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Author/s:

Winheller, S;Hattie, JA;Brown, GTL

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Factors Influencing Early Adolescents' Maths Achievement: High Quality Teaching Rather than Relationships

Sandra Winheller ^{a,*}, John A. Hattie ^b, Gavin T. L. Brown ^c

Author names and affiliations:

Sandra Winheller ^a, University of Paderborn, Faculty of Arts and Humanities, Department of Education,
Warburger Str. 100, Paderborn 33098, Germany, swinheller@uni-paderborn.de

John A. C. Hattie ^b, University of Melbourne, Melbourne Institute for Research in Education, Australia,
j.hattie@auckland.ac.nz

Gavin T. L. Brown ^c, Hong Kong Institute of Education, Curriculum & Instruction, 10 Lo Ping Rd, Tai Po, NT,
Hong Kong SAR, gtlbrown@ied.edu.hk

* Corresponding author:

Dr. Sandra Winheller, University of Paderborn, Faculty of Arts and Humanities, Department of Education,
Warburger Str. 100, 33098 Paderborn, Germany. Phone number: +49 52 51. 60-2937, Fax number: +49 52 51.
60-3243, E-mail address: swinheller@uni-paderborn.de.

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1. Introduction

School quality is a multi-faceted concept which goes beyond transmission of knowledge or the development of learning skills to include structure, teaching, curricula, affective, and social environments. Accordingly, researchers have sought to identify the interplay of affective factors and relationships within schooling that support the enhancement of academic achievement (Ainley 1999; Anderson and Bourke 2000). Epstein and McPartland (1976) operationalized quality of school life in a questionnaire that asks students to give their perceptions of school work, teaching, school climate, and students' social and task-related experiences and relationships with authorities and peers. Of the various quality of school life factors, the extent to which students felt successful in school (i.e., Achievement) has been consistently associated with elementary and high school mathematics achievement in Australia (Rothmann and McMillan, 2003). On the other hand, in Australia, other quality of life constructs have generally been uncorrelated with mathematics achievement. For example, students' scores on the 'Adventure' ("feeling excited about the work"), 'Teacher-Student relations' ("my teacher is fair to me"), 'Social integration' ("I learn to get along with other people"), or 'General satisfaction' ("I feel happy") scale were not correlated with achievement scores.

However, other studies on effective teaching have emphasized the importance of an 'inviting' climate for learning, where learning is engaging, appropriately challenging, and enjoyable (e.g., Bourke 1993; Hattie 2009b; Leonard et al., 2002). Results from the Programme for International Student Assessment (PISA) supported the importance of classroom environment and atmosphere in students' school life across countries (Schleicher 2002). Data from 31 participating countries (including New Zealand) showed that the learning environment of schools, including school climate, was one of the more important contributing factors to students' academic outcomes. In this context Mok and Flynn (2002) administered a refined version of Flynn's Quality of School Life scale (1993; orig. by Williams and Batten 1981) and found that positive classroom atmosphere contributed significantly to students' quality of school life, after controlling for students' sex and the development expectations which they had of schools. In their study, female Australian high school students had better quality of school life, as well as higher development expectations of their schools and more positive attitudes toward the classroom atmosphere than their male counterparts.

Furthermore the quality of teacher-student relationships is a central aspect of classroom climate. Eccles (2009) stated that climate was optimal when teachers who trust, are respectful to students, care about and care specifically about students' learning, provided the social-emotional and intellectual background that students need to engage, approach, and persist on academic learning tasks and to develop achievement-related self-perceptions (see also Deci and Ryan 2002; Wigfield et al., 2006).

In addition to relations with teachers, the quality of school life also depends on students' relations with their peers (Wentzel and Looney 2006; Wentzel et al., 2004). Patrick and Townsend (1995) found that perceived social competence with peers was an important factor as early as Grade 1. A collective commitment to learning was the only class variable found to be important for assessing the quality of school life among elementary school students (Bourke and Smith 1995). Hence, social perceptions of peers, particularly at high school, are significantly important for student's academic progress and achievement (Patrick et al., 1997).

However, the relationship of school quality perceptions to academic performance may be partially mediated by students' perceptions or attitudes towards the subject being used to evaluate academic (future) performance. For example, self-efficacy characterizes students' confidence that they are able to do work in a specified domain (Bandura, 1997). As a consequence, self-efficacious students agree that their assessment results are more an outcome of hard work and their engagement rather than an inborn ability (Wigfield 1994). The PISA, TIMSS, and Progress in International Reading Literacy Study (PIRLS) data show that the awareness of or belief in self-efficacy is positively related to average performance in mathematics (Satherely 2006). For example in the PISA studies, self-efficacy predicted achievement in a similar manner across all countries (i.e., $\beta = .18$ reading, $.12$ mathematics) (Marsh et al., 2006).

In this context Else-Quest and colleagues (2010) examined data from TIMSS (focus on basic math knowledge) and PISA (focus on students' ability to use their math skills in the real world) in a meta-analysis, representing 493,495 students ages 14-16 from 69 countries. Results showed that girls around the world are not worse at math than boys – on average there were only small gender differences for each – but girls felt significantly less confident in their math abilities than boys, and were less motivated to do well. These results underline girls not trusting in their abilities and the low self-efficacy expectations they have (Bandura 1997) which is well described in the literature as unfavourable attributional pattern (Baumert et al. 1998; Rustemeyer and Jubel 1996;) linked to achievement motivation (Nicholls 1984; Ziegler and Schober 2001).

Besides self-efficacy, 'liking a subject' has been shown to be an important relative to academic performance. Generally, New Zealand students 'like' mathematics. The Year 5 TIMSS-02/03 survey reported students enjoyed learning mathematics a lot, and that the reported levels of enjoyment were generally not related to achievement for Pākehā, Pasifika or Asian students (Caygill et al., 2007). Usually, across several multi-year surveys (e.g., asTTle, NEMP) positive attitudes decrease across the years (Satherely 2006). Nevertheless, 'liking of' or 'interest in' a subject has been found to have a statistically significant relationship with academic performance. Marsh and colleagues (2006) showed that 'interest in' a subject predicted achievement (i.e., $\beta = .33$ reading, $.37$ mathematics) in 25 countries involved in the PISA studies.

