

The Mathematics Enrolment Choice Motivation Instrument

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The instrument of mathematics enrolment choice motivation (MECM) is designed to measure factors that influence students' decisions to keep or drop mathematics in Year 11. Using survey responses from 289 Year 11 students, this paper presents the initial form of the instrument, examines its factor structure, internal consistency and discriminant power. The preliminary psychometric evidence supports the proposal of a reduced form with five scales for self-concept, self-efficacy, subjective value, anxiety and learning experience in mathematics. With a clearer factor structure and better item information characteristics, the short form is more practical for use with senior secondary students.

Although the proportion of senior secondary school students who have studied some form of mathematics subjects appears to be high, the enrolments at intermediate and/or advanced levels continue to decline over the last a few decades in Australia (Forgasz, 2006; Kennedy, Lyons & Quinn, 2014; Barrington & Evans, 2016). For example, more than 60 per cent of the mathematics students between 2006 and 2016 only studied elementary level mathematics (Li & Koch, 2017) that are insufficient for admission into most of the mathematically intensive disciplines in Science, Technology, Engineering and Mathematics (STEM). This raises the likelihood of a shrinking cohort of quality STEM candidates, which can have a long-term impact on the nation's economic prosperity. The declining trends in mathematics participation have received widespread attention in Australia, with the government and industries allocating substantial funds and programs voicing to increase the participation. Nonetheless, explanations for the causes, especially the non-institutional causes at individual student level, for the persistent diminishing interest in advanced mathematics seems to have not been studied as extensively as in other countries. For instance, in the United States of America the expectancy-value theory has been offered to assert that women are less likely to pursue mathematically intensive careers due to lower expectancies and values in mathematics as compared to men (Eccles et al., 1983), whereas the mindset theory (Dweck, 2002) suggested that students who are endorsing a fixed mindset on their mathematical abilities are more susceptible to reduced mathematics performance. It hence seems to be desirable to examine risk factors to the persistent trends in the voluntary mathematics enrolments.

In developing an instrument to investigate what factors have motivated students choose to or not to continue studying mathematics and what factors initiated their enrolments in specific levels of mathematical subjects, I acknowledge the inherent value of using multiple theoretical orientations to explain the differences in mathematics enrolment choice. By adopting a broad social cognitive approach, the development draws on the understanding that a mathematics enrolment choice for a student encompasses the student's *self-perceived ability* to perform mathematical tasks, the *motivation* to employ that ability (Lubinski & Benbow, 2006), and the emotion related to mathematics study (Goldin et al., 2016). Without being able to generate a feeling of satisfaction from mathematical task performance or other experience with mathematics, it is perhaps unlikely for a student to enrol in a mathematical subject. Without seeing any value of mathematics, it is equally unlikely to enrol in mathematics even though the student is highly capable. Therefore, in addition to capacity, the self-perceived competence beliefs, emotions associated with mathematics, and the value attached to mathematics each plays a key role in the enrolment decision making. Classroom

experience and interaction with mathematics illuminate students' personal values, attitudes, goals, and self-expectancies besides competence to succeed. Over time, these overall experiences accumulate to shape the development of capacity and motivation, which in turn influence enrolment choices. See Goldin et al. (2016) for a review of the research in motivation and in mathematics-related affect more broadly.

The first goal of this article is to present the instrument, for measuring motivational factors that influence students' decisions to opt in or opt out of mathematics study in senior secondary school; then analyse the psychometric properties of the instrument; and finally, propose an empirically supported shorter version of the instrument.

The Instrument

Rationale

The MECM instrument builds on a hierarchical motivation model that integrates the self-efficacy theory (Bandura, 1977) and the expectancy-value theory (Eccles et al., 1983). The model consists the components: (a) direct reasons to keep or drop mathematics, (b) self-concept in mathematics and self-efficacy in mathematics, (c) perceived values of mathematics, (d) anxiety associated with mathematics (maths anxiety); and (e) learning experience in mathematics. The hierarchy is formed following Bandura's (1977) sources of self-efficacy. In the hierarchy, block (a) sits on the top and is based on blocks (b), (c) and (d) that in turn are supported by block (e).

Self-concept is one's perception of self (Shavelson, Hubner & Stanton, 1976). Self-concept in mathematics is one's judgement of self with regarding to mathematical capability (Marsh, 1990). It is generally posited that self-concept is relatively stable and it influences the choice and direction of behaviour. Negative self-concept can undermine confidence, bias self-evaluation, and impair achievement (Byrne & Shavelson, 1986).

