between variables and provides estimates of the parameters of the model. Jacobs (1991), Bukowski, Hoza and Boivin, (1993) have argued that PLSPATH is an ideal procedure, because it provides an index of the adequacy of the model, shows the strength of each individual path in the model, and examines the direct and indirect relationships among variables. Kotte (1992) also argued that PLSPATH can be employed efficiently to identify strong and weak relationships between latent and manifest variables. Furthermore, the indices of overall adequacy show whether or not the model produces an accurate representation of relationships among variables in the model. In a causal model certain variables are singled out as causes and others as effects. Consequently, the strengths of the particular paths in the model show how strongly the linked variables are causally related to each other. PLSPATH provides a number of advantages which are most appropriate for this study. It is useful for displaying graphically the pattern of causal relationships among sets of observed and unobserved variables that influence the mathematics achievement level of students. PLSPATH is technically simple, quick and does not require strict distributional assumptions. For these and other reasons PLSPATH is referred to as a soft approach to modelling (Falk, 1987; Sellin, 1989, 1990).

It is beyond the scope of this study to detail the mathematical and technical aspects of PLSPATH. However, references such as Noonan and Wold (1988), Sellin (1989), Cheung and Keeves, (1990), Falk and Miller (1992) and Sellin and Keeves (1997) are suggested for further reading. Because PLSPATH employs a least square regression procedure in analysis it does not require that variables are normally distributed for the analysis. However, this computer program retreats from significance testing because in so many data sets the assumptions of normality are violated, or the degree of departure from normality can not be determined and because the samples employed can not be considered to be simple random samples.

Construction of PLSPATH model

The starting point in employing PLSPATH is to draw a diagram of the model to be analysed (Falk, 1987). The diagram should include both the outer and the inner models and the hypothesised links between them. In this study theoretical models of student factors that influenced mathematics achievement of Australian students on different occasions were developed prior to analysis. The models specified the variables included in the analyses and their interrelationships were hypothesised. In the path diagram, the MVs or observed variables formed the outer model, while the LVs formed the inner model. The number of MVs and LVs generated by this study for TIMS data set are shown in Figure 1. In total, 25 MVs and 10 LVs were employed in the outer and inner models respectively. The acronyms chosen for the MVs and LVs were intended to reflect their item content (see Table 2). The reader must keep in mind that these acronyms are employed throughout this paper. A list of the MVs employed in this study together with answer categories and coding are given in Appendix 1.

Outer model

Figure 1 shows the outer model relationships of the hypothesised student level factors thought to influence the achievement in mathematics of students in Australia. There were 25 hypothesised MVs . In developing the outer path model the investigator has the choice between two modes of weight estimation, called outward mode and inward mode (Sellin, 1992). Sellin states that the outward mode indicators assume that the MVs reflect the corresponding latent construct. An example of outward mode is the set of motivation and attitude towards mathematics scales which are assumed to reflect the underlying motivation and attitude of each student. Inward indicators, assume that MVs form or produce a latent construct as presented in Figure 1.

Table 2: Latent and manifest variables employed in the path models for FIMS, SIMS and TIMS data sets

Latent Variables	• **Manifest Variables**
Homeback[i]	
(Home background of student)	*Measues the socioeconomic status of student's parents* • Focc (Father's occupation) • Mocc (Mother's occupation) • Fed (Father's level of education) • Med (Mother's level of education)

	• Homebook (Number of books in home) • Siblings (Number of siblings)
Gender[o]	
(Sex of student)	*Identifies whether the student is female or male* • Sex (Sex of student)
Studage[o]	
(Age of student)	*Identifies student's age)* • Age (Age of student
Yearlevel[i]	
(Year level of students)	*identifies the level of students in school* • Year 7 • Year 8 • Year 9
Ethnicity[ai]	
(Ethnic background of the student and his/her parents)	*Identifies the country of origin of the student and his/her parents* • Fcntry (Father's country of birth) • Mcntry (Mother's country of birth) • Cntry (Student's country of birth) • Yrscntry (Number of years the student lived in Australia) • English at home (English spoken at home)
Classize[o]	
(Number of students in the class)	*Identifies the number of students in Mathematics class* • Clssize (Number of students in the class)
Views[o]	
(Student's views about mathematics teaching and school and school learning)	*Measures student's views about mathematics teaching and school and* *school learning using* • Viewmath (Views about mathematics teaching scale) • Viewsch (Views about school and school learning scale)

