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# Perception shapes experience: The influence of actual and perceived classroom environment dimensions on girls' motivations for science

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**Abstract** The classroom environment influences students' academic outcomes, but it is often students' perceptions that shape their classroom experiences. Our study examined the extent to which observed classroom environment features shaped perceptions of the classroom, and explained levels of, and changes in, girls' motivation in junior secondary school science classes across two school terms. Girls have been found to feel less capable than boys and to under-participate in science classrooms, even though their achievement levels are similar. Four teachers and five of their classrooms of students ($N = 52$) reported their perceptions of the classroom environment, and trained observers rated the 'actual' classroom environment. Students also completed questions regarding their motivations for science at both time points. Hierarchical linear modelling showed that students' perceptions of classroom structure were very important and exerted significant influence on science motivations. All of the six observed classroom dimensions affected students' extrinsic utility value, via perceptions of structure. Other classroom dimensions showed particular patterns of relationship with motivations. Teachers' perceptions of the classroom environment were often more positive than those of the students, which is congruent with previous research. The findings have implications for retaining girls in science and, thereby, addressing the gender gap in science-related vocations.

**Keywords** Classroom environment · Girls · Junior high school · Motivation · Perceptions · Science

Classroom environments have the potential to promote a positive learning climate that fosters students' motivation and engagement. Particular types of instructional practices and teacher-student interactions cultivate such constructive environments. However, students differ in their perceptions of the same classroom setting, which can result in a vast array of

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classroom experiences, within the one class of students (Wolters 2004). Socialisation of gendered norms within particular learning domains can also influence individuals' perceptions, such that particular settings are more conducive to engagement for girls or boys. Longitudinal studies have demonstrated that such differences are reflected in the varying competency beliefs and interests that girls and boys have for traditionally gender-typed subjects across the course of their schooling years (Fredricks and Eccles 2002; Frenzel et al. 2010; Jacobs et al. 2002; Nagy et al. 2010; Watt 2004; Wigfield and Eccles 2000). It has become apparent that these differences have long-term implications for higher education and the workforce, such that fewer women are involved in STEM (Science, Technology, Engineering and Mathematics) fields (e.g., Watt 2007, 2008). Working to promote the motivation of girls in early adolescence has been pursued to address the gender imbalance in those careers, since motivations are central to girls' and boys' career plans, and, early adolescence is the time when significant disengagement from school occurs (Murdock 1999). Hence, there is a specific need to know which particular aspects of different classrooms can most impact on students' motivations within the domain of science.

## Introduction

### Classroom environment

The classroom environment is particularly influential in terms of student academic outcomes (Martin and Dowson 2009) and has been defined as the "general class atmosphere including attitudes towards learning, norms of social interactions, acceptance of ideas and mistakes, and learning structures set by the teacher" (Urdan and Schoenfelder 2006, p. 340). Amalgamating a plethora of research concerning classroom environment, Pianta et al. (2008) have proposed three overarching constituents of classroom environment (emotional support, classroom organisation and instructional support), which influence the three key aspects of student engagement (behavioural, emotional and cognitive engagement).

Emotional support encompasses the teacher's ability to foster students' social and emotional functioning in the classroom. Student perception of positive emotional support from teachers is related to their high academic performance, positive social functioning and emotional wellbeing (Chang 2003; Hughes et al. 1999; Wentzel 1994, 1997, 2009). This relationship can have a positive cyclical effect such that teacher involvement promotes student engagement, and high levels of student engagement lead teachers to demonstrate further involvement (Skinner and Belmont 1993). Second, the classroom organisation dimension denotes classroom processes related to the structure and management of students' behaviour, time and attention. Middle and secondary school teachers who manage classrooms well tend to begin lessons promptly, create predictable learning environments, and ensure smooth transitions between activities, which encourage student focus and minimise behavioural disruptions (Rosenshine 1995). Third, instructional support includes the ways in which teachers implement activities to facilitate student learning. Teachers who utilise students' problem-solving skills and relate these to real-world issues give the material more relevance for students (Bransford et al. 2000). The quality of teacher feedback influences student interest, motivation and effort (Butler 1987; Good and Brophy 2008). High-quality feedback is specific and immediate and functions to scaffold students' knowledge (Butler 1987). Separating the classroom environment into its constituent dimensions allows researchers to identify the predictors and consequences for each, which can help teachers to tailor their individual teaching style to enhance their students' motivation for, and engagement in, learning.

## Teacher and student perceptions of classroom environment

Research has acknowledged the discrepancy between the 'actuality' of classrooms, and students' own perceptions of those classrooms, that inform their experiences. Objective measures of classroom environment are important for establishing the operational structure of classrooms; however, studies that focus only on objective measures of the classroom environment could miss a vital part of students' learning settings. There is large variability in students' perceptions of classroom environment (Wolters 2004) in that students in the same class do not necessarily perceive the classroom in the same way. Research comparing teacher and student perceptions of the same classroom has generally demonstrated that teachers' perceptions are more positive than those of the students (Dorman 2008; Fraser 1982; Raviv et al. 1990; Sinclair and Fraser 2002). Goodnow (1988) and Wentzel (2002) stressed the importance of focussing on student perceptions of the teacher and the classroom environment, because it is students' own perceptions that construct their reality. Many studies that investigate student perceptions of their learning environment tend to aggregate individuals' data to the class-average level, thus losing the ability to detect subtle differences in student perceptions. The present study utilised a new measure of classroom environment perceptions to assess the comparability between teacher and student perceptions of the same classroom environment. The Teacher Style Scale (TSS) was constructed by Watt and Richardson (2007), bringing together Baumrind's (1971) parenting styles and Wentzel's (2002) teaching styles. A directly parallel version, the student-reported TSS, assesses students' perceptions of the same classroom dimensions. Such a teacher self-report measure had not been developed until this point, with most studies collecting student reports of teacher style, which can be time-consuming and resource intensive.

