The Predicting and Mediational Role of Mathematics Self-efficacy: A Path Analysis

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Abstract. Bandura's (1997) self-efficacy theory posits four principal sources of information (i.e., performance accomplishment, vicarious experiences, verbal persuasion, and physiological states) through which individuals acquire and modify their self-efficacy beliefs. The objectives of the present study were to examine the predictive and mediational role of self-efficacy and the order of potency of the four sources of information for maths. Six structured multiple-choice questionnaires and an achievement test were administered to 655 primary school students. Path analysis techniques were used to infer direct and indirect effects of the four sources of information on self-efficacy, and self-efficacy on performance.

The findings differ among different grade levels. Regarding the four sources of self-efficacy information, Bandura's (1986, 1997) order of potency was confirmed for 5th and 6th grades, but not for 3rdand 4th grades. In addition, the multiple information sources were predictive of maths performance outcome. Students' self-efficacy beliefs were found to predict performance for 3rd and 4th graders, but not for 5th and 6th graders. With the exception of students' states of anxiety, ANOVA indicated no gender differences. Based on the findings found, educational implications are discussed with caveats and directions considered for future research.

Current theory in educational psychology has posited that personal cognitions influence instigation, direction, strength, and persistence of behaviours (Schunk, 1989a). One type of personal cognition refers to *self-efficacy*, defined as "people's judgements of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Besides the knowledge and skills one possesses, what individuals believe about themselves and about their academic competence in part helps to govern their academic success in schools. Ultimately, one's academic attainments can markedly differ to others' even when knowledge and skills are of the same level (Pajares & Valiante, 1999).

Bandura's (1986, 1997) social cognitive theory posits a strong sense of self-efficacy leads individuals to undertake challenging tasks (Bandura & Schunk, 1981), expend greater effort in accomplishing a given task (Salomon, 1984; Schunk, 1983a), persist longer in the face of adversaries (Bandura & Schunk, 1981; Schunk, 1982), self-regulate better than others (Zimmerman, Bandura, & Martinez-Pons, 1992), and use more effective strategies (Pintrich & De Groot, 1990).

Since Bandura's (1977) original paper, "Self-efficacy: Toward a unifying theory of behavioural change", self-efficacy has been applied in academic settings to various grade levels (e.g., primary, secondary, tertiary), content domains (reading, writing, maths, computing science), and student ability levels (average, gifted, remedial)(Schunk, 1995). In the various educational fields of research, self-efficacy has been shown to influence: goal setting (Locke & Latham, 1990; Schunk & Swartz, 1993), attributional feedback (Schunk, 1982, 1983a), performance feedback (Schunk, 1983b), predictive utility (Relich, Debus, & Walker, 1986), self-concept (Pajares & Miller, 1994), self-regulation (Schunk, 1989b, 1996), and career choice and major (Betz & Hackett, 1983).

The Predicting & Mediational Role of Self-efficacy

According to Bandura's (1986, 1997) social cognitive theory, students' self-efficacy beliefs about their academic capabilities influence their academic achievement. Students' self-efficacy beliefs act as a mediating mechanism of personal agency, mediating between other determinants of competence (e.g., skill, ability, or previous accomplishments) and their subsequent performances (Pajares & Valiante, 1999). This has received considerable theoretical and empirical attention in relation to reading, maths, and other subject disciplines in different grade levels (primary, secondary, tertiary).

There is growing evidence in the area of maths that self-efficacy predicts and mediates various motivational variables on performance outcome (e.g., Hackett, 1985; Hackett & Betz, 1989; Also see Maddux, 1995). For example, Norwich (1987) examined students' maths self-efficacy beliefs and their *subsequent* attainments and self-efficacy beliefs under conditions of differing task familiarities when other factors (e.g. self-concept) were taken into account. The findings indicated, despite the moderate correlation between maths self-efficacy beliefs and performance, maths self-efficacy beliefs alone did not contribute to maths performance, and that both prior maths performance and self-concept made significant contributions to subsequent performance. Pajares and Miller (1994) found with first-year university students a direct relation between maths self-efficacy and various motivational variables-for example, self-concept, perceived usefulness, high school experience, and maths performance. Students' maths self-efficacy was more predictive of maths problem-solving performance (B=.55), compared to the predictive effects of self-concept (B=.16), perceived usefulness (B=.10), and prior experience (B=.10). Maths self-efficacy perceptions also mediated the effects of gender and prior maths experience on maths self-concept, perceived usefulness of maths, and maths problem-solving performance. Randhawa, Beamer, and Lundberg (1993) reported similar findings using structural equation modeling techniques. A respecified model (GFI=.985, AGFI=.96) indicated both maths self-efficacy (B=.32) and maths attitude (B=.44) predicted maths performance outcome. These consistent findings indicate the important role of self-efficacy in influencing students' maths performance outcomes for different grade levels. In a longitudinal study over a one-year period, Pajares and Graham (1999) reported that maths self-efficacy was more predictive of performance than other motivational variables-such as anxiety, self-concept, self-regulatory, and engagement-for times (1) and (2)(ß = .267 for fall; ß = .272 for spring). T-tests reported a significant difference in self-efficacy and performance between time(1) and time(2); however, this could have been the result of the difference in difficulty in performance measures.