Thus, ‘liking a subject’, ‘self-efficacy’, and ‘Quality of School Life’ (QSL) evaluations have all been shown to be important predictors of academic performance. Among unresolved issues in how quality of school life factors relate to mathematics achievement is whether it is the ‘teacher’ or ‘teaching’ rather than the ‘learning environment’ that makes the difference. Oftentimes students can distinguish between the teacher and the environment: they may or may not like the teacher, or they may or may not like the methods of teaching they experience. Further, it is not always clear that ‘liking a subject’ or ‘having a sense of self-efficacy’ is more critical to success and engagement in mathematics. Their *inter-relationship* and *interplay* to the learning environment and joint effect on academic performance should be more focused. Thus, to examine better the relationship of school quality to academic performance, three blocks of variables were used, namely, (1) students’ sex and ethnicity (characteristics), (2) students’ perception of quality of school life, and (3) students’ attitudes towards mathematics. Figure 1, shows that the student characteristics variables are presumed to shape, not only their academic performance, but also their evaluation of school factors and their attitudes towards mathematics. In addition, we presume that the more general environmental evaluations predict more specific subject evaluations, rather than conversely. Moreover, we predict that in environments in which mathematics performance in general is relatively good, that school quality attitudes will have a positive impact on academic performance both directly and indirectly through more positive subject attitudes.

2. Aim of the study and conceptual framework

The focus of the present study is whether the mathematics performance of elementary and high school students is positively predicted by students’ perception of peers, teachers and the quality of the learning environment as well as by their attitudes towards mathematics like ‘liking the subject’ and ‘self-efficacy in’ this subject. The aims of this study were (1) to validate a QSL factor structure in the New Zealand school context, and (2) to explore relationships which are effective in promoting students' academic maths performance. The study evaluates claims that academic performance in mathematics is increased through possession of positive ‘liking of’ and ‘self-efficacy in’ mathematics, and through positive relations with peers, teachers, and the learning environment.

It is interesting to investigate the relationship of quality of school life perceptions in New Zealand because, unlike Australia, it has consistently high levels of performance in mathematics while being a very similar society to Australia, in terms of language, history, and educational policies. For example, in PISA 2006, involving almost 5000 15-year-old students, New Zealand had a mean below only five of the 57 countries participating, with no significant changes between 2003 and 2006 (Telford and Caygill 2007). Likewise, the Trends in

International Mathematics and Science Study (TIMSS) in 2002-2003, New Zealand students' mean achievement in mathematics was significantly higher than the mean for 46 countries participating, with no significant change in Year 9 students' mathematics performance over the eight years from 1994 to 2002 (Chamberlain, 2007).

Mathematics achievement in New Zealand, however, is not invariant by student demographic characteristics. In PISA 2006, sex differences were observed in 10 of the high-performing countries including New Zealand; on average, boys performed significantly better than girls (Telford and Caygill, 2007; see also Else-Quest et al. 2010). Moreover, Asian students in New Zealand scored 50 points above the international PISA mean (Telford and Caygill, 2007). Overall, New Zealand European (i.e., Pākehā) and Asian students' achievement was higher at all school levels than that of their Māori and Pasifika peers. This ethnic discrepancy appears in both international testing programs and in national surveys from grades 4 through 12 (e.g. Caygill et al., 2007; Leeson et al., 2005; Satherely 2006). Thus, examining New Zealand student perceptions of school quality in the context of assessing mathematics academic performance had the potential to discover whether QSL constructs, previously not associated with academic performance had different relationships in a nation that is generally high performing. Furthermore, the study permits the identification of whether other factors mediate or attenuate the influence of school quality perceptions. Additionally, given the large discrepancies in performance within New Zealand society, it was possible to examine whether student demographic characteristics contributed to the influence of school quality constructs.

2.1. Variables in the study

The conception, operationalization, and sub-hypotheses for each block are defined before reporting relationships among the three blocks of variables and to students' academic performance in mathematics.

2.1.1 Students' background - Sex and ethnicity

As discussed above, there are systematic and stable patterns of academic performance in New Zealand by ethnic group and there are reasons to believe that boys will outperform girls. Regarding these empirical findings following hypotheses will be generated:

1. Boys' academic performance will be better than girls.
2. Pākehā (NZ European) and Asian students' academic performance will be higher than that of Māori and Pasifika students.

Student's sex and ethnic background were operationalized in terms of female/male and Pākehā (NZ European), Asian, Māori, and Pasifika students. Students self-reported their ethnicity by selecting all the people groups they

believed applied to them. Standard Statistics New Zealand procedures for dealing with multiple selections were applied: (1) all selections which included Māori were classified as Māori; (2) all selections which included Pasifika but not Māori were classified as Pasifika; (3) all selections which included Asian, but not Māori or Pasifika were classified as Asian. Higher scores on students' sex and ethnicity indicated boys and non-European students.

2.1.2 Students' perception of quality of school life factors

The 'Quality of School Life' inventory, developed by Epstein and McPartland (1976), has been shown to be reliable and has meaningful interpretations in many school contexts; for example, United States (Wright and Jesness 1981), Canada (Isherwood and Ilammah 1981), and West Germany (Scheerer 1981). In Australia, based on the work of Williams and Batten (1981), a new QSL questionnaire was developed by Ainley, Reed and Miller (1986). This QSL questionnaire included two general scales 'General Satisfaction' and 'Negative Affect', together with five domain-specific scales: 'Teacher Interaction' (Relationship, Satisfaction), 'Status', 'Identity', 'Opportunity', and 'Achievement'. This 40-item multi-dimensional measure has been applied to elementary, middle, and high school students and has been widely confirmed and extensively tested in schools in different countries (Ainley and Bourke 1992; Linnakyla 1996; Mok 1992; Pang 1999; Wilson 1988).

Instead of the achievement factor, this study chose to focus on factors which had not previously been shown in QSL studies to meaningfully relate to academic performance, but which elsewhere had been shown to be influential on academic performance. It was considered that New Zealand's high academic performance in mathematics and the presence of subject-related attitudes would potentially expose new relationships between quality of school life and academic performance. Furthermore, because the QSL items were presented at the end of a 40-minute mathematics test, students did not have a great deal of time to complete many quality of school life items within a standard school period. Hence, only two factors from the QSL questionnaire of Ainley and Bourke (1992) were selected and included in the asTTle mathematics tests for each school level.

Elementary students were presented with the 'Teacher cares about me' (5 items e.g., "My teacher listens to what I say"; model synonym: 'Quality of Teachers') and 'Enthusiasm for learning' (5 items e.g., "Learning is fun"; model synonym: 'Quality of Learning') factors. High school students were presented the 'Positive peer interactions' (6 items e.g., "Other students accept me as I am"; model synonym: 'Quality of Peers') and 'Satisfaction and involvement with learning' (6 items e.g., "I always achieve a satisfactory standard in my work"; model synonym: 'Quality of Learning') factors. All responses were recorded on a four-point rating scale,

with 4 indicating a strongly favourable response (“I agree a lot”) through to a score of 1 indicating an unfavourable response (“I disagree a lot”).

