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Journal: ZDM Mathematics Education **ISSN:** 1863-9690

Volume: 49 **Issue:** 3 **Publication Date:** 01/06/2017

DOI: http://dx.doi.org/10.1007/s11858-016-0831-7

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Classroom Motivational Environment Influences on Emotional and Cognitive Dimensions of Student Interest in Mathematics

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Abstract

Interest has long been regarded as an important motivational construct in the learning of mathematics. It has been contended that the development of interest is directed by two control systems: an emotional and a cognitive. Under the former, students are attracted to activities that are enjoyable, whereas under the latter they consciously engage in tasks that might satisfy, for example, later goals. Younger students are more likely to associate emotional responses to interest-related stimuli, whereas older students tend to associate cognitive responses, suggesting qualitative developmental differences in students' interest for mathematics. Yet there are differences between the classroom motivational environments experienced by primary/elementary vs. secondary school students, and the mathematical interest and enthusiasm likely felt and expressed by primary vs. secondary teachers, which may influence dimensions of student interest. Of concern in this study is the extent to which teacher enthusiasm impacts their classroom motivational environments (mastery vs. performance goal orientation) perceived by students and reported by teachers, and thereby dimensions of students' interest for mathematics. Using survey data from 471 students in Grades 3 to 10 and 44 of their mathematics teachers, we find that students' perceptions of their teachers' enthusiasm for teaching mathematics positively predicts their perceptions of a classroom mastery environment, which in turn predicts their interest. However, at the class-level, teachers' enthusiasm for the subject of mathematics negatively predicts the emotional interest of their students. Implications of these results are discussed.

Keywords: interest, teacher-enthusiasm, classroom motivational environment, primary/elementary school, mathematics.

1. Introduction

Interest has long been considered an important motivational construct in the learning of mathematics. Motivating students to learn mathematics is increasingly a challenge for society. At a time when the need for mathematically literate graduates is greater than ever, there are lower rates of enrolment in high level mathematics courses in many parts of the world including Australia (e.g., Chinnappan et al. 2008; Kennedy et al. 2014).

Interest in mathematics is an affect associated with the knowledge and practice of the subject. It is believed to have emotional, value, and cognitive dimensions (Krapp 2007), where the emotional dimension includes the experience of enjoyment or excitement, the value dimension the extent to which the knowledge and practice of mathematics is associated with conceptions of self, and the cognitive dimension a desire to acquire new knowledge about the subject. Interest based studies have tended to focus on the affective dimensions, assessing students' enjoyment and personal valuing of learning mathematics (e.g., Trautwein et al. 2006), with fewer studies (e.g., Carmichael, Callingham, Hay, and Watson 2010)assessing all three dimensions. Yet the development of interest is believed to be directed by both emotional and cognitive control systems (Krapp 2007) and as this development occurs it is posited that interest itself undergoes qualitative changes (Hidi and Renninger 2006), in that reported positive emotions make way for, a stronger valuing, through to a desire to re-engage. Recent empirical studies have confirmed qualitative differences in students' interest for mathematics with younger students more likely to associate emotional responses to interest-related stimuli and older students cognitive responses (Frenzel et al. 2012). Taken together, these considerations suggest the need to differentiate between affective and cognitive interest dimensions.

Systematic differences are known to occur in students' interest for mathematics. In relation to gender, for example, many studies have found that boys are more interested (in terms of liking and enjoyment) in mathematics than girls (Frenzel et al. 2010; Updegraff et al. 1996; Watt 2004) including Hyde et al.'s meta-analysis (1990) and the PISA (Programme of International Student Assessment; OECD 2004) results which showed higher mathematics interest and enjoyment for 15-year old boys than girls across all 41 participating countries. A gender intensification hypothesis has not been supported by empirical data (Jacobs et al. 2002; Nagy et al. 2010; Watt 2004), whereby gender-typed activities may become more important to young adolescents over time as they conform more to gender-role stereotypes (Eccles 1987; Hill and Lynch 1983); implying that girls would become more negative about male-typed domains such as mathematics while boys become more positive. Gender differences in mathematics value have been documented as early as grade 2 (Jacobs et al. 2002).

It would then seem natural to turn to explanations in the kinds of learning environments that teachers create and students perceive. These environments include physical features of the classroom and the resources contained within, but of concern in this study are the motivational features of these environments. Achievement goal theory (AGT; Dweck and Elliot 1983; Nicholls 1984) provides a framework for investigating classroom motivational environments. From this perspective a mastery orientation, focused on understanding, vs. a performance orientation, focused on competition and grades, has been found to shape students' own achievement goals. Students who hold a *mastery goal* are motivated to learn and understand, on the other hand, performance-oriented students are motivated by their achievement relative to others: *performance approach* students through competition to demonstrate their abilities, and *performance avoidant* students by fear of showing poor performance (Elliot and Harackiewicz 1996; see also Nicholls 1989). Recently, classroom mastery vs. environment dimensions have been linked to students' mathematical task values and thereby participation choices (Lazarides and Watt 2015). In mathematics, this body of work has been concentrated at the secondary school level where students are taught by specialist mathematics teachers.

What happens in individual classrooms impacts students in complex and interwoven ways (Hattie 2009). Students' perceptions of their classroom motivational environments have been richly examined by a wealth of studies within the AGT framework. More recently teachers' enthusiasm for teaching mathematics has been found to impact student-perceived instructional quality (Kunter et al. 2008); relatedly, teachers' enjoyment of mathematics promotes students' own enjoyment in mathematics (Frenzel et al. 2009). Teachers' enthusiasm for the subject of mathematics itself, however, does not influence these perceptions of instructional quality suggesting the need to differentiate between enthusiasm for teaching mathematics and enthusiasm for the subject (Kunter et al. 2008). One process through which teachers' teaching enthusiasm and enjoyment for mathematics may impact students, is via the classroom motivational environments they create. Our study examines matched student and teacher-reported teacher's enthusiasm, its potential role in shaping experienced classroom mastery and performance environments, and thereby emotional and cognitive dimensions of student mathematical interest, across cross-sectional grades spanning primary and secondary school. The key research question for this study is

> In what ways do perceptions of teachers' enthusiasm influence their students' emotional and cognitive dimensions of interest in mathematics?