Self-efficacy refers more specifically to one's perception about one's capability to produce the desirable outcome (Bandura, 1997). Efficacy expectation is developed as an operational mechanism in self-appraisal and self-regulation. Bandura established that self-efficacy forms through mastery, vicarious, verbal persuasion, and emotive-based procedures, with the mastery experience of performance accomplishments being mostly influential. Mathematics self-efficacy is one's judgement of one's competence to perform mathematics task successfully (Pajares, 1996). It produces performance outcomes through cognitive, motivational and selection processes (Pajares & Urdan, 1999). It is generally postulated that given appropriate level of skills and adequate incentives, self-efficacy is a major determinant for people's choice of activity, amount of effort to expend, and duration to sustain the effort. Thus, self-efficacy evaluation and expectations have been frequently used to serve as a template for predicting the occurrence and persistence of behavior.

The cognitive self-evaluation in self-efficacy comprises performance-efficacy expectancy and performance-outcome expectancy (Bandura, 1977). The former is one's estimate that a given behavior will produce certain outcomes and the latter is the conviction that one can successfully execute the behavior needed to produce the outcome. Both expectancies are essential in the motivational mechanism. Outcome-expectancy alone will not produce the desired performance if the component capabilities are missing. The perception about one's ability to perform a task alone will not motivate an action either, if one perceives no benefits or rewarding.

Eccles et al. (1983) further consolidated the component performance-outcome expectancy in Bandura (1977) and expand to formally introduce the term subjective task value (STV). In her expectancy-value theory and the general model of academic choice, academic choices are linked to STV in addition to outcome expectation. Eccles defined four motivational components for STV: Intrinsic value, utility value, attainment value, and cost. Intrinsic value of a task is the enjoyment of the task. Utility value is the perceived

usefulness of the task. Attainment value is the perceived personal importance of doing well on the task. Any negative aspects in task engagement is the cost that may include performance anxiety, fear of failure or of success, effort to succeed, and lost opportunities.

Mathematics anxiety is the tendency to feel anxious when attempting to solve mathematical problems (Richardson & Suinn, 1972). Mathematics anxiety is one of the emotions developed as a reflection to the success or failure in mathematics-related behavior. As emphasised by Hannula (2012), mathematics-related emotions in turn act as a feedback system to the motivational process. Girls are found to experience an average higher level of mathematics anxiety, which is believed to be associated with their lower academic achievement. In the present study, mathematics anxiety is measured to reflect the extreme negative emotion formed through the interaction with mathematics over a period.

The Items

The initial stage of item development aimed at writing down statements relevant to each construct in a range as broad as possible (*domain defining*). This process was based on the previous research and was inspired by many existing instruments (e.g. Butler, 2016; Ko & Yi, 2011; Stevens & Olivárez, 2005). Sometimes an idea was learnt or criticised without taking any item; sometimes items were adopted or modified, but most items were newly created by following the theoretical model and incorporating responses from a small student interview. The domain list was then gone through face evaluation by experts.

There were two sub-scales for self-efficacy in the instrument. One relates to the situations that were hypothesized to be necessary for initiating the decisions to enrol in mathematics. The selected situations reflect students' self-regulated behaviours and self-control in managing mathematics study. The other sub-scale relates to questions in curriculum topics recommended by the Australian Curriculum, Assessment and Reporting Authority (ACARA) for Years 10 &11. These questions were framed to measure the *perceived* competence, so that participants did not actually solve the problems. Following recommendations of Bandura (2006), the items in both sub-scales were worded as *can do*. The inclusion of specific mathematical topics in the instrument is consistent with the recommendation in measurement development as to take into account the specificity of self-efficacy assessment (Goldin et al., 2016).

The instrument consisted scales for self-concept, self-efficacy, maths anxiety, STV and learning experience. A 7-point ruler was used for all the items, labelled as 1=*Strongly Disagree* to 7=*Strongly Agree*, or 1=*Not at all Confident* to 7=*Very Confident*.