The Four Sources of Self-efficacy Information

Individuals' self-efficacy beliefs are acquired and modified from four principal information sources. Performance experiences, as a first source, serve as an indicator of capability; vicarious experiences, as a second source, explain self-efficacy beliefs from competencies and informative comparison with the attainments of others; verbal persuasion, as a third source, refers to verbal feedback from teachers and adults; and finally physiological and affective states, imply one judging capableness, strength, and vulnerability to dysfunction. The development of self-efficacy beliefs arises from the acquirement of the four principal information sources. This, however, requires the integration, modification, weighing, and assessment of the multiple sources available.

The four sources of self-efficacy information have received increasing support from a growing body of research studies using structured multiple-choice format questionnaires in academic and maths learning. For example, in a recent study, Phan and Walker (2000), using SEM and CFA techniques, reported that the four sources of maths self-efficacy

information represented unique, though related, latent dimensions, and that three of the four sources were hierarchically represented to form a higher-order factor-Personal Experience. Performance accomplishment and emotional arousal were also found to influence maths self-efficacy perceptions. With older students, Lopez and Lent (1992) found 9th-grade students' maths self-efficacy beliefs were influenced by performance accomplishment and emotional arousal, but not vicarious learning or verbal persuasion. Hampton (1998) found performance accomplishment and vicarious experiences predicted students' academic self-efficacy beliefs for both students with learning and non-learning disabilities.

Self-efficacy researcher investigating self-efficacy perceptions in the selection of maths-related majors and careers have reported similar findings (Lent, Lopez, & Bieschke, 1991; Matsui, Matsui, & Ohnishi, 1990). For example, Matsui et al. (1990) reported that performance accomplishment, vicarious learning, and physiological states, but not social persuasion, predicted students' maths self-efficacy perceptions. Lent et al. (1991) reported that students' performance experiences were an importance source of self-efficacy information in maths self-efficacy. Though vicarious experience, verbal persuasion, and physiological states added significant bivariate zero-order correlations, they did not however account any significant variance in maths self-efficacy.

The Objectives of the Present Study

The purpose of the present study was threefold. The first objective was to examine the predicting and mediational role of maths self-efficacy. Maths was chosen in the present study due to its foundational status as being one of the core subjects focused in the National curriculum in Sydney, NSW, Australia. Drawing upon theory and research findings from prior research (e.g., Norwich, 1987; Pajares et al., 1999), a path model was constructed that included the four sources of maths self-efficacy information. To date, most research has included motivational variables that have been shown to predict maths performance outcomes-maths anxiety, self-regulatory self-efficacy, maths self-concept, aptitude, prior maths experiences, cognitive ability, and sex (e.g., Pajares, 1996; Pajares & Kranzler, 1995; Pajares & Miller, 1994), and not the four sources of self-efficacy information. The aim then was to determine whether students' perceptions of maths capability makes an independent contribution to the prediction of maths problem-solving performance when the four sources of self-efficacy information are included in the path model (See Figure 1).

The second objective of the present study was to examine Bandura's (1986, 1997) order of potency of the four sources of maths self-efficacy information. Similar investigations have reported the four principal sources to influence academic and maths self-efficacy (e.g., Hampton, 1998; Lent et al., 1991; Lopez & Lent, 1992; Matsui et al., 1990; Phan & Walker, 2000). In addition, the indirect effects of the four sources of self-efficacy information on maths problem-solving performance mediated by maths self-efficacy were also examined by path analysis techniques.

The third objective was to examine the question of overconfidence of maths self-efficacy. This area of research has received support from similar investigations (e.g., Bandura, 1997; Hackett & Betz, 1989; Pajares, 1996; Pajares & Kranzler, 1995; Pajares & Miller, 1994). Findings report that students have the tendency to overrate their self-perceptions, and that they become progressively accurate as time goes by in appraising their capabilities. The aim then was to determine differences in students' perceptions of maths capability for 3rd to 6th grade students.

STUDY 1

1. Method

Subjects

Three hundred and eighty-three students (164 girls: 219 boys) enrolling in 3rd and 4th grades from three government schools located in the South-west district of Sydney, NSW, Australia participated in the present study. The sample for this study was part of a major study for a Ph.D. research by the first author.

Procedure

The administration of the Four Sources of Self-efficacy Information instrument (FSSEI-Maths) and the Self-efficacy instrument (SEI-Maths) was conducted by the first author and a female research assistant in the students' classes. The teacher was present in the room but was not involved with administering the questionnaires. Students were assured of confidentiality that their answers would only be seen by the author and research assistant. The questionnaires were presented on an over-head projector (OHP) and were read out aloud to all students. For each question students were guided to work at the same pace, and were given 5 seconds for each question. The duration of 5 seconds had been set in advance by the researchers so that this would be long enough for students to recognise the type of a given problem but too brief to actually solve it. Students were encouraged to ask for any clarification regarding unclear items, and those students missing out on any item were given the opportunity at the end of class to complete. Once all students completed the questionnaires, they were given a 10-minute break before the achievement test. Students were given 25 minutes to complete the test. The time it took to answer the questionnaires and achievement test was approximately 60-75 minutes.

Instruments

Four Sources of Information. All participants completed the Four Sources of Self-efficacy Information instrument for maths (FSSEI-Maths) developed by the authors of this paper (Phan & Walker, 2000). The information sources measure consisted of four rationally developed 5-item scales corresponding to the four sources described by Bandura (1986). Sample items included, for example, "I always get good marks in maths" and "I am not good in maths" (Performance accomplishment); "I have a close friend who is good in maths" and "My classmates are good in maths" (Vicarious experience); "When my teacher praises me, I want to do well in maths" and " My friends tell me I am good in maths" (Verbal persuasion); and "I hate maths" and "I am always worried about maths" (Physiological states). Subjects responded on a 7-point Likert scale their level of agreement with each statement, for example, 1 (Not true at all), 4 (Average), 7 (Very true). Reliability estimates for performance accomplishment, vicarious experiences, verbal persuasion, and emotional arousal reported by Phan and Walker (2000) were .81, .66, .69, and .84, respectively.