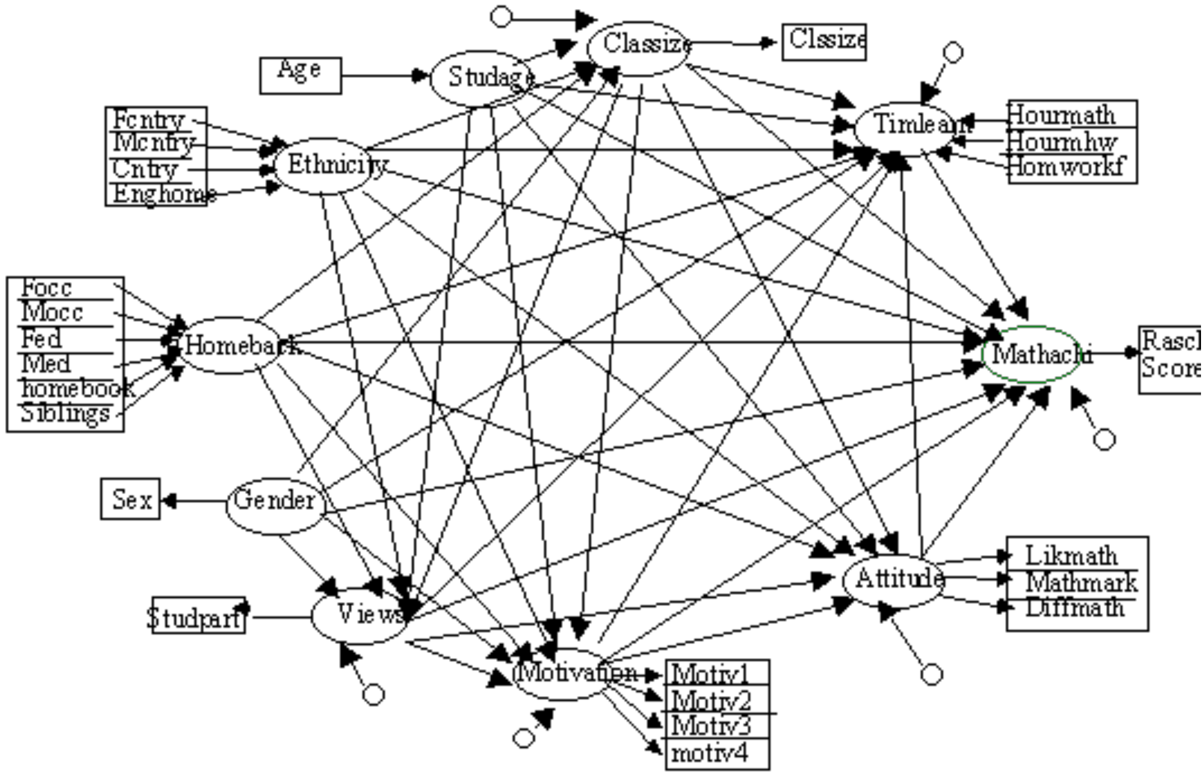
	• Studpart (Views about students' participation in mathematics teaching scale)d
Values[o]	
(The values of student towards mathematics)	*Measures student's values about mathematics employing* • Mathinso (Student's attitude towards the place of mathematics in society scale) • Contrenv (Student's attitude towards control of the environment scale)
Motivation[o]	
(Motivation of student)	*Measures the student's level of motivation using* • Hmwall (Number of hours in a week used by student to do all homework) • Attitsch (Student's attitude towards school and school learning scale) • Motiv1 to Motiv4 (Students need to do well in mathematics)[d]
Timlearn[i]	
(Time in learning)	*Assesses the amount of time used by the student to learn mathematics and to do mathematics home work and the frequency of homework given to students by their teachers* • Hourmath (Number of hours in a week used by student in learning mathematics) • Hourmhmw (Number of hours in a week used by student to do mathematics homework) • Homworkf (Frequency of mathematics homework given for students in a week)[d]
Aspirat[co]	
(Aspiration of the student)	*Measures the student's level of aspiration* • Expted (Student's expected education level) • Desired (Student's desired education level)

	• Exptocc (Student's expected occupation) • Desirocc (Student's desired occupation)
Futmath[co]	
(Future mathematics)	*Measures the student's level of expectations and wishes to take more* *mathematics courses* • Expmorma (Student's expectations to take more mathematics courses) • Wishmorma (Student's wishes to take more mathematics courses)
Attitude[o]	
(Student's attitude towards mathematics)	*Examines the attitudes of a student towards mathematics* • Belima (Mathematics is student's best liked subject)[f] • Besubma (Mathematics is student's best subject)[f] • Likemath (Mathematics is student's best liked subject) • Likmath (Students' liking of mathematics scale)[d] • Mathmark (Best mark of the students is mathematics) • Diffmath (Student's attitude towards facility of mathematics)[e]
Mathachi[o]	
(Mathematics achievement of student)	*Measures the mathematics achievement level of student by employing* • Rasch Score (Rasch estimated scores of the mathematics test)

[a] = variable considered only in SIMS and TIMS,
[c] = variable considered only in FIMS,
[d] = MVs variables considered only in TIMS,
[e] = MVs only one item was considered in TIMS,
[f] = MVs variables considered only in FIMS
[o] = Outward mode
[i] = Inward mode constructs

PLSPATH employs a factor analytic procedure for estimating the outward latent constructs. The criterion for the minimum level of a factor loading for the inclusion of a MV in this study was chosen to be 0.30 (Campbell, 1996). However, other researchers have proposed other criteria such as 0.55 (Falk and Miller, 1992), or 0.40 (Harman, 1976; Pedhazur, 1982; Keeves, 1991). MVs with loadings below the predetermined cutting point were dropped from further analysis. PLSPATH uses a regression procedure to calculate the weights of the MVs which form a LV in the inward mode, and weights below 0.07 were removed from further analysis as they indicated that the observed variable did not contribute greatly to the related

LVs (Sellin and Keeves, 1997; Sobolewski and Doran, 1996). In order to obtain a robust model, the original model was successively refined to include only significant paths.



In Figure 1 the outward mode is depicted by the arrows pointing from the LVs to their respective MVs, whereas the inward mode is shown by the arrows pointing from the MVs to the corresponding LVs. The figure shows the MVs and the corresponding LVs and the modes specified to estimate the constructs. In order to increase the predictive power of the path model, Sellin (1992) has suggested that researchers should employ the inward mode for exogenous variables and the outward mode for endogenous variables. However, there are situations where this rule would not apply. In accordance with Sellin's (1992) suggestion, the exogenous variables in this study were defined with inward estimation, while the endogenous variables except *Time in Learning*, which employed the inward mode, all were defined with outward estimation including those constructs that consisted of only one MV. In this latter case the loadings became unity (1.0) (see Figure 1).

Inner model

The inner model presented in Figure 1 shows the causal links between the LVs. The positions of the LVs in the inner model are based on theoretical considerations. Therefore, in this study of student level factors influencing student achievement in mathematics in Australia, the findings of previous studies were employed as a starting point to hypothesise the causal links between constructs in the inner model (see Figure 1). In determining the final structure of the inner model, it was recommended that direct paths with ß<0.07 should be removed, because such values show an insignificant effect in the estimation of a relationship between two LVs. Hence, the larger the ß value the larger the effect in the path model. This estimation process was repeated successively until all nonsignificant paths had been removed.

The other criterion used to assess the strength of the final path model was the maximum variance explained (R2) of the outcome variable*, Mathematics Achievement (Mathachi).* The value of R2 gives the maximum variance explained of a construct when the preceding predictor variables are included in the analysis. Thus, the larger R2, the more of the variance is explained.

The modification, trimming or deletion of variables and paths in the path model involves the removing of all paths not contributing to the LVs. The deletion or the removal of paths includes both the outer and inner model. As a result of the trimming procedure some manifest and latent variables were also removed from further analysis.

Result of the PLSPATH analysis

Tables 2 and 3 show the outer model and the inner model results for the PLSPATH analysis for the TIMS Year 8 students data set. Ten LVs and 25 MVs were included in the model. The results of the PLSPATH analyses are discussed in the following two parts. The first part addresses the results of the outer model and the second part considers the inner model.

