

# Students' Frames of Reference and Their Assessments of Interest for Statistical Literacy

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This study examines the influence of middle school students' frames of reference on their assessments of interest for statistical literacy. Based on the responses of 406 middle school students to a previously validated interest measure, the study explores students' use of *external* – perceived self-competency when compared with others – and *internal* – perceived self-competency when compared with other subjects – frames of reference on their interest assessments. The study concludes that students' assessments of interest appear to be dependent on both comparisons but only for those students who consider that they are worse at maths than their peers. The interest assessments of other students appear to be less dependent on their self-competency beliefs.

The term interest, as conceptualised in this study, is defined as a “person’s relatively enduring predisposition to reengage particular content over time” (Hidi & Renninger, 2006, p.113). Students’ interest in a domain of knowledge is known to be positively associated with deeper levels of cognitive processing, the use of self-regulatory learning strategies and their ratings on the quality of the learning experience (Schiefele, 1991). In a mathematics context, middle school students’ interest is known to influence their re-engagement with the subject, in particular their choice of senior secondary mathematics course (McPhan, Morony, Pegg, Cooksey, & Lynch, 2008). Students’ self-competency perceptions, their beliefs on how competent they are at mathematics, are known to be positively associated with their assessments of interest (Trautwein, Ludtke, Köller, Marsh, & Baumert, 2006). When students make judgements regarding their perceived competency in mathematics, it is believed that they use two different frames of reference; they compare their performance with that of their peers – external frame of reference – and/or they compare their performance with their performance in other subjects – internal frame of reference (Marsh & Hau, 2004). With two frames of reference it is hypothesised that students with achievement consistently below that of their peers may have favourable self-competency beliefs if they consider that mathematics is their best subject.

Given the close association between students’ competency beliefs and their interest, researchers have explored the influence of students’ frames of reference on their interest assessments. Students’ use of the external frame of reference was demonstrated by Trautwein et al. (2006) who reported that ninth grade students with low achievement relative to their class are likely to report low levels of interest for mathematics irrespective of their actual achievement. Demonstrating the influence of the internal frame of reference, however, has typically involved the analysis of cross-domain associations between achievement and self-concept in mathematics and language (Marsh & Hau, 2004). The typically low or zero correlations between mathematics achievement and language self-concept, despite positive correlations between mathematics and language achievement, demonstrate the use of the internal frame of reference. Goetz, Frenzel, Hall, and Pekrun (2008) used this method to explore the use of both frames of reference in students’ assessments of their enjoyment of mathematics. Their study involved cross-domain associations – mathematics and language – and reported low or negative associations



between mathematics achievement and language enjoyment, indicating that students were also making comparisons across subjects when forming self-competency beliefs. As discussed, their study relied upon cross-domain results to deduce the influence of frames of reference on students' self-competency assessments. It did not assess the use of frames of reference directly from the students. Moreover, no studies noted have specifically explored students' use of frames of reference on their interest assessment.

This study seeks to examine the influence of students' frames of reference on their assessments of interest for statistical literacy, which is defined as an ability to critically interact with messages containing statistical elements (Gal, 2003). Moreover, in line with a suggestion by Bong (1998), it seeks to examine this influence through the use of specific items that ask students to make internal and external comparisons, rather than the use of cross-domain comparisons.

## Methodology

### *Instruments Used*

All students were asked to complete the Statistical Literacy Interest Measure (SLIM), a previously validated interest instrument (Carmichael, 2008) that contains 16 self-descriptions, which students respond to using a five point Likert scale. For this sample of students, SLIM explained 67% of the variance in their responses and reported an estimated internal reliability coefficient of  $\alpha = 0.91$ .

In order to assess their frames of reference, two additional self-descriptions were included. For the external frame of reference, students were asked to respond to the self-description "Compared to others in my class I am good at maths", and for the internal frame of reference, "Out of all my subjects I usually get my best marks in maths". Both self-descriptions were answered using the same Likert scale that ranged from 1 (*Not me at all*) to 5 (*Describes me well*).

In addition to these items, teachers of students provided estimated ratings of their students' achievement in mathematics. More specifically, these ratings matched students' achievement grades and ranged from E, the lowest grade, to A.