Maths Self-Efficacy. The Self-efficacy Instrument for maths (SEI-Maths) developed by the authors contained twenty items, comprising of general, intermediate, and specific items. Subjects responded on a 7-point Likert scale their level of perceived competence, for example, 1 (Not well at all), 4 (Average), 7 (Very well). The NSW Board of Education in Australia specifies curricula (e.g., K-6 English Curriculum) in primary schools at three levels-Level (1)(1st and 2nd grades), Level (2)(3rd and 4th grades), and Level (3)(5th and 6th grades). For each level of learning (e.g. Level (1)), specific topics and sub-topics are set for students to learn. In the present study, the level examined included level(2)(i.e., 3rd & 4th grades combined). The maths self-efficacy items included, for example, "How confident are you that

you can learn Maths?" (General item), "How confident are you that you can do Addition?", "How confident are you that you can do Subtraction?" (Intermediate item), and "How confident are you that you can solve 726 - 83 =_____", and "How confident are you that you can solve (20 + 5) - 4=_____"(Specific items). Reliability estimate for the SEI-M was .92.

Achievement Test. The achievement test for maths contained 15 multiple-choice questions. The questions were taken and modified from the NSW Department of Education and Training Basic Numeracy and Literacy Skills tests (Yrs 3-4)(1998). In designing the achievement test, two cautions were taken into consideration. First, Bandura (1986, 1997) posits that predictive and explanatory power of self-efficacy assessments is maximised when there is a close correspondence between self-efficacy assessment measures and the criterial tasks with which they are being assessed. Second, Marsh, Roche, Pajares, and Miller (1997) have recommended that to ensure correlated specifics would not artificially inflate the correlation between self-efficacy and performance, the problems on which performance was assessed should be similar, but not identical, to those on which self-efficacy was measured. The questions included, for example, "Solve 15 + 20 =_____" and "What is the number that is one more than 50?". A KR20 reliability coefficient of .65 was reported for this instrument.

Analysis. The predicting and mediating role of self-efficacy and the order of potency of the four sources were evaluated using path with the Lisrel 8.30 (2000) mainframe computer program (Joreskog & Sorbom, 2000). In brief, path analysis is more advantageous than alternative statistical methods such as multiple regression analyses as it allows the researcher with a multivariate (more than one dependent variable) method to estimate structurally interpretable terms-the direct, indirect, and total effects among a set of variables (Mueller, 1996). This method, according to Cook and Campbell (1979, cited in Pajares & Kranzler, 1995), is appropriate when "theoretical, empirical, and commonsense knowledge of a problem" provides good reasons for proposing the related links between the latent variables.

Path analysis involves path diagrams, graphically representing the a priori structures, and if assumptions are met, ordinary least squares (OSL) estimates of regression coefficients can be used to estimate the strengths of the structural relationships (Kerlinger, 1986; Pedhazur, 1997). Applying the method path analysis, it is possible to test the patterns of intercorrelations between the variables in the equation and whether they are consistent with the designated a priori model proposed. In general, path analysis techniques allow for the testing of bi-directionality wherein; a *recursive* model specifies variable X structurally influence variable Y, but not vice versa, or variable Y structurally influence variable X, but not vice versa, or no structural relation is hypothesised between variable X and Y, but both X and Y might covary; a *non-recursive* model specifies variable X might structurally influence variable Y, and variable Y might structurally influence variable X.

Path analysis techniques are appropriate in allowing "[the] testing of the causal ordering of variables that is hypothesised on the basis of self-efficacy theory" (Hackett, 1985, p.50), however, they do not prove a model correct (Pajares & Kranzler, 1995). In this sense, differing proposed a priori models can provide good model fits to the data, although the indirect effects would be different in each case. Consequently, Pajares et al. (1999) have cautioned that inferences from path analytical findings must be made carefully and modesty. In essence, it was not sought in this study to make causal inferences from the findings, but to detect direct as well indirect effects on various endogenous variables (i.e., the four sources) and thus assess the mediational role of self-efficacy beliefs for maths.

Results

The Direct/Indirect Effects between Sources, self-efficacy & performance

Table 1 presents the means, standard deviations, and Pearson-Product moment correlations for the six variables in the present study. Maths self-efficacy scores ranged from 9 to 63, the possible minimum and maximum, and averaged 49.41 on the total instrument (5.49 per item on a 7-point Likert scale). Achievement scores for the 9-item performance measure averaged 52.42, and ranged from 7 to 63, respectively.

Bivariate correlations among the six variables were significant. Path analysis performed using Lisrel indicated saturated perfect model fit. Although Bandura's (1986, 1997) theory posited the four sources of information as being relevant to self-efficacy beliefs, and that the various fit indices indicated the proposed a priori models were adequate in model fit, not all paths were however significant.