Table 1 shows the psychometric evidence from selected studies in English-speaking countries for the four QSL factors used in this study. The evidence suggests that the factors have robust internal consistency characteristics across diverse samples.

Based on the literature reviewed, we expected that the following sub-hypotheses were tenable:

1. Supportive teacher treatment will be associated with liking mathematics and with higher academic performance (elementary school sample).
2. Enthusiasm for learning will be associated with self-efficacy in mathematics as a subject and with higher academic performance (elementary school sample).
3. Social involvement with classmates will be associated with liking mathematics, and higher academic performance (high school sample).
4. Satisfaction and involvement with learning will be associated with self-efficacy in mathematics and higher academic performance (high school sample).

2.1.3. *Students’ attitudes towards mathematics*

In the current study, as part of the mathematics test, students completed three items related to their self-efficacy or confidence in mathematics (e.g., “How good do you think you are at maths?”) and three-items related to interest in or liking of mathematics (e.g., “How much do you like doing maths at school?”). Items were derived from the National Education Monitoring Project with permission (Crooks and Flockton 2005) and have been shown to form two inter-correlated scales (’Otunuku and Brown, 2007). Students responded by selecting one of four “smiley” faces ranging from “very unhappy” (score=1) to “very happy” (score=4). The alpha coefficient of the six-item scale for elementary students was .83 (liking $\alpha = .70$, efficacy $\alpha = .82$) and for high school students .77 (liking $\alpha = .74$, efficacy $\alpha = .70$). Consistent with the self-efficacy research we expect that increased confidence in mathematics to lead to increased academic performance. The research literature also leads us to expect that increased liking of mathematics would contribute to increased performance. However, the effect of sex and ethnicity on attitudes towards mathematics is mixed and we expected small differences at most.

2.1.4. *Academic performance of mathematics*

To measure students’ academic performance of mathematics, the asTTle mathematics scores were derived through one-parameter item response theory (IRT) scoring. IRT scores take into account the level of difficulty of

each item answered correctly, and, hence, students are awarded marks based on the difficulty of items answered correctly instead of the number of items answered correctly (Embretson and Reise 2000). The asTTle IRT scores were transformed to a scale score (Year 6 $M = 500$, $SD = 100$), and the standard error of measurement for asTTle performance estimates has been estimated to be 15 (Hattie et al., 2004). Consistent with previous studies, we expected significant differences in mathematics performance by ethnicity; whereas we expected but small differences according to sex.

3. Study Design

The current study was a cross-sectional survey using self-administered questionnaires with closed-ended rating scales for four QSL scales (i.e., 'Teacher cares about me', 'Enthusiasm for learning' 'Positive peer interaction', 'Satisfaction with learning') and two subject-attitude scales (i.e., 'Liking of Mathematics' and 'Self-efficacy in Mathematics'). The data were collected as part of the national norming for the Assessment Tools for Teaching and Learning (asTTle) between 2000 and 2004 in New Zealand (Hattie et al., 2004). AsTTle is a curriculum-referenced, standardised-test software system which allows teachers of elementary and high schools to develop their own customized standardized tests of reading, writing, and mathematics related to norms for students in Years 4–12. There were about 1500 mathematics items in Version 4 of asTTle, and booklets of about 40 items were created using an item-matrix methodology. Each booklet consisted of about a 60:40 mixture of closed (multiple-choice, matching) and open ended (short answer, drawing) items to provide teachers creating a 40-minute test. All items were calibrated using a Rasch model on the performance of about 25 000 students who were presented with one of multiple, age-appropriate, paper-based mathematics tests. The qualities of the items, the test scores, and the reporting methods are reported in Hattie (2006) and Hattie, Holt, and Rajkumar (2008), and all are of high psychometric quality. Dependant on the school level (i.e., elementary or high school) and age, a subset of the test forms contained between 10 and 12 QSL items. Students completed these as an additional, voluntary research activity after they had finished their mathematics test. The asTTle mathematics norming for Years 8-12, using a mixture of full primary, intermediate, and high schools, took place in June 2003 (i.e., about half-way through the school year). Hence, the students had sufficient experience with their mathematics teacher to evaluate the quality of the learning environment.

3.1. Participants

Education in New Zealand follows a three-tier model with two stages of compulsory schooling; that is primary schools (elementary schools: Years 1-8, age range 5 to 13) and secondary schools (high schools; Years

9-13, age range 13 to 18). The academic year runs from late January until mid-December for primary and secondary schools and is normally broken into four 10-week terms. Within the primary sector, there are three major school types (i.e., Contributing Years 1-6 only; Intermediate Years 7-8 only, and Full Years 1-8). Within the secondary sector the majority of schools cover Years 9-13, while a minority begin at Year 7. Co-educational schools account for about two-thirds of student enrolment in the secondary sector. There are about 2000 primary schools (with an average size of about 165 students) and approximately 500 secondary schools (average size approximately 700). Almost all schools are fully-funded by the government, with only about 10% of students in private schools. Schools in lower socio-economic regions receive considerable extra funding per pupil relative to schools in wealthier regions.

Altogether 608 students from 567 different New Zealand schools answered the asTTle tests forms that had the subject attitudes questions and the QSL items. Hence, approximately one student per school was presented with a test form which had the QSL factors. The schools were distributed across socioeconomic categories and were situated in communities of varying sizes (for more on the background to the entire sample and items, see Hattie 2009a). Student ethnic backgrounds approximated NZ population distributions (71% Pākehā/New Zealand European; 14% Māori; 3% Pacific Islander; 12% Asian/Others). The elementary sample included 336 students from Grade 8 (nominal age 12) of which 181 were girls and 155 boys. The high school sample consisted of 272 students from Year 10 (nominal age 14), of which 181 were girls and 91 boys.

3.2. *Analysis Methods*

The analysis involved first confirming the expected factor structure of the QSL aspects and subject-attitudes using confirmatory factor analysis (CFA; Anderson and Gerbing, 1988). Upon finding a stable, theoretically meaningful relationship in each measurement model, multiple-group confirmatory factor analysis (MGCFA) was used to establish factorial invariance of the models for different populations of students (i.e., sex and ethnicity). The general idea of MGCFA is to compare the model fit when the individual model parameters are estimated separately for different subpopulations to the fit when certain parameters are set to be invariant across the subpopulations (Byrne, 1989, 2004). Both the changes in χ^2 (Byrne 2004) and changes in CFI (Cheung and Rensvold, 1999, 2002) are used to determine degree of invariance between groups for each model. Weak invariance is imputed when metric variance is found for regression weights, while strong invariance is imputed when scalar variance is found for regression intercepts. Then, structural equation modeling (SEM; Byrne, 2001; Klem, 2000) was carried out to investigate the inter-relationships of three structures (i.e., QSL factors, subject attitudes, mathematics performance). SEM allows the simultaneous estimation of regression paths among latent

and manifest variables in a model. Maximum-likelihood estimation was used in all analyses (Jöreskog and Sörbom, 1996).