As mentioned, much of this literature, particularly concerning mathematics motivational environments, has been concentrated at the secondary school level, when students undertake dedicated mathematics classes taught by specialist teachers. Yet, primary school is when mathematical learning and engagement foundations are set, and, when teacher and learning environment influences may be most pronounced, given that students are mostly taught by the same generalist teacher for all subjects every day (Tytler et al. 2008). It is also well-established that primary school teachers, who are mostly women, frequently report low confidence and notable anxiety concerning mathematics (Beswick et al. 2011; Beswick et al. 2006; Burton 2004). Might this depress their enthusiasm for teaching mathematics, and hence creation of mastery motivational environments, dampening the cognitive and emotional dimensions of students' mathematical interest development?

The research reported in this article was part of a national study undertaken in Australian primary and secondary schools funded by the Australian Office of the Chief Scientist. It aimed to identify classroom practices associated with positive mathematical outcomes. In this paper we focus on differentiated components of student interest as a positive mathematical outcome, and the influence of the classroom motivational environment in terms of the enthusiasm of the teacher and the extent to which she or he promotes mastery and/or performance oriented motivational environments.

1.1. Interest and its development

Motivation and interest appear inextricably linked (Murphy and Alexander 2000) with the latter closely associated with perceptions of self (Dewey 1910). Interest has been repeatedly identified as a key predictor of achievement (Heinze et al. 2005) as well as planned and actual levels of participation (e.g., Watt et al. 2012).

Interest is an affect with state and trait like properties. In the mathematics classroom, students can experience a state of interest, termed *situational interest*, as they engage in novel learning tasks (e.g., Carmichael et al. 2009). It is believed however that through repeated exposure to the transient emotional states associated with situational interest, students' interest can develop over time into a deep and enduring interest, termed *individual interest*

(Alexander 2003; Hidi and Renninger, 2006). As stated, the development of interest from situational to individual is guided by cognitive and emotional psychological control systems (Krapp 2007) that are expected to produce qualitative changes in students' interest (Hidi and Renninger 2006), suggesting the need to differentiate interest into at least emotional and cognitive dimensions, which we refer to as *emotional interest* and *cognitive interest*.

1.2. Emotional interest and its antecedents

In a learning context students may experience positive emotions, such as enjoyment and excitement, as they participate in mathematical activities provided these are interesting and/or there are expectations of success. Collative features of the activity such as the novelty associated with new technology are known to generate the emotions associated with situational interest in mathematics (Mitchell 1993). Reeve (1989) has argued that enjoyment also emerges from positive perceptions of competence; students enjoy being successful. He found that whereas collative variables, such as novelty and uncertainty, explained both student ratings of interest and enjoyment, perceptions of competence predicted enjoyment alone. Taken together, these results suggest that emotional interest in mathematics will be influenced by motivational features of the classroom learning environment and also students' perceptions of their competence in mathematics.

1.3. Cognitive interest and its antecedents

Few studies have analysed the antecedents of cognitive interest (e.g., Harp and Mayer 1997), and none noted have done so in a mathematics context. A desire to find out more about mathematics is likely to emerge when students identify gaps in their knowledge of the subject. This, in turn, is likely to occur as their knowledge of mathematics increases and thus the expectation that individual interest is likely to be more cognitively based than situational interest (Hidi and Renninger 2006). A wish to find out more about mathematics can also emerge from students' epistemic curiosity which can be aroused through collative features of the learning environment (Berlyne 1960). Students can be motivated to find out about mathematics if their teacher presents it in contexts that provide novelty, uncertainty and/or complexity. Collative features such as controversy have reportedly been associated with an enduring trait-like epistemic curiosity, but not in a mathematics context (Lowry and Johnson 1981). Taken together, these results suggest that the reported decline in interest as students age might be less for cognitive interest than for emotional interest. Further, students exposed to collative features might also report higher cognitive interest than those exposed to few or none of these features.

1.4. The classroom motivational environment

As discussed, Achievement Goal Theory provides a framework for analysing the motivational environment of the mathematics classroom and thus antecedents of students' emotional and cognitive interest. Reports demonstrate that mastery goal orientations are generally predictive of higher levels of interest (Midgley et al. 2001; Harackiewicz et al. 2008).Working in Grade 6 classrooms, Pantziara and Philippou (2015) in one of the few studies at the elementary school level identified a strong positive correlation between mastery goals and students’ interest in mathematics. Less consistent findings have been shown for performance goals; performance approach goals have sometimes been associated with higher performance and other times not (e.g., Crouzevialle and Butera 2013). However they tend not to be associated with interest (Harackiewicz et al. 2008; Pantziara and Philippou 2015).

The goal orientations of teachers themselves and their subsequent actions in the classroom can create motivational environments that have a profound influence on their students’ own goal orientations and motivation (e.g., Butler 2007; Patrick et al. 2001). For example, students in classes that emphasise a mastery approach are more likely to adopt mastery goals themselves (Meece, Anderman, and Anderman 2006). In general, students who learn mathematics in secondary school classrooms are more likely to experience a performance oriented classroom than those learning mathematics in a primary/elementary classroom (Midgley et al. 2001), which may contribute to the reported declines in interest in mathematics as students age.