Hierarchical linear modelling (HLM) is required for the analysis of clustered school-based data, thus partitioning variance appropriately by 'nesting' students' perceptions within the environments in which they are situated. Dorman (2009), among others, has argued that when the hierarchical nature of most research conducted in schools (e.g., students nested in classrooms) is ignored, data are analysed inappropriately and their potential strength is not utilised. When investigating students' attitudes and the classroom environment of chemistry lessons, Wong, Young and Fraser (1997) showed that HLM made more conservative estimates of variable-outcome relationships than typical regression procedures, because within-class variance was not treated as between-student variance for students within the same classrooms.

Jang et al. (2010) investigated the influence of observed and teacher-reported autonomy support and structure on students' observed and self-reported behavioural engagement. Analysis of the results using HLM showed that observed autonomy support uniquely predicted students' observed and self-reported behavioural engagement, whereas observed teacher structure uniquely predicted students' observed behavioural engagement. Urdan (2004) utilised HLM to investigate student perceptions of goal messages conveyed by their English teachers. This method of analysis showed that students' own perceptions were stronger predictors of goal structures than perceptions shared by the class as a whole. These studies exemplify how a more complete picture of students' experiences in the classroom is gained when HLM is employed, and student data are non-independent because of students being within the same classroom environments. Aggregating students' data to the classroom level overcomes the problem of non-independence but fails to retain the complete picture of different individuals' perceptions. The present study utilised HLM to examine relationships between observed classroom environment dimensions, students' own classroom perceptions, and consequences for their motivations from the start until later in their school year.

## Motivational theory and educational settings

The application of motivational research to educational settings has shown a marked increase over the past 20 years (Alexander 2000). A prominent and comprehensive theory explaining the processes by which motivations impact students' participation choices is the expectancy-value model of Eccles (Eccles 2005; Eccles et al. 1983), which links expectancies and values to an extensive range of psychological and social factors and which has received substantial research attention over the past two decades. The expectancy-value model proposes that students' expectations for success and the value that they attribute to a task influence their choices, performance and persistence in relation to that task. Eccles and colleagues proposed three important aspects of motivation: perceived task value, that is the importance one places on a task; perceived task difficulty, which is how hard one perceives the task to be and what level of effort is required to successfully complete it; and ability expectancies, that is, one's perception of competence and ability to perform well in a certain area. Domain-specific ability expectancies and values have been demonstrated to predict mathematics and English achievement, over and above the effects of prior achievement (Eccles et al. 1983). Furthermore, Eccles and Wigfield (1995) found that ability expectancies were positively related to perceived task value and negatively associated with task difficulty, indicating that students tended to value the activities at which they thought they were good, but held less value for activities they found more difficult and considered that they were worse at.

Perceived task value is compartmentalised further into intrinsic interest value, extrinsic utility value, attainment importance and cost. Intrinsic interest is the inherent enjoyment that one experiences from being involved in an activity. Extrinsic utility is the perceived usefulness of an activity for achieving goals. Attainment importance is the "personal importance of doing well on the task" (Eccles and Wigfield 2002, p. 119). Cost encompasses the negative experiences associated with participation in a task, such as other lost opportunities. Task values have been found to predict enrolment decisions in mathematics, physics and English, as well as involvement in sports activities, even after prior performance levels are controlled (Eccles et al. 1984). The expectancy-value model has had strong empirical support, and it was used as the theoretical framework for the current study.

## Gender and student motivation

Investigations of variations in students' ability expectancies and value across the course of their school years have revealed some important trends (Meece et al. 2009). Longitudinal research has shown declines in students' values and ability expectancies as they progress through their schooling; however, the most rapid period of decline seems to occur in the primary/elementary school years (Fredricks and Eccles 2002; Jacobs et al. 2002; Nagy et al. 2010; Wigfield and Eccles 2000). Despite the trend of declining ability expectancies appearing somewhat normative, it is worrying given its relation to performance and the relation between value beliefs and task engagement (Meece et al. 2009). Interestingly, this decline in ability expectancies is affected by gender and subject domain. Boys start school with stronger beliefs in their mathematics and sports abilities than girls, whereas girls hold more elevated ability expectancies for Language Arts (or English, in the Australian schooling context).

The expectancy-value model, which was initially developed for the specific purpose of studying gender differences in high school mathematics enrolments, proposes that ability expectancies are moderated by value beliefs about a task. That is, students choose to participate in activities at which they feel competent and to which they attach value. Therefore, it is interesting that both genders report higher valuing of the subjects in which they feel more competent. Longitudinal research that has assessed differential changes in interest and ability expectancies across the school years presents conflicting results. Some studies report that gender differences remain stable (Frenzel et al. 2010; Nagy et al. 2010; Watt 2004), whereas others report that there is convergence or divergence of gender differences (Fredricks and Eccles 2002; Jacobs et al. 2002). However, the majority of this research has been conducted in the domains of English and mathematics, with science being relatively understudied. Interesting results emerge when comparing these perceptions with students' actual achievement. Meta-analyses have demonstrated that girls and boys achieve similarly in science across their schooling years (Else-Quest et al. 2010; Friedman 1989; Hyde et al. 1990; Hyde and Linn 2006). Thus, it is clear that achievement levels do not account for students' disparate perceptions (Eccles et al. 1993). Instead, research shows that it is girls' lower perceptions of ability, talent and enjoyment of science that contribute to their lower participation (Watt 2004; Watt et al. 2006).