A number of measures of fit are less affected by sample size, model complexity, or model mis-specification. These include the standardized root mean square residual (SRMR), the root mean square error of approximation (RMSEA), and gamma hat – which have been shown to be resistant to the impact of large samples, complex models, and model misspecification (Fan and Sivo, 2007; Hu and Bentler, 1999; Vandenberg and Lance, 2000). Models with gamma hat $>.90$ and RMSEA and SRMR $<.08$ appear to approximate the data well enough to not be rejected (Marsh et al., 2004; Steiger 2000). All analyses were conducted with AMOS 7 (Arbuckle 2006).

3.3. Data imputation

Missing values were addressed prior to analysis. Participants who had missed two or more items in the QSL scale were removed and missing values were imputed for those with only one missing response. Of the 336 elementary students, 38 students left one item blank, 29 out of 272 high school students missed one item. The maximally weighted proportional factor score regression was used as estimation method, in which a substitution of the linear regression trend value for the missing values was implemented (Holmes-Smith and Rowe, 1994).

4. Results

4.1. QSL measurement properties

The results of restrictive maximum-likelihood factor analysis corroborated the expected QSL structures of students' views of quality of school life. A two-factor inter-correlated model for elementary school student responses had excellent fit ($N=336$; $\chi^2=84.14$; $df=34$; $\chi^2/df=2.48$, $p=.12$; gamma hat=.97; SRMR=.041; RMSEA=.066). The estimate of reliability for the 'Quality of Teacher' ('Teacher cares about me') was $\alpha=.88$, and for the 'Quality of Learning' ('Enthusiasm for learning') factor was $\alpha=.84$. The mean scale score was 3.28 ($SD=2.97$) for the former, and 2.7 ($SD=3.12$) for the latter (Cohen's effect size $d=.19$). The factor inter-correlation was $r=.65$. A two-factor inter-correlated model for high school student responses had good fit ($N=272$; $\chi^2=162.28$; $df=53$; $\chi^2/df=3.06$, $p=.08$; gamma hat=.94; SRMR=.055; RMSEA=.087). The estimate of reliability for the 'Quality of Peers' ('Positive peer interactions') was $\alpha=.85$, and for the 'Quality of Learning' ('Satisfaction with learning') factor was $\alpha=.86$. The mean scale score was 3.02 ($SD=3.32$) for the former, and 2.93 ($SD=3.27$) for the latter (Cohen's effect size $d=.30$). The factor inter-correlation was $r=.68$. From these analyses, there is support for using the two elementary and two high school QSL factors.

Multiple-group confirmatory factor analysis demonstrated strong invariance for three of the four comparisons made for the two QSL models (i.e., $\Delta CFI < .01$ and p value for $\Delta\chi^2 > .05$ for regression weights and intercepts) (Table 2). Only the ethnicity comparison for the high school QSL was weakly invariant, with $\Delta CFI > .01$ and p value for $\Delta\chi^2 < .05$ for regression intercepts. Given this level of invariance, it was decided to use the unconstrained QSL models in further analyses and to explore the effect of student sex and ethnicity in a structural model of how QSL and subject attitudes inter-relate with each other and mathematics performance.

4.2. Subject attitude measurement properties

The results of maximum likelihood factor analysis corroborated the expected factor structure of students' subject attitudes. The two-factor inter-correlated model for elementary students had good fit ($N=336$; $\chi^2=16.96$; $df=8$; $\chi^2/df=2.12$, $p=.15$; gamma hat=.99; SRMR=.029; RMSEA=.05). The estimate of reliability for 'Liking Maths' was $\alpha=.70$, and for the 'Self-efficacy in Maths' factor was $\alpha=.82$. The mean scale score was 7.86 (SD=2.01) for the former, and 8.79 (SD=1.82) for the latter. The factor inter-correlation was $r=.77$. The two-factor inter-correlated model for high school students had good fit ($N=272$; $\chi^2=18.08$; $df=8$; $\chi^2/df=2.26$, $p=.13$; gamma hat=.99; SRMR=.044; RMSEA=.07). The estimate of reliability for the 'Liking Maths' was $\alpha=.74$, and for the 'Self-efficacy in Maths' factor was $\alpha=.73$. The mean scale score was 7.27 (SD=2.05) for the former, and 8.17 (SD=1.70) for the latter. The factor inter-correlation was $r=.62$. There is, therefore, support for using these two scales (Table 3).

4.3. Structural relations: QSL, attitudes, and demographic variables predicting academic performance in mathematics

Initially, a structural model was tested that conformed to the hypothesised path model of student characteristics having direct effects on all QSL and subject factors and math performance; QSL having direct effects on subject factors and math performance; and subject factors having a direct effect only on math performance. The two QSL factors were inter-correlated, and the inter-correlation of the two dependent subject-attitude factors was reflected in the correlation of the residual terms. The models were trimmed by removing paths which were statistically non-significant; hence, the structural models show the most simplified set of structural relations we could detect. Such an approach results in a simpler model that is more likely to be rejected if it results in a mis-specified simplification. Alternative models in which the subject-specific factors preceded the general environment factors were tested and found not to fit the data as well as the current trimmed models.

For elementary school students the 'Teacher cares about me' influenced 'Liking Mathematics' and mathematics performance negatively, while the QSL factor 'Enthusiasm for Learning' influenced the subject attitudes positively, and 'Self-efficacy in Maths' predicted mathematics performance positively. Furthermore, it was found that 'Sex' was related to self-efficacy (boys scored higher), while 'Ethnicity' was related only to 'Liking Mathematics' (non-Europeans higher). For high school students, a similar model of relations was constructed; and a direct path from 'Quality of Learning' to academic performance was positive, while there were no statistically significant direct paths from the QSL factor 'Quality of Peers' to academic performance or from 'Liking Mathematics' to academic performance. While, the structural analyses are similar in logic, there is a noticeable difference around the role of Liking Mathematics. In both groups, QSL factors influenced subject attitudes and performance both directly and indirectly through subject attitudes, especially 'Self-efficacy in Maths'. Furthermore, student sex influenced self-efficacy, and student ethnicity influenced liking of mathematics.