Participants

Ethics clearance for a passive consent approach has been granted from states' and Catholic authorities. During late 2018 in New South Wales, Western Australia and Victoria, 289 Year 11 students, composing 26% of boys, 72% of girls, and 2% of others from CHOOSEMATHS schools, completed the survey. Due to the heavy study load for Year 11 and a tight timeline, there was not much scope to manipulate a sample selection. Likewise, the key focus of CHOOSEMATHS, to promote mathematics among school students, particularly among girls, seemed to have led to more single-sex girl schools in the sample. Participation in the survey was voluntary and anonymous. Participants responded the survey online independently in a group setting at school time, with an average completion time of approximately 15 minutes. All the Year 11 students in the participation schools were invited to undertake the survey, irrespective of whether they were studying mathematics in Year 11. However, a large proportion of non-mathematics students withdrew from the survey, which resulted in an inflated participation rate in mathematics in the sample (97%) and made it unaffordable to test the questionnaire items designed for non-mathematics students.

Analysis

Procedure

The content validity of the instrument has relied on the design stage that has incorporated the mainstream motivation theories in the previous research. The purpose of the following evaluation is to shorten the instrument's length, ideally within an average of 10 minutes, for time is critical for senior students and it also determines the response quality. A latent trait is usually multi-facet. Consequently, multiple items are necessary in constructing a scale to measure the trait. Most time, the summative score that a respondent obtained for all items of a scale constitutes the score of the scale. Ideally, a scale designed to measure a trait will have a minimum number of items that are sufficient to cover the various aspects of the trait. These items should also be agreeable to the extend to measure the same underlying factor, but meanwhile diverse enough to represent the multi-facets without too much overlapping. Such a status may be achieved through psychometric analysis. In the current study, internal consistency (IC), factor analysis (FA), and item response theory (IRT) were used in combination to test and refine the instrument.

To assess IC of a scale, apart from the Cronbach's α on all items of the scale, labelled as 'Overall' in Table 1, three other types of quantities were used for each item: 'Item-test' correlation, 'item-rest' correlation, and the Cronbach's α without the item ('item-delete' α). The item-test correlation assesses the consistency between an item and the scale, and the item-rest correlation assesses the consistency between an item and other items. They are displayed in the fifth and sixth columns of Table 1 respectively. The item-delete α , in the next column of the table, quantifies the consistency of the scale as if it were made up of all the *other* items. The criteria of low 'item-test' and/or low 'item-rest' correlations and high 'item-delete' α were used to judge the 'badness' of an item.

Table 1.

Summary Statistics, Inter-item Correlations, Cronbach's α , and Discrimination Coefficients of Items for the Scale of Self-Concept in Mathematics

Item	Item Text	Mean	SD	Item-Test Corr	Item-Rest Corr	α	Discrim Coef	Final α
cmpoth	Compared to other students in my class I am good at maths	4.64	1.57	0.815	0.770	0.918	2.872	0.857
cmpslf	Compared to my other school subjects I am good at maths	4.17	1.84	0.834	0.784	0.917	2.891	0.847
maeasy	Work in maths classes is easy for me	4.42	1.63	0.825	0.779	0.917	2.737	
dowell	I have always done well in maths	3.88	1.76	0.738	0.670	0.923	1.829	0.872
hoples*	I'm hopeless when it comes to maths	2.69	1.76	0.863	0.823	0.915	-3.390	0.850
confus*	I am always confused in my maths class	2.64	1.65	0.773	0.717	0.920	-2.328	
nobraj*	I don't have the brain to learn maths	2.43	1.81	0.737	0.665	0.923	-2.178	
2hard*	Maths is too hard for me	2.38	1.63	0.803	0.753	0.919	-2.748	
expwel	I expect to do very well in any maths class I take	4.01	1.81	0.643	0.554	0.929		
lernhi	I am confident that I can learn maths at a higher level	3.98	1.82	0.764	0.698	0.921	1.845	0.872
Overall							0.928	0.885

*: An item with an asterisk is reversed in calculating the correlations and the Cronbach's α .

Exploratory FA was utilised to examine the scale structure and linear combinations of items that contain the most information. The eigenvalues, the uniqueness of each item (i.e., the proportion of the variance for the item that is not associated with the common factor, or, 1- communality), and AIC and/or BIC were used to filter items for exclusion. Also used were the discrimination coefficient of each item estimated from the graded response model (GRM) (Samejima, 1969) and the associated total characteristic curve (TCC), for the purpose to investigate how capable an item or a set of items as a whole was in differentiating the varying level of the latent trait under study.

Results

Due to limited space, details will only be presented for self-concept and self-efficacy in mathematics.

Self-concept in Mathematics

Firstly, the item ‘I expect to do very well in any maths class I take’ was removed because without this item the (sub) scale would have $\alpha = 0.929$, a higher internal consistency than the current overall $\alpha = 0.928$ (last row in Table 1). This removal was supported by the relatively lower item-test and item-rest correlations of the item.