## Pipeline effects of motivations on workforce participation

It has been demonstrated that girls begin to lose interest in STEM subjects during secondary school, and thus fewer girls opt for advanced classes in later secondary school when they have more choice and control in the subjects that they elect to study (Watt 2008). Thus, many females restrict their educational and vocational options from an early stage in life (Sells 1980). Fewer women enrol in STEM courses at university, which impacts on the number of women entering those careers (Watt 2007). This trend has been likened to a 'leaky pipeline' that loses many girls and women as they progress along their educational track, until there is only 'a trickle' entering the STEM-related workforce (Simpkins and Davis-Kean 2005). Not only are women less likely than men to enter STEM careers (Watt 2006), but they are also more likely to leave those careers if they do enter them (Mau 2003). The gender imbalance in STEM careers perpetuates a male-dominated culture in which women's most common personal obligation, raising a family, is often ignored (Tatlı et al. 2008). Such oversights probably deter women from aspiring to and persisting in STEM career paths (Frome et al. 2008; Watt 2007). A longitudinal study has supported this assertion, with the finding that many young women who had aspired to STEM-related fields, instead, chose to pursue careers that were more suitable to their planned family obligations (Frome et al. 2006, 2008).

However, perhaps students, and girls especially, are ill-informed during secondary school about the career opportunities and requirements involving STEM skills. Increased education from teachers regarding the workforce possibilities, relevant educational preparation, and exposure to knowledge about a range of occupations could give students a better indication of what is available to them after secondary school, with the potential to spark their interest for certain careers. Discovering the reasons behind girls' decreased participation in science domains during the school years could help in formulating targeted interventions to encourage more females to stay involved in STEM which, in turn, could help to address this gender imbalance in the workforce. Investigating the impact of classroom environments on girls' motivations for science could help to identify factors conducive to maintaining and sustaining girls' motivations in this domain.

## The present study

The current study examined the extent to which observed and student-perceived classroom environment features explain changes in girls' science motivation in junior high school science over the period of two school terms. An expectancy-value theoretical framework (Eccles 2005; Eccles et al. 1983) was adopted because of the clear applicability that it has to educational settings and to explaining girls' science motivations and participation. There is an extensive research literature surrounding students' interest and perceived competence in gender-stereotyped subject domains; mathematics has received a large proportion of the investigative attention, with science being relatively understudied. Thus, the practical applicability of the existing research to retaining girls and women in the science area of STEM is somewhat limited. The current study aimed to address this gap by focusing on science classrooms. Years 7 and 8 students were targeted because junior high school is when the steepest period of decline in students' ability expectancies in mathematics seems to occur (Jacobs et al. 2002; Watt 2004), and therefore could be the most effective time for implementing efforts to maintain science motivation and participation.

Multiple perspectives of the teaching environment were examined. Gaining students' perceptions of their classroom environment, alongside teacher reports, allowed assessment of the extent of congruence versus discrepancy between their perspectives. Objective measures of classroom environment dimensions allowed testing relationships with perceived classroom dimensions. The inclusion of longitudinal data at two time points allowed students' initial motivations to be taken into account when assessing the influence of classroom environment on Time 2 motivations.

Four main hypotheses were proposed based on the literature reviewed:

(1) Students' perceived classroom environment would exert more influence on their motivations than observed classroom environment dimensions.
(2) Observed classroom environment features would impact on students' perceptions of the classroom environment.
(3) Students' extrinsic utility value would be the motivation most likely to be affected by observed and perceived classroom environment because, by definition, it is influenced by external features.
(4) Teachers' perceptions of the classroom environment would be more positive than students' perceptions for the same environment.

## Method

### Participants

Participants were 4 science teachers (3 females, 1 male) and 5 classrooms of their students from 2 independent schools in Melbourne, Australia. Student participants ($N = 52$) came from the participating teachers' classrooms. Response rates were good (84 % across time points). Student participants ranged in age from 11 to 14 years ($M = 12.79$ years, $SD = 0.75$) and all were female. Fifty-eight percent of participants ($n = 30$) were in Year

8 and 42 % ($n = 22$) were in Year 7. Eighty-eight percent of students ($n = 46$) attended an independent single-sex girls' school and the remaining 12 % of students ($n = 6$) attended an independent coeducational school.

## Materials

### *Teacher Style Scale (TSS; Watt and Richardson 2007)*

The TSS was developed from Baumrind's (1971) parenting styles and Wentzel's (2002) teaching styles to assess the teacher's perception of his/her classroom environment. The TSS consists of 29 items, rated on a 7-point Likert-type scale. The TSS items tap 4 latent constructs of expectations (e.g., To what extent do students in your classes feel that you expect them to work hard to achieve their full potential?), relatedness (e.g., To what extent do students in your classes feel they enjoy interacting with you?), negative feedback (e.g., To what extent do students in your classes feel you might react negatively towards their mistakes?) and structure (e.g., To what extent do students in your class feel there are clear expectations about student behaviour?). All TSS subscales demonstrated acceptable reliability (α ranged from 0.72 to 0.85).

### *Student-reported Teacher Style Scale (SRTS; based on Watt and Richardson 2007)*

The TSS was adapted for student respondents for collecting their parallel perceptions. The student version of the TSS consists of 29 directly parallel items, rated on the same 7-point Likert-type scales. The items of the student version of the TSS similarly load onto the 4 constructs of expectations, relatedness, negative feedback and structure. In the current study, all student-reported TSS subscales demonstrated acceptable reliability (α ranged from 0.71 to 0.87).