Table 1. Means and Zero-Order Correlations for Variables in the Study

Variables	SD	Mean	1	2	3	4	5	6
1. Performance acc	1.59(1.72)	5.38(4.63)	--	0.09	.509**	-.365**	.553**	.331**
2. Vicarious learning	1.41(1.34)	5.66(5.40)	.124*	--	.367**	.267**	0.07	-0.03
3. Verbal persuasion	1.63(1.46)	4.78(4.65)	.342**	.288**	--	0.01	.312**	0.07
4. Anxiety	1.68(1.75)	2.62(2.74)	-.329**	.119*	.119**	--	-.319**	-.166*
5. Maths self-efficacy	1.51(0.82)	5.49(6.20)	.434**	.240**	.168**	-.219**	--	.500**
6. Maths perform	10.24(2.18)	52.42(91.89)	.194**	0.11	-0.04	-.260**	.550**	--

Note: ** Correlation is significant at the 0.01 (2-tailed)

* Correlation is significant at the 0.05 (2-tailed)

For SD and mean, brackets are for 5th & 6th grades.

Bivariate correlations for 3rd & 4th grades are below diagonal and 5th & 6th grades are above diagonal.

Table 2 presents the decomposition of effects from the different paths. For maths self-efficacy, performance accomplishment (B=.260, t=3.87), verbal persuasion (B=.311, t=4.87), and physiological states (B=.852, t=22.33) were significant. For performance outcome, self-efficacy (B=.334, t=7.44), performance accomplishment (B=.112, t=-2.06), verbal persuasion (B=.289, t=-5.53), and physiological states (B=.387, t=7.96) were significant. The independent variables accounted for 65% of the variability in problem-solving performance and 72% of the variability in self-efficacy. Figure 1 presents the path model with the independent variables accounting for the variability in performance. The residual path coefficients R that represent factors affecting a specific variable but that are not measured or accounted for in the model are also shown in Figure 1.

Table 3 presents the direct and indirect effects for the path model proposed in Figure 1. As expected, path coefficients from self-efficacy (B=.474), performance accomplishment (B=-.129), verbal persuasion (-.285), and physiological states (B=.447) to performance were significant. Consistent with social cognitive theory, the direct effects of performance accomplishment (B=.212), verbal persuasion (B=.216), and physiological states (B=.694) to self-efficacy were significant, indicating that they are important sources of self-efficacy information. The strong influence of physiological states on self-efficacy compared to

performance accomplishment and verbal persuasion suggests that 3rd and 4thgrade students depend more on their states of anxiety in acquiring and developing their maths self-efficacy beliefs.

Table 2. Decomposition of Effects from the Path Analysis

Effects	Standard error		t		Standardised estimates		R^2
	1st	2nd	1st	2nd	1st	2nd	
On performance	.045	.102	7.444	1.870	.334	.190	**.653(.102)**
-of self-efficacy	.054	.053	-2.064	2.010	-.112	.107	
-of performance accomplish	.037	.054	-1.383	-1.017	-.051	-.055	
-of vicarious learning	.052	.055	-5.533	0.234	-.289	0.013	
-of verbal persuasion	.049	.042	7.964	-0.361	.387	-0.015	
-of anxiety							
On self-efficacy	.067	.032	3.870	7.258	.260	.231	**.721(.364)**
-of performance accomplish	.047	.036	-.802	.487	-.038	.018	
-of vicarious learning	.064	.037	4.865	.635	.311	.023	
-of verbal persuasion	.038	.028	22.330	-2.819	.852	-.079	
-of anxiety							

Note: For standard errors, t values, and standardised estimates, first column presents 3rd &4th grades, and second column presents 5th & 6th grades. For R^2, values are in parenthesis present 5th & 6th grades.

Table 3. Direct and Indirect Effects on Self-efficacy and Performance

Effect	Direct Effect		Indirect Effect		Total	
	1st	2nd	1st	2nd	1st	2nd
On performance	.474*	.152	.000	.000	.474*	.152
-of self-efficacy	-.129*	.183*	.100*	.076	-.029	.259*
-of performance accomplish	-.072	-.074	-.018	.004	-.090	-.070
-of vicarious learning	-.285*	.019	.103*	.007	-.182*	.026
-of verbal persuasion	.447*	-.027	.329*	-.026	.776*	-.053

-of anxiety						
On self-efficacy	.212*	.500*	.000	.000	.212*	.500*
-of performance accomplish	-.038	.030	.000	.000	-.038	.030
-of vicarious learning	.216*	.043	.000	.000	.216*	.043
-of verbal persuasion	.694*	-.173*	.000	.000	.694*	-.173*
-of anxiety						

Note: For r, direct effects, indirect effects, and total effects, first column presents 3rd &4th grades, and second column presents 5th & 6th grades. *p<.05.

In terms of gender roles, Univariate analyses of variance (ANOVA) were performed for the four sources of self-efficacy information, self-efficacy, and performance outcome. Dependent variables in the ANOVA were the four sources of self-efficacy information, self-efficacy, and performance. The independent variable was gender. ANOVA findings revealed no significant differences for the four sources of self-efficacy information, self-efficacy, or performance.

The Question of Overconfidence

Past findings (e.g., Hackett & Betz, 1989; Pajares, 1996; Pajares & Kranzler, 1995; Pajares & Miller, 1994) suggest that students are overconfident about their capabilities in solving maths problems. The analysis of overconfidence of maths self-efficacy in this study was explored using the statistical method entailed in the Hackett and Betz (1989, p.266) study. This involved computing self-efficacy/performance deviation scores (*D* scores) by separately transforming scores on the self-efficacy and performance scales to standardised scores (z scores), and then subtracting the performance z scores from the self-efficacy z scores for comparable items. Mean *D* scores were calculated for each student; these *D*-score means are an index of the average difference on each item between self-efficacy and performance with regard to maths problems.