The above discussion suggests that students taught by teachers who promote a mastery approach are themselves likely to adopt a mastery orientation and thus report higher interest. Most of the papers discussed however have focussed on the affective dimensions of interest. It is not clear whether cognitive interest would be influenced by a mastery approach or even by a performance approach.

1.5. The role of the teacher

Clearly, in order to develop students' interest and motivation, the classroom environment created by the teacher is critical. The transition to secondary school, for example, is accompanied by negative changes in self-esteem (Seidman et al. 1994), self-concept (Wigfield et al. 1991), perceived competence (Anderman and Midgley 1997), and enjoyment of school subjects (Wigfield et al. 1991) – although comparisons of the cognitive interest dimension have been under-researched. Researchers have shown such declines relate to differences in the classroom environments of primary vs. secondary schools (Eccles and Midgley 1989, 1990). Anderman et al. (2001) suggested that changes in the ways in which Grade 7 students' valued mathematics, including their interest in the subject, were impacted negatively by performance oriented classrooms. In contrast, Schukajlow and his associates (Schukajlow et al. 2012; Schukajlow and Krug 2014) identified teaching practices that promoted Grade 9 students' autonomy and perceptions of competence such as finding multiple solutions to a problem, more mastery oriented approaches, tended to impact positively on students' interest.

Teacher enthusiasm for teaching should impact on emotional interest, in as much as the latter overlaps considerably with enjoyment. Frenzel et al. (2009) reported that teacher enjoyment can positively influence students' enjoyment provided it is enacted, that is the teachers themselves are genuinely enthusiastic. In support of this Zhang (2014) reported a strong association between student perceptions of teacher enthusiasm for teaching and students' reported emotional engagement. Less clear is the impact of teachers' subject enthusiasm on students' interest. As discussed, Kunter et al. (2008) reported that teachers' subject enthusiasm was unrelated with their students' perceptions of instructional practices. Teacher subject enthusiasm, however, is conceptually similar to teacher subject interest (Kunter et al. 2011) and this has been shown to be associated with student interest (Schiefele and Schaffner 2015), though the latter study used affective measures. Given that subject interest and subject knowledge are associated (Alexander 2003) one would expect that specialist mathematics teachers should report higher levels of subject enthusiasm then their less qualified peers. In support of this, Kunter et al. (2011) reported that teachers in academic schools (Gymnasium) reported higher levels of subject enthusiasm than their peers in other schools. Might not such teachers also have that discipline knowledge necessary to present their students with those collative features necessary to generate cognitive interest?

Hypotheses

The above discussion suggests that students' experienced interest—cognitive and emotional—will be influenced by perceptions of their learning environment, and in particular the goal orientation of their classrooms, which is likely impacted by teachers' enthusiasm. Our hypothesised model is shown in Figure 1.