### *Student Motivations Questionnaire (Eccles and Wigfield 1995; adapted from Eccles and Wigfield 1995, for the Australian context by Watt 2004)*

Twenty-nine questions rated on 7-point Likert-type scales were used to assess students' ability expectancies (5 items) and task value for science; task-value subfactors were intrinsic interest value (5 items), attainment importance (3 items) and extrinsic utility value (5 items). All motivational subscale measures demonstrated acceptable reliability in the present study (α ranged from 0.83 to 0.96).

### *Classroom observations*

Classroom observations were conducted using the classroom assessment scoring system-secondary (CLASS-S), (Pianta et al. 2007). The CLASS is a research-based, widely-validated observational instrument used to assess school classroom environments in a structured format, with a particular focus on teacher–student interactions. It contains 12 dimensions in total, grouped under four overarching domains: emotional support, classroom organisation, instructional support, and student outcomes. These provide a number of broader conceptions of classroom environment than the TSS. Consequently, those dimensions of the CLASS-S that most closely resembled latent constructs of the TSS were selected for inclusion. The three dimensions selected from emotional support were positive climate, negative climate and regard for adolescent perspectives. Behaviour management was selected from the domain of classroom organization; quality of feedback from the domain of instructional support; and the single dimension from the 'student outcomes' domain (student engagement) was also observed. In the CLASS-S, each dimension is rated on a Likert-type scale scored from 1 to 7, where scores of 1–2 indicate 'low quality', 3–5 'mid-range quality', and 6–7 'high quality'.

## Procedure

One of the four participating teachers who taught science to students in Years 7 and/or 8 in Melbourne schools was drawn from a larger cohort of 1,651 participants involved in an ongoing longitudinal investigation of teacher experiences, known as the FIT-Choice project (see www.fitchoice.org). The remaining three participants were invited after referral from another teacher whose data were not included in the present study. All students in the selected classes were invited to participate. Students who gave, and whose parents also gave, informed consent participated. During Time 1 data collection, teachers completed the TSS, to obtain their perceptions of their teaching style, which took them approximately 5–10 min. Students completed the student motivation questionnaire at Times 1 and 2 during regular class time, which took most students approximately 30 min. At Time 2, students also completed the student version of the TSS to obtain their perceptions of the teaching environment and allow comparison to their teacher's report. All surveys throughout the study were administered in written format. Two trained CLASS-S observers conducted simultaneous classroom observations in order to assess the reliability of codings. Observations were conducted in 25-minute cycles and observers recorded independent scores for each of the six environment dimensions. Inter-rater reliability was satisfactory at 92 %.

## Data analyses

Because of the nested nature of the data, hierarchical linear modelling (HLM) was conducted to investigate which aspects of the classroom environment were particularly important for girls' science motivations and to partition variance in an appropriate manner. The current data satisfied the requirements of normality testing; all variables were normally distributed and considered appropriate for analysis using HLM. The two time points were included at level 1; repeated measures of students' science motivations were nested within each individual at level 2, with their Time 2 perceptions of classroom environment. Individual students were nested within their classrooms at level 3, with the classroom observation scores. Unconditional models were first composed for each variable to determine the variance partitioning at each of the 3 levels: occasions, students and classrooms. The process for model building, for each of the four student motivations, was as follows. First, linear time was added as a predictor of change in motivations between Times 1 and 2. Next, each of the student-reported TSS factors was tested for significance at level 2, and significant terms were retained. Each level 2 predictor was modelled separately for each of the four student motivations to determine which perceived classroom environment constructs affected student motivations, taking into account students' initial motivations. Level 2 predictors were not entered into the model simultaneously because of multicollinearity between student-reported TSS factors (*rs* ranged from 0.38 to 0.63, $p < 0.01$); therefore, the unique effects of predictors could not be determined. However, this turned out not to be a problem in most cases because only one significant predictor was identified. Because there were only two time points, there were insufficient degrees of freedom to estimate random slopes at levels 2 and 3; therefore, the slopes were estimated as fixed linear effects. Because level 1 variables were uncentred, coded as Time 1 = −1 and Time 2 = 0, intercept parameters refer to Time 2. Level 2 variables were group mean centred, such that students were centred within their respective group because students within each group were reporting on the same classroom environment. Next, each of the CLASS-S factors was tested for significance at level 3, and significant terms were retained. Each level 3 predictor was added separately into significant level 2 equations, again because of high correlations among the level 3 variables (*rs* ranged from −0.97 to 0.92, significant at $p < 0.01$, except for relationships of Regard for Adolescent Perspectives with each of Behaviour Management and Quality of Feedback, $r = 0.29$ and $r = 0.28$, respectively, significant at $p < 0.05$). Level 3 variables were grand mean centred, such that students were centred within the entire sample of girls studying science. An example of a mixed model for ability expectancy is shown in Eq. 1, and annotations 2–13 are explanations of each variable in the equation. Finally, one-sample *t* tests were conducted to determine if there were significant differences between students' and their teacher's perceptions of the classroom environment.