Figure 2 displays the statistically significant paths for the elementary students. The model had acceptable fit ($N=336$; $\chi^2=358.85$; $df=183$; $\chi^2/df=1.96$, $p=.16$; CFI=.91; gamma hat=.94; SRMR=.060; RMSEA=.060). Students' perceived 'Quality of Learning' positively predicted how much they liked mathematics ($\beta=.79$) and how highly they rated their self-efficacy in mathematics ($\beta=.39$). Students who perceived more positive, supportive teacher relationship liked mathematics less ($\beta=-.30$) and showed a weaker math performance ($\beta=-.21$). Further, increased 'Liking Mathematics' itself had a negative impact on math performance ($\beta=-.44$). Boys predicted higher self-efficacy ratings ($\beta=.12$), while non-majority ethnicity increased liking of mathematics ($\beta=.19$). All four self-reported attitudes (i.e., subject mathematics and quality of school life) had statistically significant regression paths on academic performance. 'Liking Maths' and 'Quality of Teacher' ratings were negative ($\beta=-.44$ and $-.21$ respectively), while 'Self-efficacy in Mathematics' and 'Quality of Learning' ratings were positive ($\beta=.73$ and $.28$ respectively). This model explained 25% of the variance ($f^2=.33$) in mathematics scores, a medium sized effect (Cohen, 1992).

Figure 3 displays the statistically significant paths only for the high school students. The model had acceptable fit ($N=272$; $\chi^2=344.46$; $df=144$; $\chi^2/df=2.39$, $p=.10$; CFI=.92; gamma hat=.94; SRMR=.063; RMSEA=.064). Students' perceived 'Quality of Learning' positively predicted how much they liked mathematics ($\beta=.67$), how highly they rated their 'Self-efficacy in Mathematics' ($\beta=.35$), and how much they achieved in mathematics ($\beta=.18$). Similar to elementary students, high school students who perceived more positive peer relationship liked mathematics less ($\beta=-.29$). Boys predicted higher self-efficacy ratings ($\beta=.14$),

while non-majority ethnicity increased liking of mathematics $\beta=.12$). ‘Self-efficacy in Mathematics’ had a statistically significant prediction to academic performance ($\beta=.35$). This model explained 20% of the variance ($f^2=.25$) in mathematics scores, a medium sized effect (Cohen, 1992).

The two models indicated that increased perception of the quality of one’s own learning predicted both greater self-efficacy and academic performance. Further, the models indicated that increased student-teacher interaction and positive relationships with classmates predicted weaker liking of mathematics and that these two constructs had either a negative or zero relationship to academic performance. Spending more time with teachers/peers and liking mathematics more were in these two samples maladaptive or irrelevant to academic performance. In contrast, consistent with self-regulation theory (Zimmerman, 2001), increased self-efficacy and increased quality of learning perceptions both resulted in increased mathematics performance, with greater effects seen among younger students. Further, as expected, boys rated their ability in mathematics more highly than girls. Minority ethnicity students had a tendency to like mathematics more than their majority ethnicity peers. These results pose interesting dilemmas in interpreting the relationship of school quality, subject attitudes, and academic performance.

5. Discussion

This study aimed to validate the Australian model of Quality of School Life (Ainley, Reed, and Miller, 1986) in the New Zealand school context contributing to elementary and high school students and, as a secondary aim, to explore relationships which are effective in promoting students’ academic maths performance. Structural equation models encompassing students’ demographic background and academic performance in mathematics – hypothesizing that students’ academic performance in math is increased through possession of positive ‘liking of’ and ‘self-efficacy in’ mathematics, and through positive relations with peers, teachers, and the learning environment – were developed and tested by using data from 336 Year 8 students from elementary schools and 272 Year 10 students from high schools in New Zealand. The identified QSL factors were replicated with good fit for use in the New Zealand school context with elementary and high schools. Hence, we can conclude that using the QSL factors is feasible; furthermore, the utility of these two QSL factors can be seen in their power to partially explain why students like or dislike mathematics and why they feel more or less confident in doing mathematics. Hence, the real value of the QSL factors appears to be in their contribution to understanding how students evaluate their confidence and their interest in school subjects. Regarding the second aim we found that the QSL factors “satisfaction with” and the “enthusiasm for learning” positively predicted

liking of mathematics, while the perception of a caring teacher and positive peer interaction all negatively predicted liking of mathematics. Furthermore, the results showed that liking mathematics itself had negative or zero impact on mathematics performance. We established, further, that mathematics performance was predicted primarily by self-efficacy ratings which were, in turn, increased by the QSL factor of “satisfaction with learning”.

The role of teacher-student relations was examined with elementary students and it was expected that supportive teacher treatment would be associated with liking mathematics and with higher academic performance. The student-teacher interactions were negatively related to mathematics performance, primarily via their mediation of decreased liking of the subject. It would seem that, in the eyes of students, interactions with teachers generate negative affect towards the subject, even though this liking is positively correlated with confidence in learning mathematics. This is a surprising result since there is strong consensus that interacting with the teacher leads to enhanced academic performance, motivation, and attitudes.

Since the data are anonymous it is not possible to directly ascertain why these students considered enhanced interaction with their teacher to have a negative effect on their liking of mathematics. However, negative affect towards a subject could arise if students believe that their teacher's interaction were a function of their own poor behaviour or performance. It may also be that being seen to have lots of time with the teacher has a negative impact on student self-concept, and consequently reduces pleasure in learning of the related subject. In other words, students who indicate much interaction with teachers sense that they are “in trouble” and consequently like this subject less. It may be that being seen to have lots of time with the teacher has a negative impact on student self-concept, and consequently reduces pleasure in learning of the related subject. This result appears consistent with other studies that have shown that parental communication and interaction with teachers leads to reduced academic outcomes (e.g., Deslandes et al. 1997; Izzo et al. 1999). What this means, since interaction with teachers is meant to be adaptive, is that the interactions are probably not focused on task-related feedback (Hattie & Timperley, 2007); it is likely these interactions are focused more on the persons self-attributes rather than on strategies that lead to improvement. An alternative explanation may lie in the distinction between interest and expertise as components of learning (Alexander, 2003). It is plausible that, with students in early adolescence, it is inappropriate to emphasise liking of mathematics as a major goal of teacher interaction with students. It may be that, had teachers placed greater emphasis on expertise rather than interest or liking of mathematics, students would have more appropriately developed greater competence in mathematics which may have led to greater liking. Future investigations into the nature of the teacher-student interactions in New Zealand mathematics classrooms are necessary to resolve this issue.