Outer Model Results

In the following discussion the weights and the factor loadings, and the communality, redundancies and the tolerances values of each MV within a construct are discussed with respect to the LV to which that MV contributes. The weights (ßs) are initially considered significant if their values are ß > 0.07, while the factor loadings (*l*s) are initially significant if *l* > 0.30. The index employed for measuring the strength of the outer model is the average of the communalities of the MVs (Falk, 1987). Furthermore Falk has argued that the higher the average of the communalities the better the outer model, and an average value of the communalities of 0.30 would generally be considered too low.

Home Background *(Homeback)*

Table 2 shows that *Homeback* is reflected by six MVs, namely *Focc, Mocc, Fed, Med, Homebook* and *Siblings.* In the hypothetical model presented in Figure 1, it was assumed to be in an inward mode. However, in the analyses, it was changed to an outward mode. Since this LV had as many as six observed or MVs the outward mode was chosen to avoid problems of multicollinearity. The loadings for five of the six MVs reflecting this antecedent construct, were 0.69, 0.59, 0.77, 0.74 and 0.58 respectively. Siblings was deleted from the model, because the factor loading was -0.06 and this value was below the critical value of 0.30. The important point here is that, in SIMS data sets the MV *Siblings* contributed to reflect *Homeback*. However, it did not reflect the same LV in TIMS. This suggested that the drop in the number of children per family and the greater uniformity in family size in 1994, when compared with 1978 in Australia has led to a decline in the importance of this factor. It is of interest to observe that both *Fed* and *Med* contribute more to the formation of the LV*Homeback* than do the other three variables. However, all were highly significant for the development of this construct. The communalities recorded in Table 3 show that the five MVs contributed to this construct.

Table 3: TIMS-Year 8 students-Outer Model Results

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Variable	Weight/Loading	Communality	Redundancy	Tolerance
Homeback[o]				
Focc	.69	.48	.00	.25
Mocc	.59	.35	.00	.21
Fed	.77	.59	.00	.48
Med	.74	.54	.00	.47
Homebook	.58	.33	.00	.09
Siblings	Deleted			
Gender[μ]				
Sex	Deleted by default			
Studageu				
Age	Deleted by default			

Ethnicity[j]				
Cntry	Deleted by default			
Fcntry	Deleted by default			
Mcntry	Deleted by default			
Enghome	Deleted by default			
Classize[u]				
Clssize	1.00	1.00	.02	.00
Views[u]				
Studpart	1.00	1.00	.007	.00
Motivation[o]				
Motiv1	.75	.57	.02	.35
Motiv2	.44	.19	.007	.11
Motiv3	.83	.70	.02	.37

Motiv4	.79	.63	.02	.24
Timlearn[i]				
Homworkf	.82	.72	.03	.02
Hourmhw	.27	.19	.009	.03
Hourmath	.42	.19	.009	.01
Attitude[o]				
Mathmrk	.83	.69	.18	.33
Diffmath	.64	.40	.11	.21
Likmath	.85	.73	.19	.26
Mathachi[u]				
Rasch score	1.00	1.00	.34	.00

MEAN COMMUNALITY 0.57

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[i] = inward mode
[o] = outward mode
[u] = unity mode

Gender

The sex of the student was used to indicate *Gender*. Thus, this LV involved a single MV. However, this MV was deleted by default, since the LV *Gender* formed by this MV did not contribute to the inner model. It is important to observe that in the 1964, and the 1978 Australian data sets, this LV showed effects on some of the endogenous LVs and was considered as an important student level factor. This suggests that because of the policies advanced by the Australian government to reduce the differences between boys' and girls' attitudes towards mathematics and schooling, gender is no longer a significant factor in the learning of mathematics at the lower secondary school level.

Ethnicity

This LV was formed from four MVs, namely *Cntry, Fcntry, Mcntry* and *Enghome*. However, this LV was deleted by default, since the LV *Ethnicity* formed by these MVs did not contribute to the inner model. In the 1978 data set, this LV showed a direct effect on mathematics achievement, however, 16 years later in 1994, it did not show any effect and was deleted by default. This suggests that students coming from the non-English speaking background are no longer suffering from serious handicaps in the learning of mathematics.

Class Size *(Classize)*

The number of students in a mathematics class was taken to indicate *Classize*. Hence, this LV comprised just a single MV called*Clssize*. Thus the loading and the communality were each unity.

Views about Mathematics *(Views)*

Studpart involves students' participation in pairs or small groups in undertaking different kinds of activities in mathematics, such as working together in pairs or in groups on a problem or project. As this latent variable consisted of only a single manifest variable it was estimated using unity mode.

Motivation towards Mathematics *(Motivation)*

Four MVs, namely, *Motiv1, Motiv2, Motiv3* and *Motiv4* were selected to reflect this outward mode LV. *Motiv1* involves the students' need to do well in mathematics to get the job they want, while *Motiv2* shows the students' need to do well in mathematics to please their parents. The students' need to do well in mathematics to get into a university or post-school course of their choice was indicated by *Motiv3,* and *Motiv4* involved the students' need to do well in mathematics to please themselves. Preliminary exploratory PLSPATH analysis suggested that all MVs contributed to the formation of this LV. The factor loadings for the four MVs were 0.75, 0.44, 0.83 and 0.79 respectively. This indicated that *Motiv3* contributed relatively more to the formation of this construct than the remaining variables, but that all four factors could be considered to reflect the LV *Motivation.*

Time in Learning *(Timlearn)*

The MVs *Homworkf, Hourmhw* and *Hourmath* formed this LV in an inward mode. Homworkf involved the frequency of mathematics homework being given to students in a week, while *Hourmhw,* was the time taken by the students to do their mathematics homework in a week. The time allowed for mathematics classes in a week was indicated by *Hourmath.* It can be seen in Table 3 that *Homworkf,* (0.82) was a noticeably higher contributor in the formation of this construct than the remaining variables. This indicates that the number of homework sessions given by the mathematics teachers in a week contributed strongly to the formation of this LV.

Attitudes towards Mathematics *(Attitude)*

Three MVs namely, *Mathmrk, Diffmath* and *Likmath* were combined to reflect this outward mode LV *Attitude.* The loadings showed that the three MVs combined well to reflect this construct. The analysis showed that MV *Likmath* (0.85) was the relatively strongest contributor in reflecting the construct compared to the other two observed variables, while the least contributor was *Diffmath* (0.64).