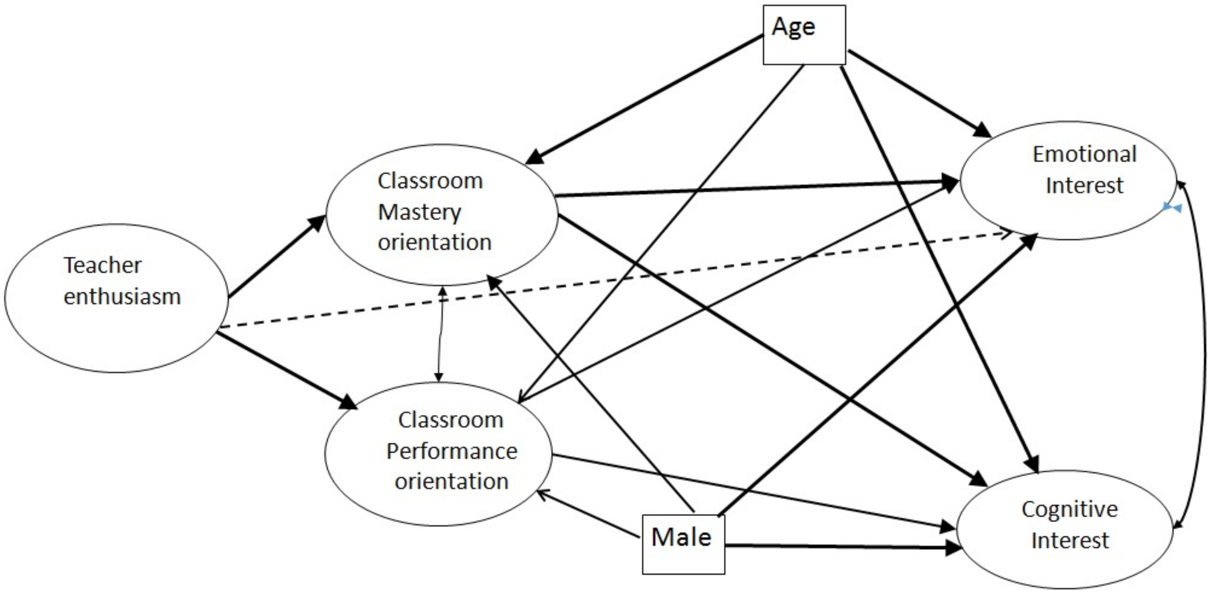

Figure 1. Hypothesised model

In this analysis, we take an across-persons approach drawing upon cross-sectional data from students and their teachers. Based on prior literature (e.g., Patrick et al. 2001), we expect that student-perceived teacher enthusiasm for teaching should predict the experienced mastery learning environment, and thence dimensions of student interest (Harackiewicz et al. 2008). Given that students could theoretically experience higher emotional interest when their teachers express high levels of positive emotion (e.g., Frenzel et al. 2009), we were unsure whether a direct path would also exist from students' perceptions of teacher enthusiasm for teaching to emotional interest (shown as a broken line in Figure 1). Because of reported declines in students' interest as they progress through school (e.g., Watt, 2004) we expected that age would directly impact both students' emotional and cognitive interest. Reported changes in the classroom motivational environment between primary and secondary schools (e.g., Tytler et al. 2008) suggest that age would also indirectly influence interest via motivational environment. As widely reported (e.g., Frenzel et al. 2010) we expected boys would exhibit higher interest levels and that gender would directly impact interest. Moreover, we expected that gender would also indirectly influence interest via classroom environment, because reports suggest girls and boys perceive the same classroom differently, with girls more likely to report lower levels of a mastery environment than boys (Lazarides and Watt 2015). We expected that mastery and performance classroom dimensions would be negatively related or unassociated, and, that interest dimensions would be strongly positively correlated. Given the salience of previous findings concerning students' emotional interest, we speculated that predictions would be stronger for emotional than cognitive interest dimensions.

In line with our earlier discussion, we hypothesised that teacher subject enthusiasm might have a direct impact on both students' reported emotional and cognitive interest. Given the hypothesised association between teacher subject knowledge and their subject enthusiasm, we expected that changes in the latter would be more evident between classes than within classes.

2. Method

2.1 Background to the study

The study was undertaken in Australia in 2015 on behalf of the Australian Office of the Chief Scientist. With the support of state authorities from across the country, school leaders were invited to include their school in a national survey of mathematics practices in schools. Ethics approval was obtained from the University of Tasmania Social Sciences Human Research Ethics Committee (Approval number H14993) and from relevant education systems approvals processes. There was no compulsion to participate and schools used a range of processes for recruiting students, depending on their internal policies. Responses were anonymous but included a self-generated ID using a procedure detailed in the online survey that allowed matching of students to teachers.

Being able to match teachers with the students that they actually teach makes this study somewhat different from others. It is notoriously difficult to achieve links between teachers and classes at scale, but this study was able to leverage off the larger study that provided the data. In addition, the spread of ages and year levels in school is greater than is observed in many research studies that focus on the constructs used in this study, providing a unique opportunity to consider relationships among teacher and student variables.

2.2 The participants

Of the 1067 students who participated in the project matching teacher data were available for 471 students, the participants in our study. The students in our study were taught by 44 teachers in 17 schools from across Australia. Of the 471 students, 47% were male and the ages of students ranged from 8 to 16 years (*M* = 11.2 years, *SD* = 2.0). Students were enrolled in Years (Grades) 3 to 10 of school, with the number of students in each level reported in Table 1. Almost two-thirds (64%) of the students attended primary/elementary school where mathematics is taught by a generalist teacher; the remaining students attended secondary school where mathematics is usually taught by subject specialists. The 17 schools were located in a range of metropolitan, provincial and remote areas across all states of Australia. Information on the socio-economic advantage of the school was available in the form of the Index of Community Socio-Educational Advantage (ICSEA), a measure standardised to have a mean of 1000 and a standard deviation of 100 (ACARA, 2013).

Table 1

Distribution of Students and Teachers Across Year (Grade) Levels

	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Students	9	53	158	48	120	20	57	6
Teachers	1	5	11	7	15	3	7	1

Mathematics teachers of these students provided demographic information. In regard to their highest educational qualification, five teachers held post-graduate degrees, nine held graduate diplomas or certificates, and the remainder held bachelor degrees. Of the 44 teachers, five were less than 30 years old, nine aged 31— 40 years, 18 aged 41—50 years, 10 aged 51—60 years, and the remaining two were older than 60. Seven teachers had taught for less than five years, 13 between six—10 years, eight between 11—15 years, six between 16—20 years, and the remaining 10 for more than 20 years.

2.3 Instruments

Key constructs[1] were assessed via online self-report questionnaires provided to students and their teachers. Teachers were permitted to explain terms if their students seemed confused, and to read the questions to the students if needed. In some younger classrooms hard copies of the surveys were provided.

Students. Measures of students' cognitive (SCI) and emotional (SEI) interest were assessed using7-point response scales ranging from 1 (*not at all*) through to 7 (*extremely*). Cognitive interest was assessed by three items from Frenzel et al. (2012; e.g., "After a math class, I am often curious about what we are going to do in the next lesson") and emotional interest by three items from Eccles and Wigfield (2002; adapted to the Australian context by Watt, 2004; e.g., "I like maths more than my other subjects at school").

Students were also asked to report on aspects of their learning environment, including their teacher's enthusiasm for teaching mathematics (STE), and perceptions of the performance (SCP) and mastery (SCM) orientation of their classroom environment. Student-perceived teacher enthusiasm was assessed by five items from Kunter et al. (2008; e.g., "our

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[1]Items were taken from surveys previously conducted in Australia and were not piloted in this study because of time constraints.

teacher teaches maths with great enthusiasm) rated on 5-point response scales ranging from 1 (*not at all*) through to 5(*extremely*). Student-perceived classroom performance and mastery orientations were assessed using items from the Patterns of Adaptive Learning Survey (PALS; Midgley et al.2000)on5-point response scales ranging from 1 (*not at all true*) through to 5(*extremely*). Three performance items included "our teacher tells us how we compare to other students"; three mastery items included "our teacher wants us to understand our maths, not just memorise it".

Teachers. Teachers also reported on classroom motivational environment dimensions using the teacher items of the PALS performance (TCP) and mastery (TCM) environments in their classes (not exactly parallel to the student items), using 5-point response scales ranging from 1 (*not at all true*) through to 5 (*very true*). Six performance items included "students who get good grades are pointed out as an example to others"; six mastery items included "Students are told that making mistakes is OK as long as they are learning and improving. ". Teachers' subject enthusiasm was assessed with five items (e.g., "I find mathematics exciting and try to convey my enthusiasm to students") taken from Pekrun et al. (2011) but measured on a 7-point scale ranging from 1 (*not at all true*) through to 7 (*very true*). Reliabilities for all scales used in the study are shown in Table 2, which also includes descriptive statistics and latent correlations among study constructs.