### *Sample Design and Participants*

A convenience sample<sup>8</sup> of 406 students was chosen so that it would be representative of the Australian middle school population. Consequently a range of government and independent schools from three Australian states were targeted and then students invited to participate. Of this sample, 59% were from Tasmania, 20% from Victoria and the remainder from Queensland. Most students (65%) attended independent schools and the majority (85%) were in Years 7, 8 or 9. The mean age of students was 13.6 years and just over one half (53%) were female.

### *Analysis of Data*

Data was in most cases analysed using non-parametric methods such as the chi-square test of association, and graphical methods. In addition to this, group means were compared using the analysis of variance (ANOVA). In order to maintain adequate sample size it was

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<sup>8</sup> Since the sample was non-random, cited *p*-values are notional, as are tests of statistical significance.

necessary to collapse the original five categories in the frames of reference questions to three. More specifically, student responses of 1 or 2 on the original scales were grouped into one category indicating a negative comparison, responses of 3 were retained as a single category indicating a neutral comparison, and responses of 4 and 5 were grouped into a single category indicating a positive comparison.

## Results

A cross-tabulation of students' responses to the two frames of reference (FoR) questions is shown in Table 1. It indicates that most (64%) students had similar assessments on both frames of reference, especially those who had negative or positive assessments on both.

Table 1  
*Cross Tabulation of Students' Responses to FoR Items*

		Internal FoR			Total
		Negative	Neutral	Positive	
External FoR	Negative	128	22	6	156
	Neutral	38	35	30	103
	Positive	15	34	98	147
	Total	181	91	134	406

### *Relationship with Prior Mathematics Achievement*

Students' prior achievement grades were adjusted to reflect their grade relative to the class median. A four-category variable was obtained that ranged from an achievement of two or more grades below the class median to an achievement of one or more grades above the class median. The cross-tabulation of this variable against the external frame of reference question is shown in Table 2. As is seen from this table, students' perception of their ability relative to their class approximately matched their teachers' estimates ( $\chi_6^2 = 47, p = 0.00$ ). Students' responses to the internal FoR question were also associated with their relative prior achievement grades ( $\chi_6^2 = 40, p = 0.00$ ), but not as strongly.

Table 2  
*Cross Tabulation of Students' Relative Maths Grade Against Their Responses to External FoR*

		Maths grade relative to the class median			Total	
		$\leq -2$		Median		
External FoR	Negative	12	48	67	21	148
	Neutral	7	23	53	16	99
	Positive	4	8	76	49	137
	Total	23	79	196	86	384

### Relationship with Interest

Based on their responses to the SLIM, students were assigned an interest for statistical literacy score. There is a clear relationship between students' responses to the frame of reference (FoR) questions and their level of interest. The mean interest score of students with negative competency assessments on the external FoR is less than that for students with neutral or positive assessments ( $F = 38, p = 0.00$ ). Similarly, the mean interest score for students with negative competency assessments on the internal FoR is less than that of students with neutral or positive assessments ( $F = 23, p = 0.00$ ). The interaction was examined graphically and is shown in Figure 1, which displays mean interest scores for each of the nine groups reported in Table 1 as well as 95% confidence intervals for statistically distinct groups. As is seen from this figure, for most students there is little association between their interest for statistical literacy and their responses to either FoR question, group means were close to zero for seven of the nine groups. The exception is for those students who provided negative assessments on the external FoR. This group of students also appeared to use an internal FoR. Statistically significant differences in mean interest levels occurred between students who had negative assessments on both frames of reference and those with neutral and positive assessments on the external FoR. In addition to this, there is a statistically significant difference in interest between students with negative assessments on both FoR questions, and those with a negative assessment on the external FoR and a positive assessment on the internal FoR, although as is shown in Table 1 the later group consists of only six students.