Mathematics Achievement *(Mathachi)*

This LV consists of a single MV, namely *Rasch score.*

In summary, for the outer model, among the 25 hypothesised MVs that contributed to the ten constructs, seven MVs were removed from further analysis, because they were associated with latent variables that did not contribute to the model and one of the MVs, *Siblings,* was removed from the analysis, because its loading was below the critical value of 0.30. *Gender, Studage* and*Ethnicity* were hypothesised to influence the other predictors and the outcome measure in the inner model. However, these LVs failed to have any effect on any of the endogenous LVs. Hence, they were deleted from the analyses.

Thus, the MVs namely *Sex, Age, Cntry, Fcntry, Mcntry* and *Enghome* which were hypothesised to form *Gender, Studage* and*Ethnicity* respectively, were also deleted from the analyses. Consequently, the remaining 18 MVs contributed to the construction of the remaining seven LVs. The average of the communalities of the MVs was 0.57 which indicated that the model was a sound model.

Inner Model Results

In this section the results of the inner model are presented. Table 4 shows the beta (ß), correlation and tolerance coefficients and R2 and Table 5 presents the direct, indirect and total effects, correlations, fit and R2 values. There are seven LVs in the final model, and the results of the analyses of these LVs are presented in Figure 2.

Among the seven LVs, *Homeback*, was an exogenous LV, which meant that it was not influenced by any other LV. The discussion in this section considers the six endogenous LVs that were assumed to be influenced by another LV in the hypothesised model.

Class Size *(Classize)*

Four factors namely, *Homeback*, *Gender*, *Studage* and *Ethnicity* were hypothesised to influence this construct. However, only*Homeback* (0.16) influenced the LV *Classize* (see Tables 4 and 5 and Figure 2). This meant that those students from higher socioeconomic status backgrounds were in larger class groups for mathematics. The explained variance (R2=0.03) for this construct was very small.

Views about Mathematics *(Views)*

Five LVs were hypothesised to influence this LV which was concerned with students' participation in pairs or small groups in undertaking different kinds of activities in mathematics, such as working together in pairs or in groups on a problem or project. Among these factors only one LV namely *Classize* (-0.08) influenced this LV directly, while *Homeback* (-0.01) acted indirectly (see Tables 4 and 5 and Figure 2). The variance explained (R2=0.01) for this construct was very small. The value for *Classize* was negative which indicated that students from small class groups expressed stronger *Views* about mathematics than students from large class groups (see Tables 4 and 5 and Figure2). Furthermore, the indirect effect of *Homeback* (-0.01) revealed that students from lower socioeconomic status backgrounds indirectly expressed stronger *Views* about mathematics than students from higher socioeconomic backgrounds. Therefore, from the analysis it would seem possible to conclude that students' *Views* about mathematics were influenced by *Classize*. It is also important to point out that *Home Background* influenced the students' *Views*about mathematics indirectly through the mediating variable, *Classize*.

Table 4: TIMS-Year-8 Students- Inner Model Betas

Variable	Beta	Correlation	Tolerance	R^2
Classize				.03
Homeback	.16	.16	.00	
Views				.01

Classize	-.08	-.08	.00
Motivation			.04
Homeback	.11	.11	.0005
Views	.15	.15	.0005
Timlearn			.05
Homeback	.17	.18	.01
Views	-.09	-.08	.02
Motivation	.09	.10	.03
Attitude			.26
Homeback	.09	.14	.01
Views	.09	.16	.02
Motivation	.48	.50	.03
Mathachi			.34

Homeback	.23	.35	.06
Classize	.20	.32	.07
Views	-.12	-.11	.04
Timlearn	.21	.34	.08
Attitude	.30	.36	.06
MEAN R^2			0.12

Motivation towards Mathematics *(Motivation)*

Six LVs were hypothesised as factors that influenced students' *Motivation* towards mathematics. In Table 5 only three of the hypothesised factors are shown to influence this construct either directly, indirectly, or in both ways.
Only *Homeback*, *Classize* and *Views* influenced*Motivation* (see Table 5 and Figure 2), and the total effects of these variables were 0.11, -0.01 and 0.15 for *Homeback, Classize* and *Views*respectively. *Homeback* influenced *Motivation* both directly (0.11) and indirectly (-0.002), while, *Views* (0.15) showed only a direct effect on this construct. However, *Classize* (-0.01) influenced this construct only indirectly and to a very slight extent. The variance explained for this construct was 0.04. In general, the findings can be summarised as follows:

a. students from higher socioeconomic status backgrounds expressed stronger *Motivation* towards mathematics than students from lower socioeconomic backgrounds; and
b. students who expressed stronger *Views* about mathematics also expressed stronger *Motivation* towards mathematics.