2.4 Analyses

We commenced our analysis by investigating the factor structure of the interest dimensions; confirmatory factor analyses examined whether a two-dimensional structure of interest was superior to a single interest factor. We then investigated associations between key variables and constructs, commencing with student-level and then teacher-level variables.

We tested the hypothesised model using multilevel structural equation models (Muthén and Asparouhov 2010)to accommodate the nested nature of these data. Because of the lack of statistical power, teacher variables were not included into a teacher-level model in this analysis. The models were estimated using the option “type = MULTILEVEL” of MPlus version 7 (Muthén and Muthén 2012). Missing data at the student level were imputed using Bayesian analysis as described in the MPlus manual (Muthén and Muthén 2012). Evaluation of the model was based on the comparative fit index (CFI, Bentler 1990), the root mean square error of approximation (RMSEA, Hu and Bentler 1999) and the standardised root mean square residual at both the within ($SRMR_w$) and between ($SRMR_b$) levels. Acceptable fit is demonstrated when the CFI > 0.9 and the remaining indices are less than 0.05 (Byrne 2012).

Testing of the hypothesised effect of subject enthusiasm on cognitive interest was undertaken using multilevel means-as-outcomes regression analysis, also using MPlus.

3. Results

In this section the results of the study are presented to answer the research question posed: In what ways do perceptions of teachers’ enthusiasm influence their students’ emotional and cognitive dimensions of interest in mathematics?

3.1 Dimensionality of interest constructs

Given the strong correlation between the factors measuring emotional and cognitive interest (see Table 2), a confirmatory factor analysis was undertaken to assess whether our hypothesised two separate but correlated interest components fitted these data better than a single interest construct with six indicators. The analysis indicated that our hypothesised structure fitted these data satisfactorily (RMSEA = .04, CFI = .99) but that a single interest factor less so (RMSEA = .12, CFI = .95). Moreover, based on a scaled[2] chi-square difference test, the hypothesised two-factor model improved fit significantly ($\Delta\chi^2 = 16.1, \Delta df = 6.8, p < .01$).

3.2 Bivariate associations and mean differences

Based on observed factor scores, boys reported higher emotional interest (*d* = 0.28, *t* = 2.97, *df* = 453) and cognitive interest (*d* = 0.23, *t* = 2.50, *df* = 454) than girls. There were no gender differences in perceived teacher enthusiasm for teaching, perceptions of mastery, or performance classroom motivational environments. Age was negatively associated with student perceptions of teacher enthusiasm for teaching (*r* = -.31, *df* = 451, *p*< .01), a classroom performance environment (*r* = -.14, *df* = 464, *p*< .05) and a classroom mastery environment (*r* =- .34, *df* = 462, *p*< .01). It was also negatively associated with their emotional interest (*r* = -.37, *df* = 457, *p*< .01) and cognitive interest (*r* = -.44, *df* = 458, *p*< .01) and there were no significant differences between these two correlations. ICSEA, on the other hand, was not associated with students' perceptions of their class environment, but positively associated with students' reports of their emotional interest (*r* = .23, *df* = 457, *p*< .01) and cognitive interest (*r* = .20, *df* = 458, *p*< .01).

There were no significant bivariate associations between teachers' perceptions of the learning environment and demographic variables such as their age or highest educational qualification. ICSEA however was positively associated with teachers' perceptions of a performance environment (*r* = .26, *df* = 469, *p*< .01) and negatively associated with their perceptions of a mastery environment (*r* = -.34, *df* = 469, *p*< .01), suggesting that higher socio-economic status schools, which are typically independent in Australia, are more likely to emphasise competitive performance than lower socio-economic status schools.

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[2] As described in Muthén and Muthén (2012).

Table 2

Descriptive Statistics and Correlations for Study Constructs

Construct	M	SD	MV	α	ICC(1)	ICC(2)	SCI	SEI	STE	SCP	SCM	TSE	TCP	TCM
Cognitive interest (SCI)	4.27	1.67	2%	0.80	.25	.78	1.00	.87**	.37**	.02	.38**	-.17**	.19**	.01
Emotional interest (SEI)	4.35	1.91	3%	0.91	.20	.73		1.00	.34**	.01	.42**	-.09	.21**	-.06
Perceived teaching enthusiasm (STE)	4.50	1.21	4%	0.89	.25	.77			1.00	.11	.86**	.01	-.14	.13
Perceived classroom performance (SCP)	2.68	1.30	1%	0.71	.25	.78				1.00	.11	-.11	.28**	-.15
Perceived classroom mastery (SCM)	4.72	1.15	1%	0.76	.31	.82					1.00	-.04	-.14	.08
Teacher subject enthusiasm (TSE)	5.84	1.00	0%	0.93								1.00	-.36*	.37*
Teacher classroom performance (TCP)	2.25	0.86	0%	0.78									1.00	-.49**
Teacher classroom mastery (TCM)	3.88	0.54	0%	0.78										1.00

* $p < .05$, ** $p < .01$
MV rate of missing values at the scale level
ICC(1) the amount of individual-level variance explained by group membership.
ICC(2) is a measure of the reliability of the group means (see Bartko, 1976)

3.3 Testing the hypothesised model

Class sizes ranged from 3 to 42[3] (M = 10.8). Small classes were retained because a substantial proportion of the sample (15%) was in classes with fewer than eight participants, and in many cases, these were from remote areas of Australia where class sizes are especially small. The intra-class coefficients for students' emotional and cognitive interest, calculated on the factor scores, were 0.20 and 0.25 respectively, suggesting that a substantial proportion of the variance in the dependent variables could be attributed to between class effects.