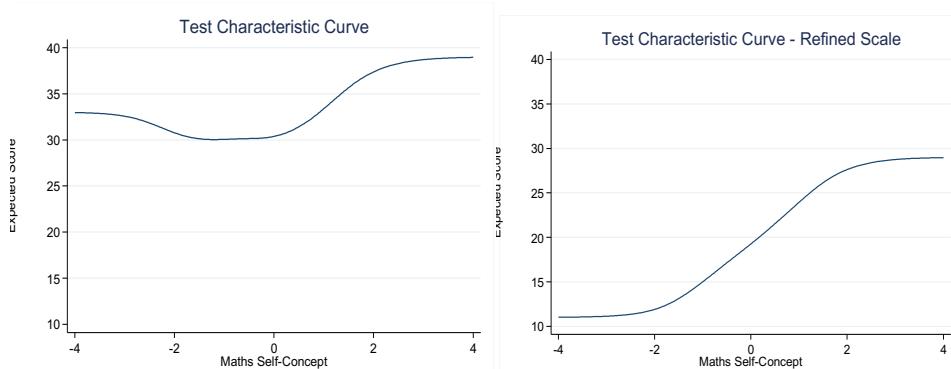


Figure 1. Test characteristic curves for the initial (left) and the refined (right) scales.

Secondly, to determine whether the remaining items would constitute a scale that can adequately measure self-concept in mathematics, a GRM was fitted to the data and the estimated discrimination coefficients are shown in the second last column of Table 1. On the left of Figure 1, the characteristic curve of the scale estimated from the GRM displays the expected score of the scale along the trait ‘Maths Self-Concept’. The horizontal axis in TCC represents the standardised latent trait, assumed to be normally distributed over (-4, 4). Noticeably, a U-shape presented over the range of (-2, 1.5) in the latent trait continuum. This violated the essential requirement of a scale: a unique correspondence between a value in the scale and a given level in the latent trait. The U-shape indicated that some different trait levels, such as -3 and 1.5, were expected to receive an identical score. Hence, the scale items must be further examined.

Table 2.

Correlation Matrix of the Items After the First Iteration of Removal of One Item

	cmpoth	cmpslef	maeasy	dowell	hoples	confus	nobrai	2hard	lernhi
cmpoth	1.000								
cmpslef	0.750	1.000							
maeasy	0.760	0.749	1.000						
dowell	0.525	0.565	0.594	1.000					
hoples	-0.697	-0.677	-0.660	-0.598	1.000				
confus	-0.600	-0.548	-0.640	-0.475	0.723	1.000			
nobrai	-0.499	-0.521	-0.485	-0.467	0.645	0.552	1.000		
2hard	-0.607	-0.590	-0.588	-0.457	0.724	0.718	0.766	1.000	
lernhi	0.518	0.593	0.535	0.597	-0.582	-0.482	-0.511	-0.512	1.000

Next, the correlation matrix (Table 2) of the remaining items revealed that items were highly correlated in each of the following clusters: (a) cmpoth cmapslef scmaeasy and (b) 2hard hoples confus nobrai. For each cluster, a comparison of the discrimination across

items and a subsequent removal of the least discriminant one, (i.e., the item with the smallest discrimination coefficient in absolute value, `maeasy` and `nobrai` here) improved the quality of the scale, but a U shape was still present in the TCC. Hence, the process of excluding the least discriminant item from each highly correlated cluster continued and resulted in the removal of `confus`, as the least discriminant within the cluster `2hard` `hoples` `confus` in the second iteration, and `sc2hard`, as the less discriminant in the pair `hoples` `2hard`. This reduced the scale to contain items `cmpoth` `cmps1f` `dowell` `hoples` `lernhi`.

Table 3.