Time in Learning *(Timlearn)*

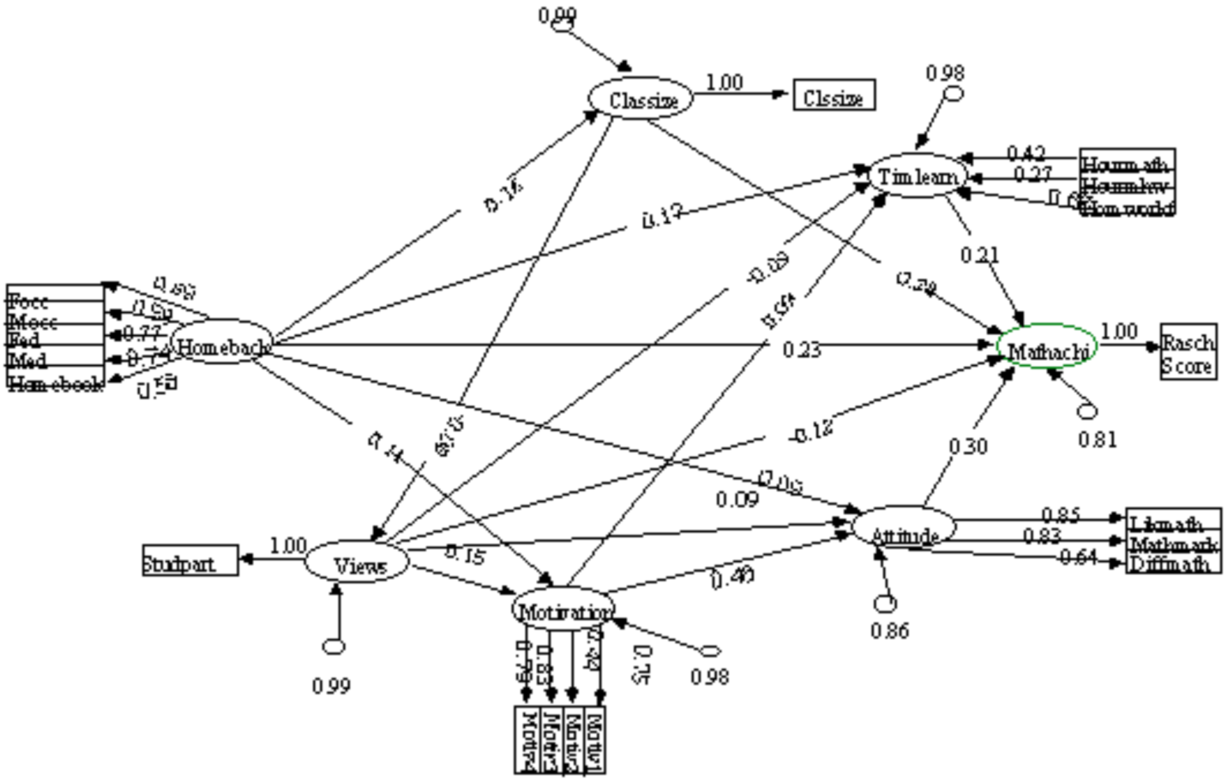
Seven LVs were hypothesised to influence this construct. However, the result of the analysis revealed that only *Homeback* (direct effect = 0.17, indirect effect = 0.01, total effect = 0.18) and *Views* (direct effect = -0.09, indirect effect =0.01, total effect = -0.07) showed direct and indirect effects while, *Motivation* (0.09) showed only a direct effect on this construct (see Table 5 and Figure 2). *Homeback* indicated that students from higher socioeconomic status backgrounds were likely to spend more time in learning mathematics than students from lower socioeconomic status backgrounds. Furthermore, *Motivation* also influenced this LV directly. Students who indicated stronger*Motivation* towards mathematics were likely to spend more time on mathematics than students who expressed less *Motivation* towards mathematics. The effect of *Views* on *Timlearn* is negative. This indicates that students who showed less participation in pair or group work in mathematics were likely to spend more time in learning mathematics than those students who participated more in group work. Meanwhile, *Classize* showed a very small indirect effect (0.006) acting through the mediating variables *Views* and *Motivation* (see Table 5). The remaining LVs did not show any influence on this LV. The R2 (0.05) value for this construct was small.

Table 5: TIMS - Year 8 students - Inner Model Statistics

Variable	**Direct**	**Indirect**	**Total**	**Correlation**	**Fit**	**R2**
Classize						.03
Homeback	.16	-	.16	.16	-	
Views						.01
Homeback	-	-.01	-.01	-.02	-.01	
Classize	-.08	-	-.08	-.08		

Motivation					.04
Homeback	.11	-.002	.11	.11	-
Classize	-	-.01	-.01	.06	.05
Views	.15	-	.15	.15	-
Timlearn					.05
Homeback	.17	.01	.18	.18	-
Classize	-	.006	.006	.21	.18
Views	-.09	.01	-.07	-.08	-
Motivation	.09	-	.09	.10	-
Attitude					.26
Homeback	.09	.05	.14	.14	-
Classize	-	-.01	-.01	.09	.08
Views	.09	.07	.16	.16	-

Motivation	.48	-	.48	.50	-
Mathachi					.34
Homeback	.23	.11	.35	.35	-
Classize	.20	.007	.21	.32	-
Views	-.12	.03	-.08	-.11	-
Motivation	-	.16	.16	.15	-.04
Timlearn	.21	-	.21	.34	-
Attitude	.30	-	.30	.36	-
Mean R^2					.12



Attitudes towards Mathematics *(Attitude)*

Eight LVs were hypothesised to influence students *Attitudes towards Mathematics*. The result of the PLSPATH analysis demonstrated that four of the hypothesised LVs showed direct and/or indirect effects on this construct. *Home Background* and *Views about Mathematics* showed both direct and indirect effects on *Attitudes towards Mathematics*. The total effects of *Homeback* and *Views* were 0.14 and 0.16 respectively (see Table 5 and Figure 2). *Classize* showed only an indirect effect of -0.01. However, *Motivation* towards mathematics showed a direct effect (0.48) on *Attitudes towards Mathematics* and the effect of this LV was much stronger than the other two variables which showed both direct and indirect effects. Thus, students who expressed stronger motivation towards mathematics, students from higher socioeconomic status backgrounds and those students who indicated more positive views about mathematics expressed more positive attitudes towards mathematics than students who expressed weaker motivation, students from lower socioeconomic backgrounds and students who expressed weaker views about mathematics. The important point here was that *Gender* did not have any effect on *Attitudes towards Mathematics* when other variables were taken into account. Previous Australian research findings have revealed that boys had more positive attitudes towards mathematics than did girls (Keeves, 1972; Fraser, 1980; Schofield, 1981; Ballenden et al., 1985). However, the findings here did not support these previous findings. In previous analyses in which other variables are taken into account, namely 1964, 13-year-old students, 1964 Year 8 students and 1978 13-year-old students, data analyses involving both 13-year-old in 1964 and 1978 and Year 8 students in 1964 indicated that boys expressed more positive attitudes towards mathematics than girls. However, in 1994, there was no gender effect either direct or indirectly on *Attitudes towards Mathematics.* Thus the effects of*Gender*, would appear to have changed over time in respect to attitudes towards the learning of mathematics.

Mathematics Achievement *(Mathachi)*

Students' level of mathematics achievement was hypothesised to be influenced by nine LVs. The result of the PLS analysis revealed that three of the nine factors influenced *Mathematics Achievement* both directly and indirectly, while one other factor influenced *Mathematics Achievement* indirectly (see Tables 4 and 5 and Figure 2) and two factors showed only a direct effect. The factors that did not show any effect on the outcome variable were *Gender, Studage* and *Ethnicity* and since these variables did not enter the model in any way, they do not appear in the final analyses presented. The five factors that had a direct influence on *Mathematics Achievement* were *Homeback, Classize, Views, Timlearn and Attitude*.

Direct Effects

The five factors that had a direct influence on Mathematics Achievement are discussed in greater detail as follows.