$$\begin{aligned} AE_{ijk} = {} & \gamma_{000} + \gamma_{001} \times \left(RFAP_k - \overline{RFAP_{\cdot}}\right) + \gamma_{010} \times \left(NEG_{jk} - \overline{NEG_{\cdot k}}\right) + \gamma_{011} \times \left(NEG_{jk} - \overline{NEG_{\cdot k}}\right) \\ & \times \left(RFAP_k - \overline{RFAP_{\cdot}}\right) + \gamma_{100} \times TIME_{ijk} + \gamma_{101} \times \left(RFAP_k - \overline{RFAP_{\cdot}}\right) \times TIME_{ijk} \\ & + \gamma_{110} \times \left(NEG_{jk} - \overline{NEG_{\cdot k}}\right) \times TIME_{ijk} + \gamma_{111} \times \left(NEG_{jk} - \overline{NEG_{\cdot k}}\right) \\ & \times \left(RFAP_k - \overline{RFAP_{\cdot}}\right) \times TIME_{ijk} + r_{0jk} + u_{00k} + e_{ijk} \end{aligned} \quad (1)$$

| | | |
|---|---|---|
| $AE_{ijk}$ | is the outcome of ability expectancy at time i for student j in class k | (2) |
| $\gamma_{000}$ | is the class average of ability expectancy | (3) |
| $\gamma_{001} \times \left(RFAP_k - \overline{RFAP_{\cdot}}\right)$ | is the direct effect of regard for adolescent perspectives on ability expectancy | (4) |
| $\gamma_{010} \times \left(NEG_{jk} - \overline{NEG_{\cdot k}}\right)$ | is the class average added effect of negativity | (5) |
| $\gamma_{011} \times \left(NEG_{jk} - \overline{NEG_{\cdot k}}\right) \times \left(RFAP_k - \overline{RFAP_{\cdot}}\right)$ | is the indirect effect of regard for adolescent perspectives on ability expectancy, via negativity | (6) |
| $\gamma_{100} \times TIME_{ijk}$ | is the class average change in ability expectancy | (7) |
| $\gamma_{101} \times \left(RFAP_k - \overline{RFAP_{\cdot}}\right) \times TIME_{ijk}$ | is the direct effect of regard for adolescent perspectives on change in ability expectancy | (8) |
| $\gamma_{110} \times \left(NEG_{jk} - \overline{NEG_{\cdot k}}\right) \times TIME_{ijk}$ | is the class average of change in ability expectancy associated with negativity | (9) |
| $\gamma_{111} \times \left(NEG_{jk} - \overline{NEG_{\cdot k}}\right) \times \left(RFAP_k - \overline{RFAP_{\cdot}}\right) \times TIME_{ijk}$ | is the indirect effect of regard for adolescent perspectives on change in ability expectancy, via negativity | (10) |
| $r_{0jk}$ | is the variation around the level 2 intercept for student j in class k | (11) |
| $u_{00k}$ | is the variation around the level 3 intercept in class k | (12) |
| $e_{ijk}$ | is the variation around the level 1 intercept at time i for student j in class k | (13) |

## Results

### Hierarchical linear modeling

#### *Unconditional models*

A considerable amount of variance in students' motivations was explained across time points (25–49 %; level 1) and at the individual level (41–58 %; level 2) but less variance was explained at the classroom level (10–34 %; level 3). A large amount of variance in students' perceptions of their class environments was explained at the individual level (15–54 %), with less variance accounted for at the classroom level (12–17 %). Classroom observation variables had all of their variation explained at level 3, because these observational data were collected and coded at the classroom level, and therefore every student in the same class had the same data for those variables.

#### *HLM results*

A total of 46 models was estimated. Results from these analyses are presented in Tables 2, 3, and 4. The initial two-level model showed that girls' perceptions of structure within the classroom influenced their extrinsic utility value for science. Students who perceived low structure had lower extrinsic utility value than those who perceived high structure, and their extrinsic utility value declined over time. However students who perceived high structure had stable extrinsic utility values.

When classroom environment dimensions were added to the model, it was found that all six dimensions had significant indirect effects on students' extrinsic utility values via their perceptions of a structured classroom setting (see summary in Table 1). Positive climate, negative climate, regard for adolescent perspectives, quality of feedback and student engagement all affected students' Time 2 extrinsic utility value, as well as their change in extrinsic utility value, indirectly through perceptions of structure. Behaviour management

**Table 1** Summary of significant three-level analysis effects of classroom environment factors and student perceptions of structure on student extrinsic utility value

| Fixed effect | Coefficient | Standard error | $t$ | df | $p$ |
|---|---|---|---|---|---|
| Indirect effect of PC on EUV, via STRUC, $\gamma_{011}$ | −0.953 | 0.294 | −3.236 | 48 | 0.003 |
| Indirect effect of PC on EUV change, via STRUC, $\gamma_{111}$ | −0.817 | 0.308 | −2.650 | 91 | 0.010 |
| Indirect effect of NC on EUV, via STRUC, $\gamma_{011}$ | 0.964 | 0.317 | 3.038 | 48 | 0.004 |
| Indirect effect of NC on EUV change, via STRUC, $\gamma_{111}$ | 0.934 | 0.329 | 2.843 | 91 | 0.006 |
| Indirect effect of RfAP on EUV, via STRUC, $\gamma_{011}$ | −0.987 | 0.328 | −3.006 | 48 | 0.005 |
| Indirect effect of RfAP on EUV change, via STRUC, $\gamma_{111}$ | −0.847 | 0.339 | −2.496 | 91 | 0.015 |
| Indirect effect of BM on EUV change, via STRUC, $\gamma_{111}$ | −0.555 | 0.240 | −2.312 | 91 | 0.023 |
| Indirect effect of QoF on EUV, via STRUC, $\gamma_{011}$ | −1.796 | 0.555 | −3.235 | 48 | 0.003 |
| Indirect effect of QoF on EUV change, via STRUC, $\gamma_{111}$ | 0.588 | 0.588 | −2.317 | 91 | 0.023 |
| Indirect effect of SE on EUV, via STRUC, $\gamma_{011}$ | −0.477 | 0.170 | −2.804 | 48 | 0.008 |
| Indirect effect of SE on EUV change, via STRUC, $\gamma_{111}$ | −0.490 | 0.173 | −2.837 | 91 | 0.006 |