The Scale of Self-Efficacy in Mathematics (for Year 10 & 11 Students in Australia)

Item	Item Text	Retained
<i>Situation-specific ($\alpha=0.857$)</i>		
<code>sgoal</code>	Set goals to direct your activities in maths study	*
<code>smotiv</code>	Motivate yourself to do school work in maths	*
<code>ssummar</code>	Summarize the topics of study in maths	*
<code>sdead</code>	Finish your maths assignments by the deadline	*
<code>sclari</code>	Clarify doubts in maths in class	*
<code>smostd</code>	Learn the most difficult content if you try hard	*
<code>smarks</code>	Obtain the marks you want if you try hard	*
<code>stime</code>	Use your study time wisely for maths	*
<code>scontin</code>	Continue working even if have trouble learning the material	*
<code>sunint</code>	Keep working on maths even when the material is uninteresting	*
<code>slower</code>	Continue learning maths even if your grade is lower than expected	*
<code>sothint</code>	Study maths when there are other interesting things to do	*
<code>steam</code>	Be part of a problem-solving team, expressing your ideas	*
<i>Topic-specific ($\alpha=0.894$)</i>		
<code>ttiles</code>	Calculate the number of square meters of tiles needed to cover a floor	*
<code>tinves</code>	Calculate the final value of an investment using compound interest	*
<code>tphytha</code>	Find the length of an unknown side using Pythagoras	*
<code>ttrigo</code>	Using Trigonometry to find the size of an unknown angle of a triangle	*
<code>tparab</code>	Determining the x-intercepts and turning points of parabolas	*
<code>tsimpl</code>	Simplify expressions that have surds in them	*
<code>tlogri</code>	Find the logarithm of a positive number	*
<code>troot</code>	Determine if the square root of a given number is rational	*

*: The items marked with asterisks were retained in the scale.

Finally, the refined scale was highly discriminant and had an overall α value 0.885 (the last column in Table 1). More importantly, as shown on the right side of Figure 1, the resultant TCC became monotonic and it stretched to a wider range of expected scores than did the original scale. Therefore, a difference in the latent trait is more noticeable when measured by the refined scale. In the comparison of models with different number of factors, both AIC and BIC pointed to a two-factor model, which, in this application, was coincided with the fact that there were two positive eigenvalues in the FA. The rotated factor loadings indicated that the refined scale measures two related aspects in mathematics self-concept: an overall self-evaluation of mathematical capability, captured by `cmpoth` `cmps1f` `hoples`, and a self-appraisal and self-inference along the time dimension, captured by `dowell` `lernhi` – the belief of having done well in the past and being able to do well in the future.

Self-efficacy in Mathematics

The self-efficacy scale, displayed in Table 3, consists of two sub-scales: self-efficacy specific to situations related to mathematics learning and self-efficacy specific to

mathematics topics expected for Year 10 and 11 students to master. Correlation analysis of the situation specific items found that the internal consistency without the item ‘Be part of a problem-solving team, expressing your ideas’ was higher than the internal consistency with it. The associated TCC was monotonical too. However, the high α value, 0.934, indicated redundancy in the remaining items. After several iterations, the items sgoal sclari smostd sunint sothint steam were removed, as the less discriminant one within a cluster of highly correlated items or because the items had overwhelmingly agreeable responses. For example, between the highly correlated pair ‘Learn the most difficult content if you try hard’ and ‘Obtain the marks you want if you try hard’, the former was substantially less informative than the latter for individuals in the latent trait spectrum (-4, -2) (or, the ratings 1 and 2 in the response category). This can be seen from the lower position of the dashed line relative to the solid line in Figure 2, where the information function for a fixed value of the latent trait is the expected value of the square of the first derivative of log likelihood function (Samejima, 1969) under the GRM. Given that the two items were similar outside (-4, -2), between the two the item that can estimate the latent trait with greater precision in (-4, -2) was chosen. The refined sub-scale had $\alpha=0.857$, satisfactorily high, and a monotonical TCC taking the scores in (5, 35). BIC showed that the predominant structure, accounting for 83.5% of the total variation, measures the degree of persistence in the course of mathematics study.

Among the 8 mathematics questions for the topic sub-scale, ‘Find the logarithm of a positive number’ was firstly removed, because it had the lowest ‘item-rest’ correlation and a very low discrimination 0.665 corresponding to a nearly flat characteristic curve over the entire latent trait continuum. After the removal of this item, it was found that the item ‘Determine if the square root of a given number is rational’ also needed to be excluded for achieving an overall IC that is higher than each ‘item-deletion’ α . The sub-scale consisting of the remaining items had α value 0.894 and the corresponding total characteristic curve was monotonic. However, the TCC was quite flat beyond 2 in the latent trait continuum, indicating that the sub-scale was unable to adequately measure the high response categories. Therefore, 2 ‘harder’ new items ‘Solve a pair of simultaneous equations using the elimination or substitution method’ and ‘Calculate and interpret the probabilities of various events associated with a given probability distribution, by hand in simple cases’ were added to the sub-scale, in the hope to better measure the 6 and 7 response categories.