*Home Background (Homeback)***.** This LV influenced the mathematics achievement level of Year 8 students directly (0.23) and also with a sizeable indirect effect (0.11). The total effect of this variable on *Mathematics Achievement* was 0.35. *Homeback* was the strongest of the factors that influenced this criterion variable. This result indicated that students from higher socioeconomic status backgrounds were likely to achieve at a higher level in mathematics than students from lower socioeconomic status backgrounds within this TIMS Year 8 sample. Previous Australian research findings into the effects of socioeconomic status on mathematics achievement have indicated that students from higher socioeconomic status family backgrounds were likely to achieve at a higher level than their classmates from lower socioeconomic backgrounds (Keeves, 1968; Rosier, 1980; Ainley et al., 1990). A weaker effect was observed in the FIMSB sample which involved Year 8 students as did the TIMS sample, but the FIMSB sample was restricted to students from government schools only, whereas the TIMS sample included all types of schools.

Class Size (Classize). This was a LV that influenced *Mathematics Achievement* of students directly (0.20) and indirectly (0.007). The total effect was 0.21. This variable indicates that students from larger class groups achieve at a higher level in mathematics than students from smaller class groups. This finding was consistent with the findings in FIMSA, FIMSB and SIMS data sets.

Views about Mathematics (Views). *Views* also had direct (-0.12) and indirect (0.03) effects on *Mathematics Achievement.* This variable influenced *Mathematics Achievement* negatively. Thus, the variable indicated that those students who expressed less participation in working together in pairs or in small groups on different kinds of mathematical activities were likely to achieve at a higher level in mathematics than those who indicated more participation in working together in pairs or in small groups (see Table 5 and Figure 2).

Time in Learning Mathematics (Timlearn). This LV influenced *Mathematics Achievement* directly. It was the third strongest (ß = 0.21) variable that had a direct effect on *Mathematics Achievement* (see Tables 4 and 5 and Figure 2). The evidence showed that students who spent more time in learning mathematics were higher achievers in mathematics than students who spent less time in learning mathematics. While this latent variable included time spent in mathematics classes, the most important variate forming this variable was the number of times mathematics homework was assigned in a week. In part the change in composition of this variable could account for its increased contribution in TIMS compared to FIMS and SIMS. However, its greater contribution could arise from greater variability in the 1990s to time given to learning in mathematics classes and on homework.

Attitudes towards Mathematics (Attitude). This LV influenced *Mathematics Achievement* directly. It was the strongest (ß = 0.30) variable that had a direct effect on *Mathematics Achievement* (see Tables 4 and 5 and Figure 2). The evidence showed that students who expressed more positive attitudes towards mathematics were higher achievers in mathematics than students who expressed less positive attitudes. This observation was consistent with previous Australian research findings (Keeves, 1972; Schofield, 1981; Milne, 1992).

Indirect Effects

Motivation towards Mathematics (Motivation). Motivation was the only factor that showed an indirect (0.16) effect on *Mathematics Achievement* operating through *Attitude*. The results indicated that highly motivated students towards mathematics were likely to achieve at a higher level in mathematics than less motivated students (see Table 5 and Figure 2). The important point here was that gender did not exhibit any effect on *Mathematics Achievement.*

A further interesting finding was that the *Age* of the student did not show any influence on the outcome variable *Mathematics Achievement,* even though a grade sample was under survey. The background (*Ethnicity*) of the student also did not show a direct or indirect effect on the outcome variable.

Conclusion

Twenty five MVs and nine LV were originally hypothesised to influence the *Mathematics Achievement* level of Year 8 students who participated in the Third IEA Mathematics Study in Australia. Among the 25 MVs, seven were removed from further analysis, because the loading of *Siblings* was below the critical value of 0.30, and the LVs which were formed by the remaining six deleted MVs did not contribute to the inner model and were consequently removed from the analysis.

The results of the analysis revealed that among the nine hypothesised LVs only five of them were identified as student level factors that influenced the mathematics achievements of Year 8 students in Australia in 1994. These student level factors were *Homeback, Classize, Views*, *Timlearn* and *Attitude.* However, *Motivation* influenced the criterion variable indirectly through *Attitude*. The mean of the R2 values of the endogenous variables of the inner model was 0.12, which showed that the model was not a strong model. However, 34 per cent of the variance of the criterion variable of *Mathematics Achievement* was explained by the latent variables in the model.

Comparisons between Different Occasions

Table 6 presents the direct and indirect effects of LVs identified as student level factors that influenced mathematics achievement on the different occasions. The first column shows the variables, while the remaining columns show the direct, indirect and total effects of each variable on Mathematics Achievement on each occasion. The direct effects of each variable on the outcome measure *Mathematics Achievement* were considered to indicate the relative strengths of the factors that influenced Mathematics Achievement on the different occasions.

Home Background

This construct showed direct and indirect influence on the outcome variable on all occasions except in FIMSA (see Table 6). In FIMSA, it showed only an indirect influence. When FIMSA and SIMS were compared it would appear that the impact of home background had increased markedly over time. In 1964, in FIMSA, the effect was indirect while 14 years later the effect was both direct and indirect. It is important to remember that both groups involved only 13-year-old students. Furthermore, when Year 8 students in FIMSB (0.08) and TIMS (0.23) were compared it would appear that the effect of home background had increased markedly over the last three decades. However, this is almost certainly a consequence not of greater inequity but of a difference in the sample design employed in 1978, and in 1994 when students from nongovernment schools were included in the investigation compared with 1964 when they were not included. Most of the students in non-government schools would be from higher socioeconomic status backgrounds, therefore, there was greater variability in this predictor LV in 1978 and 1994 compared with 1964, and hence stronger effects were detected on the two later occasions compared to the former occasion.