The two outcome variables were students' emotional interest (SEI) and cognitive interest (SCI). The variables tapping the class environment were students' perceptions of a classroom performance environment (SCP) and mastery environment (SCM), both in turn predicted by their perceptions of teacher enthusiasm for teaching mathematics (STE). We commenced the analysis by fitting the student-level variables with grouping by teachers in order to test our hypothesised model shown in Figure 1. The model, shown as Model 1 in Table 3, reported satisfactory fit except at the between class level, which was possibly due to our inclusion of small class-sizes. All hypothesized paths between key constructs were significant at the 5% level, except the path from SCP to SCI (β = -.04, p = .44). Further, age and sex reported direct influences on SCI and SEI, but only age had an indirect influence; it influenced SEI through SCM. This model is shown in Figure 3, where significant paths (at the 5% level) include standardised (STDYX standardisation) effects.

We then tested whether a direct path also existed from STE to the emotional interest dimension, as shown as a broken line in Figure 1. This model, shown as Model 2, did not report any significant difference in fit and STE failed to have any significant direct effect on emotional interest (β = -.04, p = .75) though maintaining hypothesised indirect effects. This confirmed our hypothesis that the relationship between students' perceptions of teacher

[3] In this case, two classes at the same year level were taught by the same teacher.

enthusiasm for teaching and their own interest, was mediated by their perceptions of the classroom motivational environment.

Table 3

Summary of multivariate models

Model	χ^2 (df)	*RMSEA*	*CFI*	*SRMRw*	*SRMRb*	*N/p*
Model 1	392 (273)	.03	.91	.04	.49	5.6
Model 2	390 (271)	.03	.91	.04	.49	5.5
Model 3	28.8 (23)	.02	.97	.02	.12	14.3
Model 4	27.9 (23)	.02	.98	.02	.10	14.3

$\chi^2(df)$chi-square value and degrees of freedom

N/p ratio of number of observations to the number of free parameters

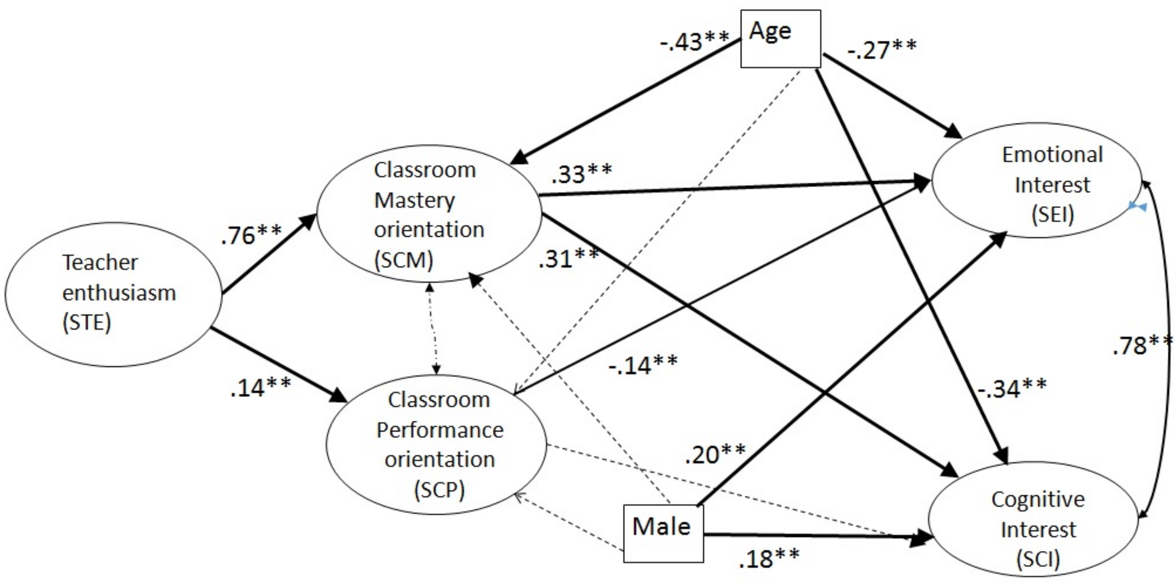

Figure 3: Final student level model.[4]

[4]Significant paths are shown with unbroken lines.

3.4 Testing the impact of teacher subject enthusiasm on student interest

As indicated in Table 2, teachers' reports of their subject enthusiasm were negatively associated with students' cognitive interest and not at all related with students' emotional interest. Given the reported associations between age, sex and both types of interest, two multilevel means-as-outcomes regression models were used to control for these student level fixed effects. These models were used to test our hypothesis that teacher subject enthusiasm would have a direct impact on both students' emotional and cognitive interest, but at the between class level. Fit for both models was satisfactory and is reported in Table 3 as Model 3 (predicting cognitive interest) and Model 4 (predicting emotional interest).The results of Model 3 indicate a significant negative effect of teacher subject enthusiasm on students' cognitive interest (β = -.57, p<.01), and significant effects for student age (β = -.49, p<.01) and gender (β = .16, p<.01). The direction of this relationship was unexpected and a plot of class means of cognitive interest against teacher's observed subject enthusiasm is shown in Figure 2, which indicates that the relationship was more pronounced in primary classes. The results of Model 4 indicate no significant effect of teacher subject enthusiasm on students' emotional interest (β = -.12, p>.05), but significant effects for student age (β = -.42, p<.01) and gender (β = .17, p<.01).