Final Words

Understanding factors that influence choices in mathematics enrolments is essential to the objective to change the persistent declining participation in advanced mathematics across the country. Such an understanding would be impossible without data. With the help of a valid survey instrument, production of quantitative data via the instrument is relatively cost-effective. The depth of understanding from the data is determined by the data quality that, in turn, is determined by the quality of the instrument.

A great deal of research has been conducted in the field of psychology of mathematics education. The current work is an application of the existing theories to help design an instrument for uncovering the motivational factors. The work started with the identification of a set of theories among numerous alternatives. Sometimes, items proposed for a scale can be unsuitable, even though the writing was guided by the theories and existing research. The reliability of the items must be tested using empirical data. The test is achievable using statistical techniques. In the process of psychometric analysis, a certain level of subjectivity is inevitable. Sometimes, an exclusion of a different item may lead to a scale with equally good properties. The correlation, factor, and the IRT analyses used in the paper all depend on the specific data set, which should be considered when using data produced by the instrument in the future.

References

- Dweck, C. S. (2002). The development of ability conceptions. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation. A volume in the educational psychology series: Vol. xvii*, (p. 57–88). San Diego, CA: Academic Press.
- Lubinski, D., & Benbow, C. P. (2006). Study of mathematically precocious youth after 35 years: uncovering antecedents for the development of math-science expertise. *Perspectives on Psychological Science*, 1, 316– 345.
- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84, 191-215.
- Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.). *Self-efficacy beliefs of adolescents*, (Volume 5, pp. 307-337). Greenwich, CT: Information Age Publishing.
- Butler, K.L. (2016). *Motivation for mathematics: The development and initial validation of an abbreviated instrument*. PhD Thesis, University of South Florida.
- Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.). *Achievement and achievement motivation* (pp. 75-146). San Fransisco, CA: W. H. Freeman.
- Goldin, G. A., Hannula, M. S., Heyd-Metzuyanim, E., Jansen, A., Kaasila, R., Lutovac, S., ..., Zhang, Q. (2016). *Attitudes, beliefs, motivation and identity in mathematics education: An overview of the field and future directions*. The Netherlands: Springer Open.
- Hannula, M. S. (2012). Exploring new dimensions of mathematics-related affect: embodied and social theories. *Research in Mathematics Education*, 14, 137-161.
- Ko, H. K., & Yi, H. S. (2011). Development and validation of a mathematics anxiety scale for students. *Asia Pacific Education Review*, 12, 509-521.
- Luttrell, V. R., Callen, B. W., Allen, C. S., Wood, M. D., Deeds, D. G., & Richard, D. C. S. (2010). The mathematics value inventory for general education students: Development and initial validation. *Educational and Psychological Measurement*, 70, 142-160.
- Li, N., & Koch, I. (2017). *Gender report: Participation, performance and attitudes towards mathematics*. Melbourne: Australian Mathematical Sciences Institute.
- Marat, D. (2005). Assessing mathematics self-efficacy of diverse students from secondary schools in Auckland: implications for academic achievement. *Issues in Educational Research*, 15, 37-68.
- Marsh, H. W., & O'Neill, R. (1984). Self-description questionnaire III: The construct validity of multidimensional self-concept ratings by late adolescents. *Journal of Educational Measurement*, 21, 153-174.
- Marsh, H. W. (1990). The structure of academic self-concept: The Marsh/Shavelson Model. *Journal of Educational Psychology*, 82, 623-636.
- Martin, A. J. (2001). The student motivation Scale: A tool for measuring and enhancing motivation. *Australian Journal of Guidance and Counselling*, 11, 1-20.
- Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the mathematics anxiety rating scale. *Educational and Psychological Measurement*, 42, 551-557.
- Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: psychometric data. *Journal of Counseling Psychology*, 19, 551-554.
- Samejima, F. (1969). *Estimation of latent ability using a response pattern of graded scores*. Psychometrika Monograph Supplement, 34(4, Pt. 2), 100. Supplement, no. 17.
- Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research*, 46, 407–441.
- Stevens, T., & Olivárez, A. Jr. (2005). Development and evaluation of the Mathematics Interest Inventory. *Measurement & Evaluation in Counseling & Development*, 38, 141–152.
- Suinn, R. M., & Winston, E. H. (2003). The mathematics anxiety rating scale, a brief version: psychometric data. *Psychological Reports*, 92, 167-173.