Table 6: Comparisons of Student factors that influence Mathematics Achievements on Different Occasions

	FIMSA (13-year-old)			**FIMSB (Year 8)**			**SIMS (13-year-old)**			**TIMS (Year 8)**		
Variable	**D**	**I**	**T**	**D**	**I**	**T**	**D**	**I**	**T**	**D**	**I**	**T**
Homeback	NE	0.17	0.17	0.08	0.13	0.20	0.27	0.09	0.37	0.23	0.11	0.35
Gender	NE	-0.01	-0.01	NE	-0.02	-0.02	NE	-0.02	-0.02	NE	NI	
Studage	NC			NE	NI	-	NC			NE	NI	
Classize	0.17	0.04	0.21	0.19	0.03	0.22	0.21	0.01	0.22	0.20	0.01	0.21
Motivation [a]	0.10	0.05	0.15	0.29	0.04	0.33	NE	0.07	0.07	NE	0.16	0.16
Timlearn [b]	NE	NI		NE	NI	-	NE	NI		0.21	NI	0.21
Attitude	0.09	NI	0.09	0.09	NI	0.09	0.28	NI	0.28	0.30	NI	0.30
Aspiration	0.25	0.004		0.25	NE	0.03	0.03			NC		
Futmath	NE	0.02	0.02	0.10	0.02	0.13	NC			NC		
Yearlevel	0.49	-0.005	0.49	NC			0.29	0.01	0.30	NC		

Views [a]	NE	0.01	0.01	NE	0.01	0.01	NE	0.002	0.002	-0.12	0.03	-0.08
Values	NE	0.08	0.08		NE	0.08	0.08	NE	0.01	0.01	NC	

Gender

In all Australian groups, namely FIMSA, FIMSB and SIMS *Gender* had only an indirect effect on Mathematics Achievement, furthermore, it showed neither a direct nor an indirect effect in TIMS.

Student Age

All students in FIMSA and SIMS were 13-year-olds, therefore *Student Age* was not considered as a factor in these analyses. However, in FIMSB and TIMS student age was a potential factor, since these groups were all Year 8 students, who were not of the same age group. There was no direct or indirect effect on achievement for either of the Australian data sets. Thus, student age was not found to be a factor that influenced *Mathematics Achievement* in Australia. The reason might be related to small age differences among Australian students. In FIMSB the age of students ranged from 11 to 16 years and for TIMS ranged from 12.0 to 16.3 years.

Class Size

The other factor which was considered in all the five groups of students was *Classize*. In all groups it showed both direct and indirect effects on the outcome variable. The class size effect on *Mathematics Achievement* between 1964 (0.19) and 1994 (0.20) in Australia was of median strength. The interesting point is that students from larger groups were likely to achieve at a higher level in mathematics in 1964 and the same and perhaps an even greater effect was found after a 30-year period. Thus the finding suggests that to achieve better results, mathematics students should be in larger class groups. This finding was consistent with the results reported by Pidgeon's (1967). From the analysis of the English FIMS data set, he reported that "there is evidence particularly with pupils up to 'O' level that higher mathematics performance is associated with larger classes" (Pidgeon, 1967, p. 140).

Motivation towards Mathematics

Motivation showed both direct and indirect effects on the outcome variable for FIMSA, FIMSB and only an indirect effect for SIMS and TIMS data sets. The direct and indirect effect for FIMSA, FIMSB and the indirect effect for SIMS and TIMS suggest that the effect of*Motivation* on *Mathematics Achievement* declined over time. It has been reduced from both direct and indirect effects in 1964 to only an indirect effect in 1978 for 13-year-olds and 1994 for Year 8 students. However, the MVs forming this LV were not identical. In 1964, the manifest variables were *Hmwall,* which involved the number of hours in a week given by students to all homework and *Attitsch*, a nine item scale measuring students' attitude towards school and school learning. Whereas in 1994 the MVs involved students' need to do well in mathematics. Therefore, the results might not be comparable, but the MVs were similar for 1964 and 1978 13-year-old students.

Time in learning Mathematics

Time in learning mathematics was hypothesised as a factor that would influence Mathematics Achievement for all the four groups of students. However, it was found that there was only a direct effect on the outcome variable in the TIMS data set. In Australia in 1994 students who spent more time in learning mathematics were likely to achieve at a higher level than those who spent less time in learning the same subject. The interesting point is that in Australia both in 1964 and 1978 *Timlearn* did not show either direct or an indirect effects on *Mathematics Achievement.* However, in 1994 it showed a direct effect (0.21) on *Mathematics Achievement.* This suggests that the effects of *Time in learning mathematics* increased between occasions and it became one of the student level factors that had a significant influence on *Mathematics Achievement*. The MVs which formed this LV in all samples were the time allocated for students to learn mathematics in a week and the time taken by students to do their mathematics homework in a week. These two variables formed the LV for the FIMSA, FIMSB, and SIMS data sets, but for the TIMS data set the frequency of homework given by the teacher in a week was an additional MV that helped to form *Timlearn*. This MV was also a strong contributor (0.82) in the formation of this construct. Therefore, the increased effect in TIMS might be a consequence of the inclusion of this additional observed variable. However, the changed effect might be due to greater variability among student groups in the time given to learning mathematics on the later occasion than on the earlier occasions. There is also a possible conclusion that the frequency of homework given in a week is more important than the time spent in doing homework to achieve a higher level of performance in mathematics.

Attitudes towards Mathematics.

This LV was found to influence *Mathematics Achievement* and it showed a direct effect for all groups of students. In Australia over time, that is between 1964, 1978 and 1994, *Attitudes towards Mathematics* greatly increased in their effects on *Mathematics Achievement.* In 1964 the effect was 0.09 while this direct effect over a 30-year period had increased to 0.30. However, in 1964 *Aspiration* and *Futmath*were included as variables in the analysis, but in 1978 and in 1994 these two variables could not be introduced into the model. The total effect of *Attitude* (0.09), *Aspiration* (0.25) and *Futmath* (-0.02) for FIMSA data set was 0.32, while for FIMSB the combined effect was 0.25 (see Table 6). If these two variables were excluded from the analyses, the effect of *Attitude* would probably have been increased. Hence, the increase in the effect of attitude on the outcome variable in 1978 and 1994 might have been due to the removal of the influence of these surrogate variables for *Attitude*. Moreover, in all samples those students who had positive attitudes towards mathematics were likely to be higher achievers in mathematics than other students. Clearly it is important to find ways and means to improve the attitudes of students towards mathematics.

Year Level

Students in FIMSA and in SIMS were from Years 7, 8 and 9. Hence, Year level was considered to be a factor that influenced*Mathematics Achievement* for these two groups of students. In both groups which were age samples, *Year Level* showed direct and indirect effects on the outcome variable. This indicated that *Year Level* influenced *Mathematics Achievement,* that is to say, the higher a student's year level the higher his or her level of mathematics achievement. Year level continued to be a factor from 1964 to 1978. However, it is important to observe that the total effect was markedly stronger for FIMSA than SIMS. This may be consequence of the inclusion of primary school Year 7 students in FIMSA samples for New South Wales, the largest state. By the time the SIMS study was conducted in 1978 New South Wales had reorganised its educational system and Grade 7 was at the secondary school level.