*EUV* Extrinsic utility value, *STRUC* structure, *PC* positive climate, *NC* negative climate, *RfAP* regard for adolescent perspectives, *BM* behaviour management, *QoF* quality of feedback, *SE* student engagement

**Table 2** Three-level analysis of effects of regard for adolescent perspectives and teacher negativity on student ability expectancies

| Fixed effect | Coefficient | Standard error | $t$ | df | $p$ |
|---|---|---|---|---|---|
| Model for time 2 AE, $\pi_0$ | | | | | |
| Model for student average AE, $\beta_{00}$ | | | | | |
| Class average AE, $\gamma_{000}$ | 4.615 | 0.226 | 20.401 | 3 | 0.000 |
| Direct effect of RfAP on AE, $\gamma_{001}$ | −0.874 | 0.677 | −1.291 | 3 | 0.287 |
| Model for added effect of NEG on AE, $\beta_{01}$ | | | | | |
| Class average added effect of NEG, $\gamma_{010}$ | −0.253 | 0.125 | −2.026 | 48 | 0.048 |
| Indirect effect of RfAP on AE, via NEG, $\gamma_{011}$ | −0.020 | 0.286 | −0.070 | 48 | 0.945 |
| Model for change in AE, $\pi_1$ | | | | | |
| Model for student average change in AE, $\beta_{10}$ | | | | | |
| Class average change in AE, $\gamma_{100}$ | 0.189 | 0.109 | 1.732 | 91 | 0.086 |
| Direct effect of RfAP on AE change, $\gamma_{101}$ | −1.042 | 0.315 | −3.309 | 91 | 0.002 |
| Model for added effect of NEG on AE change, $\beta_{11}$ | | | | | |
| Class average of AE change associated with NEG, $\gamma_{110}$ | −0.016 | 0.101 | −0.159 | 91 | 0.874 |
| Indirect effect of RfAP on AE change, via NEG, $\gamma_{111}$ | 0.102 | 0.232 | 0.440 | 91 | 0.660 |

| Random effect | Variance component | df | $\chi^2$ | $p$ |
|---|---|---|---|---|
| Level 1, $e_{ijk}$ | 0.293 | | | |
| Level 2, $r_{0jk}$ | 0.605 | 44 | 226.507 | 0.000 |
| Level 3, $u_{00k}$ | 0.163 | 3 | 14.495 | 0.003 |

*AE* ability expectancies, *NEG* negativity, *RfAP* regard for adolescent perspectives

had an indirect effect on change in extrinsic utility value, via structure. Students began the year with very similar extrinsic utility values for science, but those who perceived low structure in classrooms with low positive climates experienced a decline in their extrinsic utility value for science over time. Classrooms with negative climates led to decreases in students' extrinsic utility values; however, the decrease was largest for students who perceived the classroom to have high structure. Declines in extrinsic utility value across time were largest for students who perceived structure to be low and were in classrooms which had low regard for adolescent perspectives; but those students who perceived high structure, and were also in classrooms with low regard for adolescent perspectives, had the highest extrinsic utility value for science at both time points. Students who were in classrooms with low behaviour management and perceived low structure had the largest declines in extrinsic utility values over time; but students who perceived high structure in classrooms with low behaviour management had the highest ability expectancies. Students who were in classrooms with low quality of feedback and perceived the classroom to have high structure were the only students to show increases in their extrinsic utility values across time; the other three groups all showed declines, with students who had perceptions of low structure in classrooms with low quality of feedback showing the lowest extrinsic utility values. Students who were in classes with low student engagement, but perceived there to be high structure, had the highest extrinsic utility values at Time 1; however, these values declined over time to be level with those of students from the other groups. Random effects from each model indicated that there were further residual effects left to be explained at each level.

**Table 3** Three-level analysis of effects of quality of feedback and teacher structure on student attainment importance

| Fixed effect | Coefficient | Standard error | *t* | df | *p* |
|---|---|---|---|---|---|
| Model for time 2 AI, $\pi_0$ | | | | | |
| Model for student average AI, $\beta_{00}$ | | | | | |
| Class average AI, $\gamma_{000}$ | 5.017 | 0.351 | 14.292 | 3 | 0.000 |
| Direct effect of QoF on AI, $\gamma_{001}$ | 0.690 | 1.208 | 0.571 | 3 | 0.607 |
| Model for added effect of STRUC on AI, $\beta_{01}$ | | | | | |
| Class average added effect of STRUC, $\gamma_{010}$ | −0.023 | 0.160 | −0.141 | 48 | 0.889 |
| Indirect effect of QoF on AI, via STRUC, $\gamma_{011}$ | −1.345 | 0.576 | −2.338 | 48 | 0.024 |
| Model for change in AI, $\pi_1$ | | | | | |
| Model for student average change in AI, $\beta_{10}$ | | | | | |
| Class average change in AI, $\gamma_{100}$ | 0.138 | 0.126 | 1.094 | 91 | 0.277 |
| Direct effect of QoF on AI change, $\gamma_{101}$ | −0.393 | 0.441 | −0.890 | 91 | 0.376 |
| Model for added effect of STRUC on AE change, $\beta_{11}$ | | | | | |
| Class average of AI change associated with STRUC, $\gamma_{110}$ | 0.105 | 0.140 | 0.754 | 91 | 0.453 |
| Indirect effect of QoF on AI change, via STRUC, $\gamma_{111}$ | −0.800 | 0.504 | −1.589 | 91 | 0.115 |

| Random effect | Variance component | df | $\chi^2$ | *p* |
|---|---|---|---|---|
| Level 1, $e_{ijk}$ | 0.388 | | | |
| Level 2, $r_{0jk}$ | 0.653 | 44 | 193.904 | 0.000 |
| Level 3, $u_{00k}$ | 0.507 | 3 | 31.245 | 0.000 |