Table 4 presents the overestimation, underestimation, and congruence for maths self-efficacy. According to Dowling (1978, cited in Hackett & Betz, 1989), *D* scores are classified into five categories: overconfident (*D* scores>0.8), somewhat overconfident (0.4< *D* score<0.8), congruent (0.4>*D* score>-0.4), somewhat underconfident (-0.4>*D*score>-0.8), and underconfident (*D* score<-0.8). The percentage of boys and girls falling into each *D*-score category is presented. Overall, 53% of the students had D scores in the congruent range. Twenty-three percent of students were in the overconfident range (somewhat overconfident or overconfident), and 24% were in the underconfident range (somewhat underconfident or underconfident). In terms of gender roles, 17% of girls were classified as overconfident, 50% congruence and 33% as underconfident, compared to 29% of the boys classified as overconfident, 56% congruence and 16% as underconfident.

STUDY 2

Method

Subjects

Two hundred seventy-two students (104 girls: 116 boys) enrolling in 5th and 6th grades from the three same government schools mentioned in Study I participated in the preset study. The sample for this study was part of a major study for a Ph.D. research by the first author.

Procedure

The administration of the Four Sources of Self-efficacy Information instrument (FSSEI-M) and the Self-efficacy instrument (SEI-M) was conducted by the first author and a female research assistant in the students' classes. The teacher was present in the room but was not involved with administering the questionnaires. Students were assured of confidentiality that their answers would only be seen by the author and research assistant.

Instruments.

Four Sources of Information. For the Four Sources of Self-efficacy Information Instrument for maths (FSSEI-M), the structured multiple-choice instrument was the same instrument administered for 3rd and 4th grade students (See Study 1 for details of items).

Maths Self-efficacy. The Self-efficacy Instrument for maths (SEI-M) developed by the authors contained twenty items, comprising of general, intermediate, and specific items. This maths self-efficacy measure corresponded closely to the K-Yr6 Maths Curriculum. The maths self-efficacy items (SEI-M) included, for example, "How confident are you that you can learn Maths?" (General item), "How confident are you that you can do Addition?", "How confident are you that you can do Subtraction?" (Intermediate item), and "How confident are you that you can choose which one of these numbers is between 1.3 and 1.5-a) 1.04, b) 1.43, c) 1.20, d) 1.51?", and "How confident are you that you can solve '200 grams of solid butter becomes about one cup of melted butter. How many grams of solid butter are needed to make 1/4 cup of melted butter?" (Specific items). Reliability estimate for the SEI-M was .89.

Achievement Test. The achievement test for maths contained 15 multiple-choice questions. The questions were taken and modified from the NSW department of education Basic Numeracy and Literacy Skills tests (Yrs 5-6)(1998). Sample items included "Solve 14 + 15 = _____" and "9 multiply _____= 36". A KR20 reliability coefficient of .63 was reported for this instrument.

Table 4. Frequency of Overconfidence and Underconfidence by Gender

D Score category	Female		male		Total	
	1st	2nd	1st	2nd	1st	2nd
Overconfident	3.5%	1.2%	6.7%	4.3%	5.2%	2.9%
(above 0.8)	13.2%	16.1%	22.2%	21.5%	18.1%	18.9%
Somewhat overconfident	50.0%	66.7%	55.5%	55.9%	53.0%	61.0%

(from 0.4 to 0.8)	13.1%	9.8%	8.2%	8.6%	10.4%	9.2%
Congruence	20.2%	6.2%	7.4%	9.7%	13.3%	8.0%
(from - 0.4 to + 0.4)						
Somewhat underconfident						
(from - 0.8 to - 0.4)						
Underconfident						
(below - 0.8)						

Note: 1st column presents 3rd & 4th grades; 2nd column presents 5th & 6th grades.

Results

The Direct/Indirect Effects between Sources, self-efficacy & performance

Table 1 presents the means, standard deviations, and Pearson-Product moment correlations for the six variables in the present study. Maths self-efficacy scores ranged from 12 to 84, the possible minimum and maximum, and averaged 74.4 respectively on the total instrument (6.20 per item on a 7-point Likert scale). Achievement scores for the 15-item performance measure averaged 12.47 and ranged from 1 to 15 respectively.

Bivariate correlations among the six variables for maths were significant. Path analysis performed using Lisrel for the proposed path model indicated saturated perfect model fit. Although Bandura's (1986, 1997) theory posited the four sources of information as being relevant to self-efficacy beliefs, and that the various fit indices indicated the proposed a priori models were adequate in model fit, not all paths were however significant.

Table 2 presents the decomposition of effects from path analysis. For maths self-efficacy, performance accomplishment (B=.231, t=7.26) and physiological states (B=-.08, t=2.82) were significant. For performance outcome, only performance accomplishment (B=.107, t=-2.01) was significant. The independent variables accounted for 10% of the variability in problem-solving performance and 36% of the variability in self-efficacy. Figure 2 presents the path model with the independent variables accounting for the variability in performance. The residual path coefficients R that represent factors affecting a specific variable but that are not measured or accounted for in the model are also shown in Figure 2.

Table 3 presents the direct and indirect effects for the path model proposed in Figure 2. Unexpectedly, only path coefficient from performance accomplishment (B=.183) to performance was significant. Consistent with social cognitive theory, the direct effects of performance accomplishment (B=.500) and physiological states (B=-.173) to self-efficacy were significant, indicating that they are important sources of self-efficacy information. The strong influence of mastery experiences on self-efficacy compared to physiological states confirms Bandura's (1986, 1997) proposition regarding the order of potency.