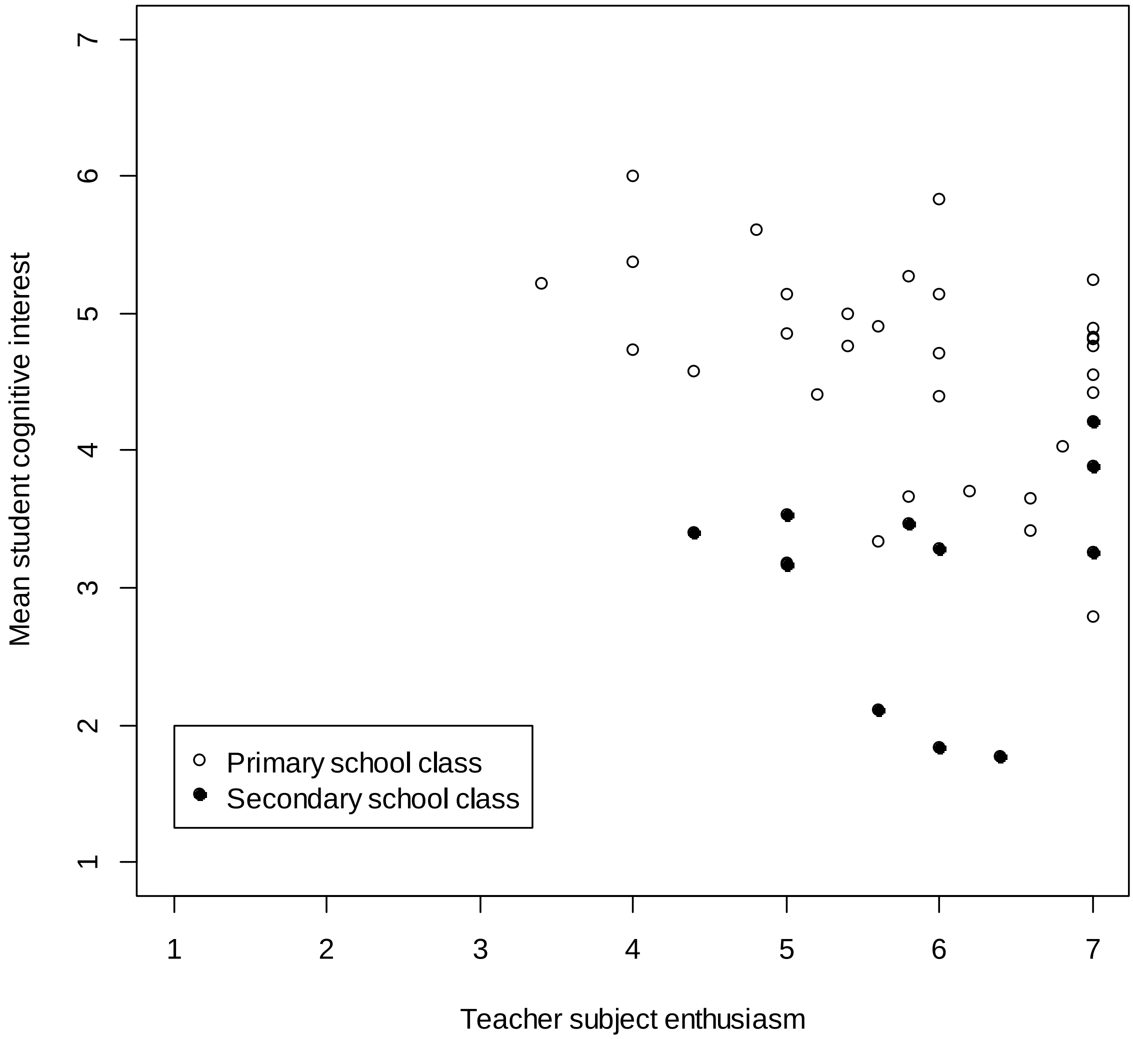

Figure 2: Mean student cognitive interest levels by teacher subject enthusiasm.

4. Discussion

The research question for this study, "In what ways do perceptions of teachers' enthusiasm influence their students' emotional and cognitive dimensions of interest in mathematics" was addressed using multilevel structural equation modelling. In this section the findings and implications are considered.

4.1 Classroom environment influences on student interest

The findings in general mirror those of previous work, although the sample comprised both primary (elementary) and secondary aged students and their teachers, whereas earlier work had tended to focus on secondary classrooms. Direct relationships at the within class level were mainly as hypothesised. Age had a direct negative influence on both emotional (β = -.27, p <.01) and cognitive interest (β = -.34, p <.01), in that older students tended to be less interested than younger ones, similar to results from studies undertaken only in high school classes (Frenzel et al. 2010; Jacobs et al. 2002; Nagy et al. 2010; Watt, 2004). Similarly, as reported in the literature, boys were significantly more interested in mathematics than girls (Jacobs et al. 2002), reporting higher levels of emotional (β = .20, p <.01) and cognitive (β = .18, p <.01) interest. In line with the literature, students' perceptions of a performance environment in their class appeared to undermine their interest, especially their emotional interest (β = -.14, p <.01). In other words, they liked mathematics less when they perceived a performance oriented environment.

Student perceived teacher's enthusiasm for teaching impacted positively on perceptions of classroom mastery (β = .76, p <.01) and performance environments (β = .14, p <.01), and these in turn had an impact on students' emotional and cognitive interest. The effects were different, however, for emotional interest (SEI) and cognitive interest (SCI). Perceptions of classroom mastery predicted both emotional (β = .33, p <.01) and cognitive (β = .31, p <.01) interest in mathematics almost equally. Perceptions of classroom performance (SCP) was significantly negatively associated only with emotional interest (SEI), suggesting that students' perceptions of a classroom performance goal orientation had a somewhat detrimental effect on their enjoyment of mathematics. This may be due to externally controlling features observed in classroom performance environments (Patrick et al. 2001). The items comprising our SEI construct emphasised enjoyment and interest. Consequently students indicating a high classroom performance environment may not have experienced enjoyment during mathematics lessons because of a perceived lack of control. On the other hand, the cognitive interest items used in the study emphasised epistemic curiosity, which may be more influenced by specific pedagogical practices, such as how teachers relate material to interesting contexts, rather than motivational aspects of the classroom.