*AI* attainment importance, *STRUC* structure, *QoF* quality of feedback

Regard for adolescent perspectives had a direct effect on students' changes in ability expectancies for science. The fixed and random effects are shown in Table 2. Results from the two-level model show that students who perceived the classroom to be less negative had higher ability expectancies than students who perceived the classroom to be more negative. The three-level model produced some unexpected results, with students' ability expectancies being higher in classrooms that had low regard for adolescent perspectives, regardless of whether students perceived low or high negativity. In classrooms where regard for adolescent perspectives was high, students' ability expectancies remained stable and high across time. The random effects shown in Table 2 indicate that there was still significant residual variance in the model to be explained.

Quality of feedback had an indirect effect on girls' Time 2 attainment importance via perceptions of structure (Table 3). Girls started the year with similar levels of attainment importance, but those who perceived their class to be more structured experienced an increase in their attainment importance; whereas those who perceived their class to be less structured had stable attainment importance. Students who perceived high structure in classrooms with low quality of feedback were the only group to make gains in their attainment importance. Interestingly, girls who perceived low structure in classrooms with low quality of feedback had stable attainment importance motivations, which were the highest of all the groups at both timepoints. The random effects shown in Table 3 indicate that there was still significant residual variance in the model to be explained.

**Table 4** Two-level analysis of effects of teacher relatedness on student intrinsic interest value

| Fixed effect | Coefficient | Standard error | $t$ | df | $p$ |
|---|---|---|---|---|---|
| Model for time 2 IIV, $\pi_0$ | | | | | |
| Model for student average IIV, $\beta_{00}$ | | | | | |
| Class average IIV, $\gamma_{000}$ | 4.592 | 0.313 | 14.678 | 4 | 0.000 |
| Model for added effect of REL on IIV, $\beta_{01}$ | | | | | |
| Class average added effect of REL, $\gamma_{010}$ | 0.369 | 0.169 | 2.187 | 48 | 0.034 |
| Model for change in IIV, $\pi_1$ | | | | | |
| Model for student average change in IIV, $\beta_{10}$ | | | | | |
| Class average change in IIV, $\gamma_{100}$ | −0.166 | 0.137 | −1.214 | 95 | 0.228 |
| Model for added effect of REL on IIV change, $\beta_{11}$ | | | | | |
| Class average of IIV change associated with REL, $\gamma_{110}$ | 0.260 | 0.131 | 1.983 | 95 | 0.050 |

| Random effect | Variance component | df | $\chi^2$ | $p$ |
|---|---|---|---|---|
| Level 1, $e_{ijk}$ | 0.458 | | | |
| Level 2, $r_{0jk}$ | 1.077 | 44 | 251.602 | 0.000 |
| Level 3, $u_{00k}$ | 0.330 | 4 | 15.449 | 0.004 |

*IIV* intrinsic interest value, *REL* relatedness

**Table 5** One-sample *t*-tests of class mean SRTS with teacher reported TSS

| Class | Teacher style variable | Mean difference | $t$ | df | $p$ |
|---|---|---|---|---|---|
| 1 | Expectations | −0.05 | −0.25 | 9 | 0.81 |
| | Relatedness | −0.34 | −1.44 | 9 | 0.18 |
| | Negativity | 0.18 | 0.82 | 9 | 0.44 |
| | Structure | −1.01 | −4.41 | 9 | 0.00 |
| 2 | Expectations | 0.28 | 2.16 | 11 | 0.05 |
| | Relatedness | −0.79 | −2.95 | 11 | 0.01 |
| | Negativity | −0.38 | −0.99 | 11 | 0.34 |
| | Structure | −0.47 | −1.61 | 11 | 0.14 |
| 3 | Expectations | −0.71 | −2.26 | 13 | 0.04 |
| | Relatedness | −0.82 | −2.58 | 13 | 0.02 |
| | Negativity | 0.48 | 1.20 | 13 | 0.25 |
| | Structure | −1.38 | −3.08 | 13 | 0.01 |
| 4 | Expectations | −0.32 | −2.75 | 9 | 0.02 |
| | Relatedness | 0.27 | 0.60 | 9 | 0.57 |
| | Negativity | 0.36 | 1.16 | 9 | 0.28 |
| | Structure | 0.67 | 2.93 | 9 | 0.02 |
| 5 | Expectations | −0.39 | 1.34 | 5 | 0.24 |
| | Relatedness | −1.45 | −3.91 | 5 | 0.01 |
| | Negativity | 1.00 | 3.67 | 5 | 0.02 |
| | Structure | −1.00 | −2.90 | 5 | 0.03 |

Relatedness affected students' intrinsic interest value at Time 2 and their change in intrinsic interest across time (Table 4). Students who perceived their classroom to have low relatedness showed diminished intrinsic interest over time, whereas those who perceived the classroom to have high relatedness had steady and high intrinsic motivations for science. There was a trend for structure to affect students' change in intrinsic interest value, with students who perceived low levels of structure tending to show a decrease in intrinsic interest value at Time 2. However, this did not reach statistical significance ($p = 0.082$).