In terms of gender roles, Univariate analyses of variance (ANOVA) were performed for gender and self-efficacy. Dependent variables in the ANOVA were the four sources of self-efficacy information, self-efficacy, and performance. The independent variable was gender. ANOVA results revealed a significant univariate effect for maths physiological states, F(1,

189)=10.493; p<.001. No other significant ANOVA findings were found either for the four sources, self-efficacy, or performance.

The Question of Overconfidence

The question of overconfidence was examined using the statistical method employed in study 1. Table 4 presents the overestimation, underestimation, and congruence for maths. Overall, 61% of the students had *D* scores in the congruent range. Twenty-one percent of students were in the overconfident range (somewhat overconfident or overconfident), and 17% were in the underconfident range (somewhat underconfident or underconfident). In terms of gender differences, 17% of girls were classified as overconfident and 16% as underconfident, compared to 26% of the boys classified as overconfident and 18% as underconfident.

Discussion of Findings

The first objective of this research was to investigate the predicting and mediational role of maths self-efficacy. Path findings emerging from this research revealed that students' self-efficacy beliefs about their maths made an independent contribution to the prediction of their maths problem-solving performance when other motivational variables were controlled. In addition, the information sources performance experiences, verbal persuasion, and physiological states were predictive of maths problem-solving performance. Regarding prior maths experiences, researchers exploring the predicting and mediational role of maths self-efficacy have reported similar findings (Pajares & Kranzler, 1995; Pajares & Miller, 1994). Finally, maths self-efficacy mediated the effects from multiple sources of self-efficacy information onto maths-problem performance.

The second objective of this research was to examine Bandura's (1986, 1997) order of potency of the sources of self-efficacy information. From Study I, findings reported that students' states of emotional arousal were most influential in maths self-efficacy, followed by verbal persuasion and performance accomplishments. It is of particular importance to note that this finding supports Bong and Clarke's (1999) assertion, wherein young students often lack the relevant mastery experiences to develop their perceptions of capability depend on alternative sources of self-efficacy information to develop their maths self-efficacy beliefs. In contrast to this finding, Study II reported findings which confirm Bandura's (1986, 1997) order of potency for two sources of self-efficacy information-performance accomplishment and physiological states. Analysis of variance reported gender differences wherein girls in 5^{th} and 6^{th} grades were more anxious than boys. This suggests that over time, boys and girls become more differentiated in their states of emotional arousal.

The implication of concern involves the relevant information sources required in the acquirement and modification of maths self-efficacy. The findings in the present studies confirm Bandura's (1986, 1997) theory, wherein self-efficacy beliefs are acquired and modified from personal experiences, social persuasion from peers and adults, and physiological states. As students develop over time, they become more selective in their choice of choosing the right source of self-efficacy information when acquiring and developing their maths self-efficacy judgements. The fact that vicarious learning did not account any significant variance in this study emphasises the need to make and acknowledge this source. For example, through verbal persuasion, "Look how Tom is doing, and follow his steps" and "See if you can do this like Sarah!", vicarious learning may be encouraged to students.

The third objective of this research was to investigate students' accuracy of self-perceptions of maths capability. Findings from both studies are consistent with recent findings from

similar investigations (e.g., Pajares, 1996; Pajares & Miller, 1994; Pajares & Kranzler, 1995). Older students (5th & 6th grades) were found to be more congruent in their perceptions of maths capabilities than younger students (3rd & 4th grades), who showed tendencies to overrate and underrate their perceptions of maths capabilities. This suggests then that over time, students progressively become more accurate in appraising their maths capabilities. In this research, 5th and 6th grade students represent the highest academic strata of the student population *in relation* to a primary school setting and thus either possess or develop more accurate self-perceptions than do their younger counterparts. This finding of accuracy, according to Pajares (1996), is a two-edged sword, as Bandura (1986) suggests that some overestimation of capability is useful as this encourages and increases effort and persistence. Furthermore, though this accurate estimation of self-perceptions enables students to more accurately assess their problem-solving strategies, it does however limit students' sense of optimism and lower levels of self-efficacy primary functions-for example, effort, persistence, and perseverance (Bandura, 1997).

Though the findings in this study add further impetus to the field of self-efficacy, there are methodological caveats and directions that should be considered in future research. It is the intent of the authors here to address only salient methodological problems and directions that are of most pressing concern in this area of self-efficacy research. For those who are interested in a detailed analysis of methodological problems and limitations in self-efficacy, they are advised to consult elsewhere (e.g., Hackett & Betz, 1995; Pajares, 1997). Firstly, the findings in the present study should extend to other subject disciplines. A review of literature in self-efficacy research has seen considerable theoretical and empirical attention paid to maths and writing (Pajares, 1996; Pajares & Kranzler, 1995; Pajares & Valiante, 1999). Recently, the Department of Education and Training (1998) in Australia has restructured their policies to place more emphasis in literacy and science and technologies in classroom learning, and not just maths.