The quality of social involvement with classmates was investigated with high school students and it was expected that better relations would be associated with liking mathematics and higher academic performance and that satisfaction and involvement with learning would be associated with self-efficacy in mathematics and higher academic performance. Apparently, peer relationships are indirectly related to enhancing high school students' academic performance, only to the extent they are correlated with the students' perceptions of the quality of learning. Increases in perceptions of the quality of peer relations led to decreased liking of mathematics. Without being able to investigate directly why peer relations in this sample would have a negative effect on liking mathematics, we consider that in adolescence, social peer relations become increasingly important but these are not always conducive to academic learning (Carroll et al., 2009). Changing attitudes, other interests, and themes like spending time with mates or discovering sexuality, can become more important than subject or school related content (Behnken et al., 1991; Fend 1997; Krapp and Weidenmann 2001). Hence, it is likely that in order to maintain or develop or as a consequence of peer relations, students may have to adopt a negative posture towards mathematics; perhaps to be cool with your friends you must not like maths.

In both studies the effect of student perceptions of the quality of the learning had positive impacts on performance and subject-related attitudes. Among elementary students, their perceptions of their personal engagement in mathematics (as expressed by their enjoyment, interest, excitement, and effort in mathematics) that are more important than whether they consider their teacher is fair, helpful, or attentive to them. Among high school students, their perceptions of personal engagement (i.e., effort, coping, involvement, and success) were much more important than whether their peers were friendly, accepting, and easy to relate to. The quality of learning perceptions increased self-efficacy ratings and academic performance and appear to function as an adaptive facet of self-regulation (Zimmerman, 2001); students who are actively involved in learning gain self-efficacy and increased performance.

The relationship of 'liking math' to students' academic performance was interesting. Among New Zealand elementary students, enhanced liking of mathematics resulted in worse mathematics performance, while among high school students liking mathematics was irrelevant to performance. This pattern may reflect a developmental process in which the effect of liking diminishes for older students which is a consistent result with findings of Rothmann and McMillan (1994). It may be that as students become more aware of the personal consequences of high-stakes examinations or assessments in high school, their perception of their own personal engagement in appropriately challenging instruction becomes more potent in contributing to their academic achievement. Likewise, as adolescents develop, their meta-cognitive abilities, which includes awareness of instructional quality and self-monitoring, may contribute more powerfully to their achievement. These possible explanations

are consistent with goal and self-regulating theories of learning (Deci and Ryan 1985; Pintrich and Schunk 1996; Rheinberg 2000). Further, it is possible that an overemphasis on personal interest at acclimation stages of expertise development (Alexander, 2003) without a concomitant emphasis on instructional guidance into content and strategies would hinder the development of competence. The high school students had greater mathematics knowledge and the negative effect of liking had become a neutral effect; perhaps by higher education, strong personal liking would have a positive effect on performance. Nonetheless, the current cross-sectional study is not able to address such developmental hypotheses.

The two studies have interesting implications for educational practice, at least in New Zealand. To increase mathematics performance, teachers should focus more on enhancing the quality of learning and student self-efficacy, than prioritising peer or teacher-student relations and liking of mathematics. Students who have confidence and belief in their ability to control their engagement and learning activities achieve more. This recommendation is necessary, since it is possible that teachers can encourage students to like mathematics without at the same time equipping them to do better in the subject. Teaching students to like a subject appears to require instructional activities that may be considered a precursor but not the optimal way to enhance academic performance. This result – the tendency to like mathematics – is somewhat more noticeable among minority ethnicity students. For example, ‘Otunuku and Brown (2007) found similar non-significant correlations between liking and academic performance among Pasifika and Māori students. Hence, it seems teachers would do well to help students who have limited and fragmented knowledge about mathematics by giving

“guidance in determining what content is central and what is peripheral, what information is accurate and well supported, and what information is inaccurate or unsubstantiated [...] explicit instruction on how to be strategic within a domain [...] assistance in forging a personal connection to a domain [...] this rooted relevance will help novices see the value of the academic content and find the will to persist in the face of the inevitable challenges and frustrations that will surely arise.” (Alexander, 2003, p. 12).

The points we have made in this study about the QSL and subject attitudes are somewhat speculative, though plausible. We do not have direct evidence from two cross-sectional surveys to prove the interpretations and recommendations offered here. Indeed, future work with the QSL model would do well to test these interpretations through well-designed studies that attempt to test the analyses and interpretations identified herein. Specifically, future studies could overcome weaknesses in this study by (1) using the full QSL inventory, (2) using longitudinal, rather than cross-sectional, data sets, (3) experimentally manipulating the quality of teaching and classroom experiences, (4) using alternatives to standardised tests as measures of academic

performance, and (5) ensuring that data for the hypothesised causal model is collected sequentially rather than simultaneously. Such studies would have the potential to demonstrate whether the results we have reported are a function of the samples and exploratory analytic techniques adopted. Nonetheless, this study has shown that students' quality of learning evaluations contribute to enhanced academic performance, especially through increased self-efficacy and the potential importance of using QSL ratings in understanding individual students' reasons for their learning performance.

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Table 1. Psychometric characteristics of four QSL scales for studies conducted in English-speaking schools

Study	country	Grades	N	<u>Elementary school</u>		<u>High school</u>	
				Teacher cares about me	Enthusiasm for learning	Positive peer interactions	Satisfaction and involvement with learning
1. Ainley, Reed, & Miller, 1986	Australia	7-12	8464	$\alpha=.83$; $M=17.6$; $SD=3.4$	$\alpha=.83$; $M=13.7$; $SD=3.2$	$\alpha=.78$; $M=18.8$; $SD=2.9$	$\alpha=.77$; $M=15.4$; $SD=2.5$
	2a.		980			$\alpha=.91$; $M=n.a.$; $SD=n.a.$	$\alpha=.79$; $M=n.a.$; $SD=n.a.$
2. Wilson, 1988	Australia						
	2b. United States of America		138			$\alpha=.72$; $M=n.a.$; $SD=n.a.$	$\alpha=.71$; $M=n.a.$; $SD=n.a.$
	3a.	5-6	3086	$\alpha=.83$; $M=3.35$; $SD=.64$	$\alpha=.78$; $M=2.83$; $SD=.67$		
3. Ainley & Bourke, 1992	Australia						
	3b. Hunter region, Australia	5-6	1239	$\alpha=.84$; $M=3.25$; $SD=.73$	$\alpha=.81$; $M=2.68$; $SD=.75$		
4. Bourke & Smith, 1995	Australia	11	749				$\alpha= n.a.$; $M=3.3$; $SD=.64$
5. Mok & Flynn 2002	Australia	12	8265			$\alpha=n.a.$; $M=3.85$; $SD=.66$	$\alpha=n.a.$; $M=3.48$; $SD=.68$

Note. α =Cronbach's alpha coefficient; n.a.=not provided by the author(s).