Views about Mathematics

Views was considered to be a factor that would influence *Mathematics Achievement* for the FIMSA, FIMSB, SIMS and TIMS data sets. However, *Views* showed only a direct effect for the TIMS data set and very weak indirect effects for the other three Australian data sets. The effect of *Views* on the outcome variable for the TIMS data set showed that *Views* was a student level factor that influenced*Mathematics Achievement*. However, it is important to observe that the influence of *Views* was very small, specially for the SIMS study. Therefore, the effects of *Views* on the outcome measure were weak and did not change greatly between 1964 and 1978 in Australia. Furthermore, this factor showed change from an indirect effect in 1964 to a direct effect in 1994. However, the MV that formed the LV in 1964 involved students' views about the methods employed by their mathematics teachers during the teaching-learning process, while in 1994 the MV involved the students' participation in working together in pairs or in small groups on different kinds of mathematical activities. These findings would seem to suggest that such student participatory activities could have a detrimental effect on student learning as measured by the mathematics tests employed in these studies.

Values about Mathematics

Like *Views*, *Values* were considered to be a factor that would influence *Mathematics Achievement* for FIMSA, FIMSB and SIMS data sets. The variable was not considered in the TIMS data set. The variable was formed from two MVs namely, *Mathinso* which measured the attitude of students towards the place of mathematics in society and *Contrenv* which measured students' attitudes towards the relationship of man to his environment. This LV showed only indirect effects for the three Australian data sets. It is important to observe that the influence was very small, especially for SIMS where it was only 0.01. Consequently, it was possible to conclude that the effect of*Values* on the outcome measure did not change greatly over time in Australia.

The indicator used to select similarities and the differences between factors that influenced *Mathematics Achievement* over time was the direct effects of the same variable for all groups on the outcome variable. Consequently, the first comparison was between FIMSA and SIMS, while the second comparison was between FIMSB and TIMS data sets.

Similarities and Differences between FIMSA and SIMS

Class Size, Attitudes towards Mathematics and *Year Level* continued to be factors that influenced *Mathematics Achievements* between FIMSA and SIMS, that is between 1964 and 1978. Moreover, *Gender*, *Views* and *Values* continued to influence *Mathematics Achievements* from 1964 to 1978 indirectly (see Table 6). However, *Time in Learning* did not show any effect either in 1964 or in 1978.

There were differences between 1964 and 1978 with respect to two variables, *Home Background* and *Motivation*. *Home Background* was not directly a factor influencing the outcome variable for FIMSA, but it was found to be a strong factor in 1978. On the other hand*Motivation* was a direct factor in FIMSA and was not a direct factor in SIMS, since it showed only an indirect effect. This might be as a consequence of a difference in the sample design employed in 1978, in which students from nongovernment schools were included. Most of the students in non-government schools would be from higher socioeconomic status backgrounds, therefore, there would have been greater variability in this predictor variable and the greater likelihood of an effect being detected.

Therefore, *Class Size, Attitudes towards Mathematics* and *Year Level* were student level factors that had a stable influence on mathematics achievement over time. *Home Background* increased from an indirect effect in 1964 to a direct effect in 1978, while *Motivation* declined from a direct effect in 1964 to an indirect effect in 1978.

Similarities and Differences between FIMSB and TIMS

Among the nine LVs which were hypothesised to influence *Mathematics Achievement*, three factors influenced students' *Mathematics Achievement* on both occasions in 1964 and 1994 at the Year 8 level. These variables were *Home Background*, *Class Size* and *Attitudes towards Mathematics* (see Table 6). All three LVs had effects on the outcome measure which had increased in 1994 when compared to the 1964 data set. These three variables are student level factors influencing mathematics achievement for the last 30 years. Consequently, the findings of this investigation indicate that students from higher socioeconomic status backgrounds, students from larger class groups and students who expressed more positive attitudes towards mathematics are likely to achieve at a higher level in mathematics.

The other similarity between the two Australian groups was that *Student Age* did not show any effect on the outcome variable.

The differences between the FIMSB and TIMS studies were in *Gender*, *Views, Motivation* and *Time in Learning.* In FIMSB, *Gender*showed an a trivial indirect effect on the outcome variable, while *Gender* did not show any effect for the TIMS data set. *Motivation*showed a direct effect and was considered an important factor in FIMSB, however, its contribution was reduced to an indirect effect for the TIMS data set. Furthermore, *Views* showed a direct effect in TIMS, but only an indirect effect for the FIMSB data set. The other major difference was for *Time in Learning* mathematics, this variable did not have any effect in 1964, but it showed a direct effect of 0.21 in 1994. However, it is important to recognise that the MVs which formed *Motivation* and *Views* in 1964 and 1994 were different in nature and an additional strong variable (frequency of mathematics homework) was included to form the *Time in Learning* variable in 1994.

Conclusions and Recomendations

The results of the path analyses for the three different data sets (FIMS, SIMS and TIMS) have revealed that the home background of students, number of students in class and attitudes of students towards mathematics are student level factors influencing achievement in mathematics over the last 30 years. Time in learning mathematics did not show any influence both in 1964 and 1978. However, it influenced the 1994 students' achievement directly, the main reason perhaps being the inclusion of a new and strong manifest variable, frequency of mathematics homework in a week. The findings recorded in their paper are consistent with Carroll's (1963) model of school learning. Carroll has argued that perseverance (motivation, attitude) and time for learning are some of the factors that influence school learning. These factors advanced by Carroll continue to influence the Australian students' mathematics achievement. Thus, teachers, school administrators and curriculum designers need to consider the following points to improve the achievement level of students in mathematics.

1. Teachers should be aware of the importance of attitudes towards mathematics in the teaching learning process in mathematics, since students

who expressed more positive attitudes towards mathematics, achieved at a higher level than those students who expressed less positive attitudes towards the same subject. In view of the importance of mathematics for the technological development of the nation, teachers should develop ways and means to improve the attitudes of students towards mathematics.

2. School administrators should also be ready to provide the necessary assistance for those students who are from a lower socioeconomic background in order to improve their achievement level in mathematics, since the evidence suggested that students from higher socioeconomic background status families achieved at a higher level in mathematics than those students from lower socioeconomic status families.

3. Curriculum designers should provide enough time for students to learn mathematics and to provide regular homework during a school week, since the number of mathematics homework sessions in a week showed more influence on mathematics achievement than the time the students spent on doing their assignments.

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