Secondly, though path analysis techniques are robust in handling cross-sectional data and allow researchers to explore the different predicting and mediational paths between different motivational variables (Georgiou, 1999), they do not however allow researchers to predict causal inference between self-efficacy and performance outcomes. When one time point is measured, the influence of one variable onto another variable may in fact be artificially inflated. In addition, path analysis uses composite scores to form measured variables (e.g., self-efficacy, performance), where errors are considered as negligible. Recently, a more stringent, rigorous statistical technique, structural equation modeling (SEM), has been increasingly recommended and used in self-efficacy research (e.g., Randhawa, Beamer, & Lundberg, 1993; Skaalvik & Rankin, 1998). In brief, the advantage of SEM compared to other multivariate methods is that both latent and measured variables are included in the final analysis; thus, in total, a structural model contains only latent and measured variables with their respective errors accounted for. According to Marsh and associates (e.g., Marsh, 1990; Marsh & Yeung, 1997), to explore the possibility of causal inference between self-efficacy and different motivational variables (e.g., performance), multiple time points *and* SEM should be used simultaneously.

Thirdly, regarding the four sources of information, future research should explore the different latent possibilities of the four efficacy information sources for different subject disciplines. As entailed, in a recent study, Phan and Walker (2000) used Confirmatory factor analysis (CFA) to examine the latent structure of the four maths self-efficacy sources with 3rd and 4th grade students. Similar confirmatory analytic findings have also been found with older students (Lent et al., 1996), wherein the four sources represented distinct, though related, latent dimensions, and that three of the four sources formed a higher-order factor.

Fourthly, one limitation in any motivational research where young children are involved is the fatigue-and-boredom factor. As was the case in this study where two structured questionnaires were used, effort was made to make each item and instrument short and precise. Thus, the instruments administered in this study do not lend themselves to reflect all aspects of the four sources. For example, the vicarious learning scale only reflected peer learning and not adult learning. Thus, future research should have more refined measurements, for example, structured multiple questionnaires reflecting adult vicarious learning (e.g., "My parents are good in maths"), qualitative interview, reflecting the questions of how children acquire and modify their self-efficacy beliefs. In a recent study, Lent, Brown, Gover, and Sukhvender (1996) used the technique of Thought-Listing Analysis to cognitive analyse and assess the four maths sources of self-efficacy information. This cognitive method may help to illuminate how students process efficacy-relevant information and arrive at efficacy estimates under more natural conditions.

Finally, Bandura's (1986) theory cautions that "ill-defined global measures of perceived self-efficacy or defective assessments of performance will yield discordances" (p.397). Any assessment regarding specificity of measurement that does not conform to the guidelines established results in ambiguous and inconclusive findings (Pajares & Miller, 1995). In a recent study, Pajares and Miller (1995) treated the three subscales of Betz and Hackett's (1983) Maths Self-efficacy Scale (MSES) as three separate scores and not as one generalised score. Students' confidence to succeed in a maths-related course, problem, or task was predictive respectively to their outcomes related to maths course, problem, and tasks. In primary schools, often the assessment of a students' overall performances in a subject domain do not involve quizzes, tests, or end-of-term or year-examinations for that matter; instead, an overall accumulative mark is usually preferred, consisting of teachers' gradings (e.g., A, B, C) for in-and-out of class activities, self-and-group presentation, or take-home projects consisting of several days of work. It would be noteworthy then to include longitudinal, qualitative research wherein self-efficacy assessment consists of more than one level of specificity (i.e., global, intermediate, specific), for example, "I can learn maths", "I can participate well in maths activities", and "I can complete these tasks and activities in one week". Subsequent performance outcomes could include the activities, problems, and tasks mentioned tailoring closely to the different levels of specificity.

Overall, the findings in this research provide further evidence regarding the predicting and mediating relations between self-efficacy beliefs and performance outcomes. For 3rdand 4th grade students, path analytic findings revealed three of the four sources were predictive of maths self-efficacy beliefs. Students' self-efficacy beliefs were also predictive of performance outcomes. For 5th and 6th grade students, findings were supportive of Bandura's (1986, 1997) order of potency with two of the four sources-performance accomplishment and physiological states. Students' self-efficacy beliefs, however, were not predictive of performance outcomes. Finally, older students were more accurate in their judgements of perceived self-efficacy beliefs regarding maths capabilities compared to younger students.