Table 2. QSL Model multi-group comparison invariance statistics

QSL Model	Configural	Metric	Scalar
Multi-group comparison	(RMSEA)	(ΔCFI ; p value for $\Delta\chi^2$)	(ΔCFI ; p value for $\Delta\chi^2$)
Elementary			
Sex	.069	$\Delta\text{CFI}=.001$; $p_{\Delta\chi^2}=.57$	$\Delta\text{CFI}=.002$; $p_{\Delta\chi^2}=.67$
Ethnicity	.071	$\Delta\text{CFI}=.001$; $p_{\Delta\chi^2}=.32$	$\Delta\text{CFI}=.002$; $p_{\Delta\chi^2}=.29$
High school			
Sex	.048	$\Delta\text{CFI}=.001$; $p_{\Delta\chi^2}=.37$	$\Delta\text{CFI}=.006$; $p_{\Delta\chi^2}=.09$
Ethnicity	.054	$\Delta\text{CFI}=.001$; $p_{\Delta\chi^2}=.47$	$\Delta\text{CFI}=.120$; $p_{\Delta\chi^2}<.01$

Note. RMSEA=root mean square error of approximation; CFI=comparative fit index; model comparisons *not* invariant when $\Delta\text{CFI}>.01$ and when $p_{\Delta\chi^2}<.05$

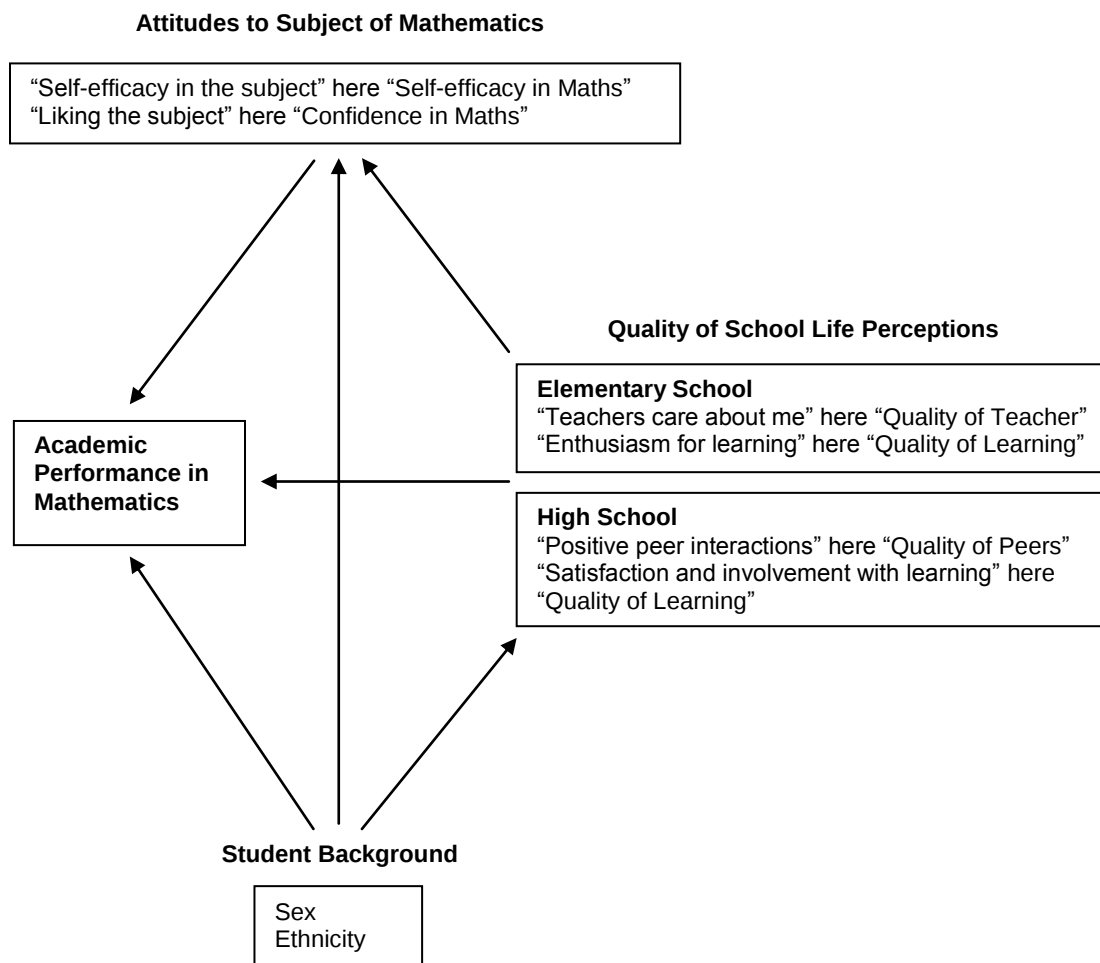
Table 3. Intercorrelations between the attitude and achievement variables