Only some of the hypothesised indirect effects were evident in the final model. As expected, age had an indirect effect on emotional interest via perceived mastery environment ($\beta = -.43$, $p < .01$), suggesting that there may be a subtle shift in teachers' approaches to teaching as students move through school. The changes in pedagogy as students move into the high school years are well established. Interestingly age had a much smaller influence on a perceived performance environment ($\beta = -.15$, $p = .11$) indicating that children of all ages experience performance environments and it is not unique to secondary school contexts. Given findings that older students' tend to provide cognitive interest responses to interesting stimuli (Frenzel et al. 2012) we had expected that the impact of age on cognitive interest would have been higher than its impact on emotional interest. Yet this was not the case possibly due to the way we have conceptualised emotional and cognitive interest. Gender did not have any significant impact on either perceived mastery or performance environments, counter to recent findings that girls reported lower levels of perceived mastery environment in mathematics lessons (Lazarides and Watt 2015) than boys.

As proposed by Kunter et al. (2011), two causal chains might explain the relationships between the key study constructs. Through their positive emotions, enthusiastic teachers might generate emotional contagion amongst their students and thus higher levels of emotional interest. They may also invest in activities such as more professional development or seeking out stimulating resources related to mathematics, generating higher levels of students' cognitive interest. Patrick et al. (2001) observed the actions of teachers in high mastery and high performance oriented classrooms and found that the former were more likely to be enthusiastic and encouraging than the latter. Together with our results, this suggests that enthusiastic teachers are more inclined to motivate their students intrinsically, perhaps through encouragement to master the material, whereas less enthusiastic teachers may be more inclined to motivate their students extrinsically, perhaps through encouragement to perform better against external benchmarks. Teacher enthusiasm for teaching may therefore be a necessary component for creating and maintaining a mastery oriented environment. A performance oriented environment may instead rely less on enthusiasm and more on extrinsic goals.

4.2 The impact of teachers' perceptions of subject enthusiasm on students' interest

Because teachers were asked about their enthusiasm for teaching mathematics, we could consider these findings in relation to their own students' cognitive and emotional interest. We had conjectured that a teacher's subject enthusiasm would be positively associated with both interest dimensions. Contrary to findings by Schiefele and Schaffner (2015) there was no association between teacher subject enthusiasm and emotional interest. Further, there was a significant negative relationship between teachers' subject enthusiasm and students' cognitive interest. Arguably an enthusiasm for the subject of mathematics might lead to non-instructional aspects that impact negatively on children's interest. For example, teachers with strong subject enthusiasm are likely to be highly competent mathematically. They may hold concomitant beliefs about mathematics and students' capacity to achieve in mathematics (Beswick 2011), which impact on the classroom motivational environments that they develop, and hence their students' interest.

4.3 Study limitations

Although the study provides important results from a recent Australian project, there are limitations that may influence our conclusions. Our measure of emotional interest focussed on enjoyment items and did not include items that assessed the value associated with interest. For this analysis focused on influences of the classroom goal climate and teachers' enthusiasm, our measure of interest had a focus on liking mathematics, which is similar to enjoyment, and on curiosity as an indicator of cognitive interest. Values are affected by broader social contexts (Frenzel et al., 2010) and hence we chose not to include them in this analysis, potentially contributing to some findings that were in disagreement with the literature. Further, our study was cross-sectional and utilised correlational data to test a predictive path model, limiting causal claims that can be inferred. Finally, due to our decision to retain small class sizes and our relatively small sample, we were unable to model teacher-level data with the student-level data.

4.4 Implications

The strong relationship between students' perceptions of teachers' enthusiasm (STE) and students' perceptions of a mastery motivational environment (SCM), that in turn affects students' emotional and cognitive interest, implies that professional learning programmes for teachers should focus not only on content and pedagogical knowledge, but also on developing teachers' attitudes and thinking about mathematics. Enthusiasm for teaching mathematics may not be able to be taught but, in the same way that school students can be infected by their teachers' enthusiasm, it seems likely that enthusiastic mathematics educators could have a similar effect on pre-service and in-service teachers. This challenge is considerable given primary teachers' documented negative feelings and attitudes towards mathematics (Beswick et al. 2006), and the growing issue in Australia of a dearth of qualified mathematics teachers in secondary schools (Weldon 2016). There are messages for schools as well. Although enthusiasm for teaching cannot be mandated, it is possible to create conditions in which enthusiasm for teaching mathematics is more likely to develop. A focus on developing mastery oriented classrooms, using suggestions from research such as that of Schukajlow and his colleagues (Schukajlow et al. 2012, 2014), could be a starting point. It is important for future mathematics development that the trend away from studying mathematics is arrested. This study suggests that positive intervention with teachers could have an impact on students' emotional and cognitive interest in mathematics through the nature of the classroom motivational environments that teachers create.

5. Acknowledgement

This study was funded by the Office of the Chief Scientist (OCS). The opinions expressed in this article are those of the authors and project team and do not necessarily reflect the view of the OCS. The involvement and contributions of A/Prof. Judy Anderson, Prof. Kim Beswick, A/Prof. Vince Geiger, Prof. Merrilyn Goos, Dr. Derek Hurrel, Dr. Christopher Hurst, and Dr. Tracey Muir are acknowledged.

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