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Appendix

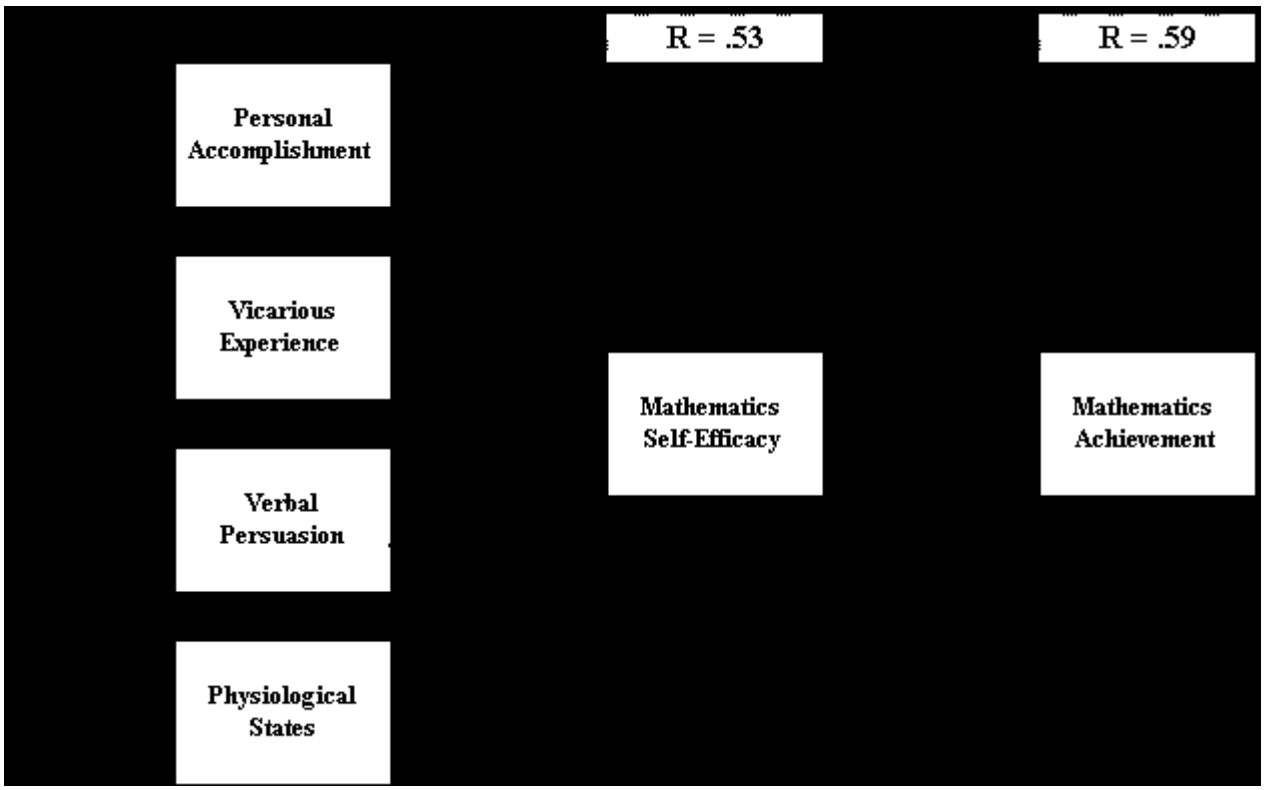

Figure 1. A Path analysis between the four sources, self-efficacy, & performance.

Note: Standardised coefficients are enclosed in parenthesis and significant coefficients are indicated by *, $p<.05$. N=383.

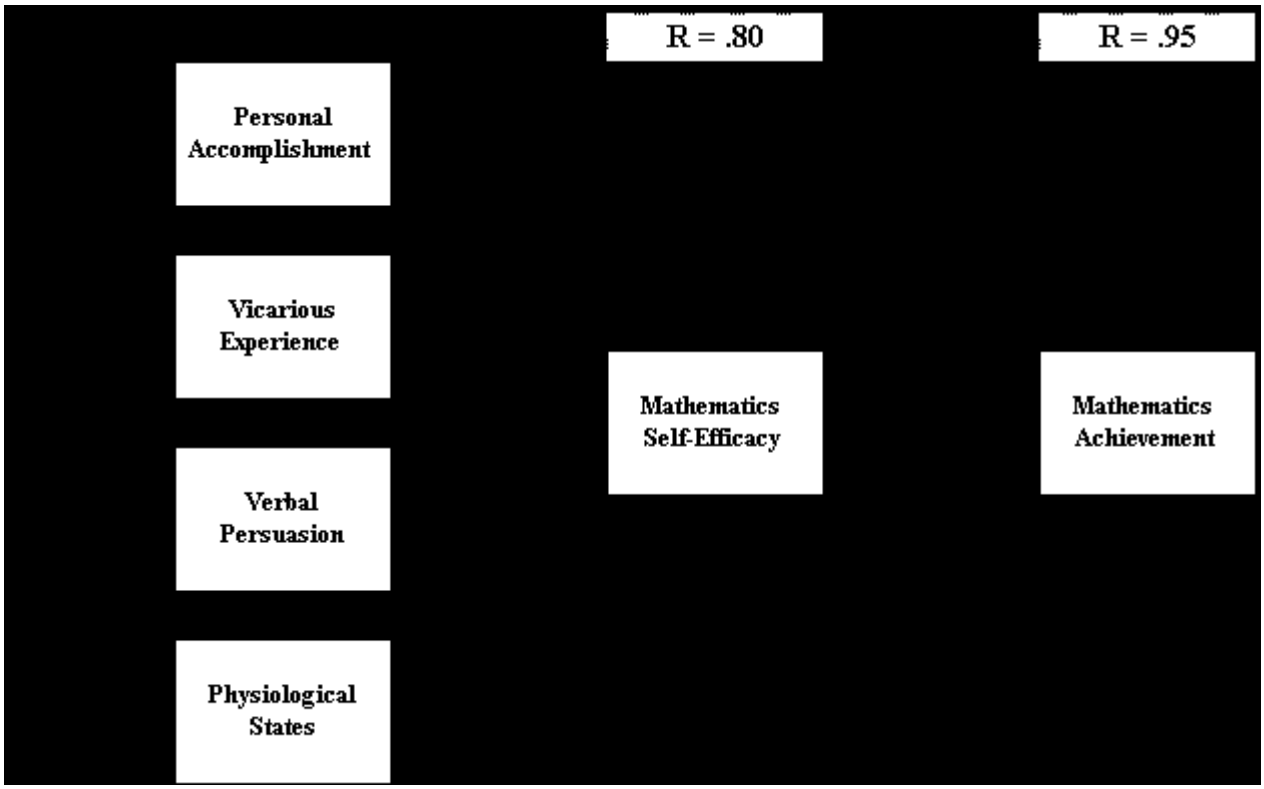

Figure 2. A Path analysis between the four sources, self-efficacy, & performance.

Note: Standardised coefficients are enclosed in parenthesis and significant coefficients are indicated by *, p<.05. N=272.