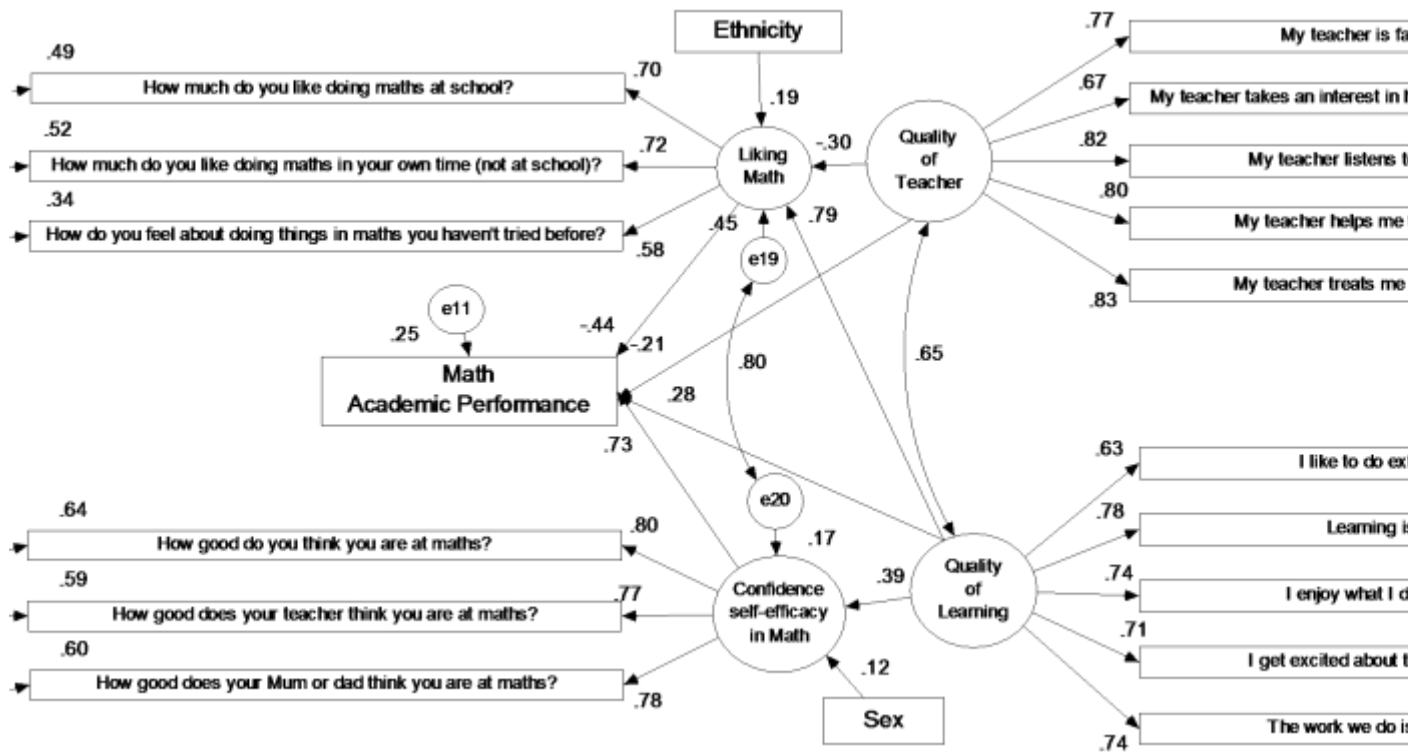
	<u>Elementary</u>		<u>High School</u>		<u>Attitudes</u>		<u>Performance</u>
	Quality of Teachers	Quality of Learning	Quality of Peers	Quality of Learning	Liking Maths	Maths Efficacy	Maths Achievement
Quality of Teachers	1.00						
Quality of Learning	.55**	1.00					
Quality of Peers			1.00				
Quality of Learning			.62**	1.00			
Liking Maths	.19**	.50**	.06	.31**	1.00		
Maths Efficacy	.19**	.31**	.01	.15**	.45**	1.00	
Maths Achievement	.04	.14**	.12**	.26**	.09**	.07**	1.00

Note. ** $p < .001$

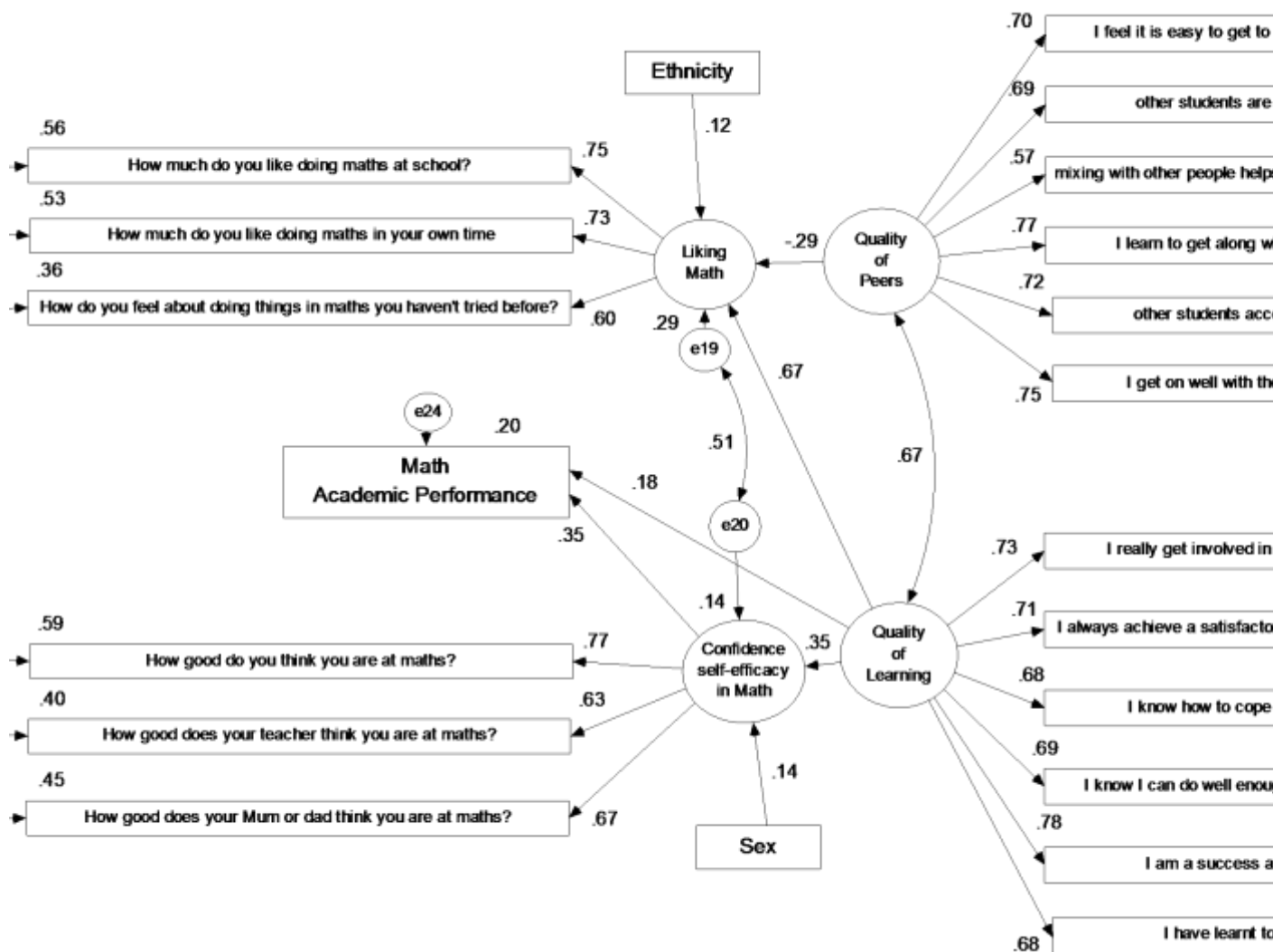
Figure Captions.

- Figure 1. Hypothesised QSL, subject, and background effects on academic performance in mathematics
- Figure 2. Final Model with Standardized Regression Weights for Elementary School
- Figure 3. Final Model with Standardized Regression Weights for High School





Note. Path values are standardised beta regression weights; squared multiple correlations shown.



Note. Path values are standardised beta regression weights; squared multiple correlations shown.