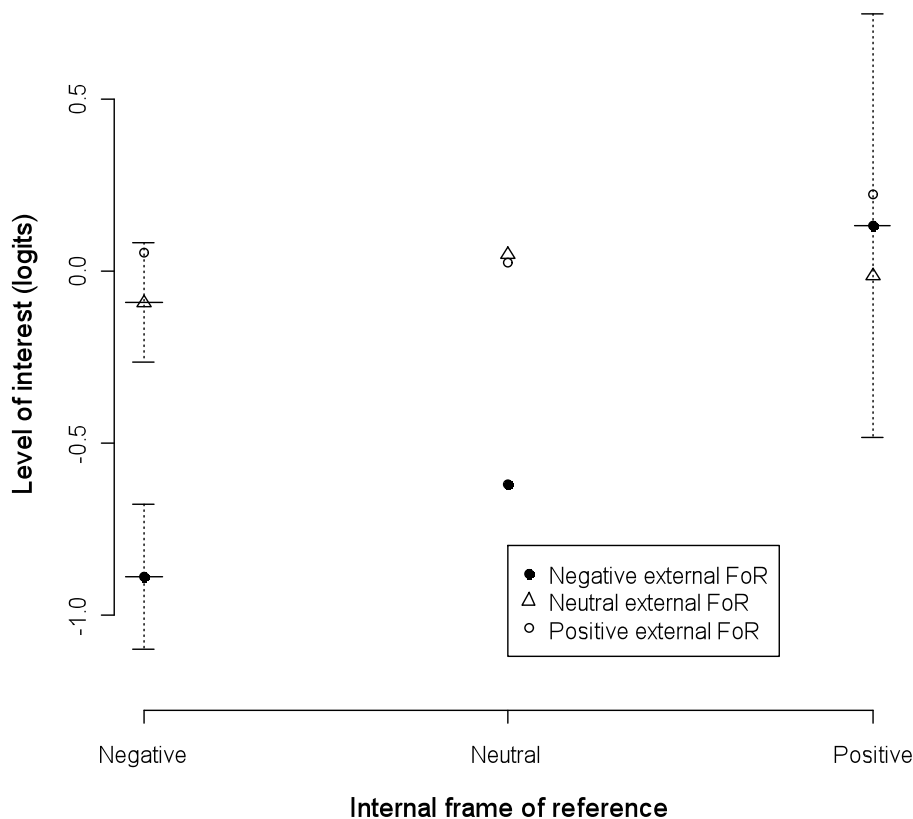


Figure 1. Mean interest scores against response on FoR items

## Discussion and Implications

In this study a sample of middle school students were asked to indicate their perceived level of competence in mathematics using two frames of reference. Their responses were then compared to their level of interest for statistical literacy and group means were analysed for differences. A cross-tabulation of responses indicated that students' assessments on one frame of reference (FoR) were in most cases the same as their assessment on the other. In addition to this, students' assessments of self-competency in mathematics approximately agreed with their teachers' estimates of their achievement. The results also suggested that taken separately, students' assessments on either FoR were positively associated with their interest. For example, students who considered that they are worse at mathematics than their peers reported lower levels of interest for statistical literacy than students who considered that they are the same or better than their peers. Similarly, students who considered mathematics is their worst subject reported lower levels of interest for statistical literacy than those who considered that it is their best subject.

Given the apparent influence of both frames of references on students' interest for statistical literacy, the interaction of the two was then examined. This analysis suggested that apart from students who considered that they are worse at maths than their peers; students' interest assessments were relatively independent of their frame of reference assessment. For students who believed that they are worse at maths than their peers, however, competency assessments using both frames of reference appeared to influence their interest. These results suggest that self-competency perceptions have their greatest influence on interest or rather lack of interest, for those students with relatively negative self-competency perceptions and that such students are more likely to use both frames of reference. Interventions aimed at increasing students' interest for statistical literacy, should therefore make the greatest gains if they focus on enhancing the self-competency beliefs of such students.

In this study, frames of reference questions were focussed on mathematics in general, while interest assessments were specifically for statistical literacy. All Australian students encounter the underlying concepts of statistical literacy in the mathematics curriculum. Yet it is expected that many students will encounter statistical messages in other subjects and indeed in non-school contexts. It is possible that the apparent lack of association between FoR assessment and interest score for students who considered that they are equal or better than their peers in mathematics, could be attributed to perceived differences in the two domains. Students with relatively positive mathematics self-competency beliefs may be able to disentangle their perceived competency in mathematics from their perceived competency in statistical literacy, which in fact may span a number of subject domains. Consequently their mathematics self-competency beliefs may have a minimal influence on their interest for statistical literacy. Those students with relatively negative mathematics self-competency beliefs, however, may not be able to distinguish between the two domains. Instead providing low interest assessments for statistical literacy because they do not feel competent in the mathematics classroom.

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