*Did students' and teachers' perceptions of the environment differ?*

One-sample *t*-tests were conducted between student perceptions of the classroom environment and corresponding teacher reports of the same classroom to determine if differences between their perceptions were statistically significant (see Table 5). Positive mean differences indicate that the students perceived the classroom to be more positive, whereas negative values show the reverse. Results varied based on class: four classes perceived a significant difference in classroom structure; three classes believed that the classroom was less structured than their teacher reported; and one class reported that it was more structured. Three classes perceived their classroom environment to exhibit significantly less relatedness than the teacher reported; two classes thought that the classroom had lower expectations than the teacher perceived; another class believed that classroom expectations were higher. Only one class perceived their environment to be more negative than the teacher had reported.

## Discussion

Results supported the four hypotheses, with girls' perceptions of the classroom environment being more influential for their science motivations than the observed classroom environment. However, the observed classroom dimensions still displayed important effects on students' classroom environment perceptions.

### Importance of student perceptions

Results of the present study provide evidence for the impact of girls' perceptions of classroom environment on their motivations towards science in early secondary school. As predicted, students' own perceptions of the classroom were more influential than the observed, or 'actual', classroom environment. Perceptions of structure emerged as a key influence on all three measured motivational values: attainment importance, extrinsic utility and intrinsic interest in science. When the level 3 'objective' classroom observations were added to models, students fared worse if their perceptions of classroom structure were low, even when their classroom was observed to be high on other helpful environment dimensions. These results highlight the importance of a structured classroom environment for girls' extrinsic utility values for learning science. Jang et al. (2010), also using HLM analyses, similarly found that structure influenced students' observed behavioural engagement in high school science, mathematics, English and social studies classrooms. Previous research has also shown that teacher-provided structure enhances students' perceived competence, self-regulated learning, internal locus of control and behavioural engagement (Sierens et al. 2009; Skinner and Belmont 1993; Skinner et al. 2008). Research has shown that teachers create structured classrooms by having explicit and understandable instructions, ongoing directions to guide students through their actions, and constructive feedback (Brophy 1986; Reeve 2006; Skinner and Belmont 1993; Skinner et al. 1998). These results support this study's assertion that students' perceptions of class structure shape their classroom experiences and influence their science motivations.

Perceptions of relatedness were identified as a significant predictor of girls' science motivations. Relatedness had a protective effect, such that girls who perceived high levels of relatedness in the classroom had stable intrinsic interest for science across time; but girls who thought that the class exhibited low relatedness showed diminished intrinsic interest over time. The construct of relatedness encompasses a sense of teacher involvement, including treating students fairly, considering their feelings, and taking an interest in them (Wentzel 2009). Research suggests that students who perceive their teacher to be warm and caring exhibit greater intrinsic motivation (Ryan and Grolnick 1986; Ryan et al. 1994). Other research has shown that student interest is fostered by teacher enthusiasm and the application of information to practical situations (Bergin 1999; Patrick et al. 2000; Wigfield and Eccles 1992); but student interest is hampered by competitive learning environments and teacher sarcasm (Flink et al. 1990; Turner et al. 2002). It seems that having a positive relationship with their teacher maintains girls' intrinsic interest for science.

## Autonomy-supportive classrooms

These results highlight the importance of perceptions of structure and relatedness in the classroom to facilitate motivations for learning science. These results are consistent with self-determination theory (SDT), which proposes three psychological preconditions of learning: autonomy, relatedness and competence (Deci and Ryan 2010). Structure is closely associated with autonomy support and involves the clear communication of expectations, accompanied with direction and guidance of students (Reeve 2006). Research shows that students' motivation and learning are facilitated when teachers create a structured classroom environment that is also autonomy-supportive (Reeve 2006; Reeve et al. 2004). Although the current study did not explicitly examine autonomy support, it provides evidence for the influence that structure alone can have on students' intrinsic interest, extrinsic utility and attainment importance values. Given that teacher expectations are closely tied to structure and autonomy support (Reeve 2006), it is noteworthy that student perceptions of teacher expectations did not significantly influence their motivations. This result is likely because the measure of students' expectation perceptions in the TSS included both teacher-related ability expectations and developmentally appropriate behavioural expectations; but, because it is the ability expectations that are specifically tied to structure and autonomy support (Reeve 2006), the effect is likely to be diminished by the other behaviourally based items.

The current results also support the importance of relatedness as proposed in SDT. Self-determination theory posits that relatedness is fostered through emotional support and showing an interest in students' wellbeing (Deci and Ryan 2010). There is a wealth of research demonstrating the positive academic and social outcomes for students who perceive a sense of relatedness and belonging with their teachers and peers (see Wentzel 2009). Deci and Ryan (2010) argue that relatedness might not be a proximal factor for enhancing motivations but instead that it is a necessary base from which students can flourish. The current results support this assertion because student perceptions of high relatedness maintained intrinsic motivation but did not enhance it; however students who perceived low classroom relatedness showed declines in their intrinsic interest for science.

Taken together, the demonstrated importance of structure and relatedness from the present study fit with and provide further support for the learning framework of SDT.

### Importance of the observed classroom environment

Objective classroom dimensions also affected girls' perceptions of the classroom environment. Student perceptions of structure within the classroom were significantly influenced by positive climate, negative climate, regard for adolescent perspectives, behaviour management, quality of feedback and student engagement. These results indicate that, although student perceptions of the classroom are very influential in terms of their motivations, the objectively-measured classroom features were also involved in this process through shaping those perceptions. Some interesting results emerged when the effects of observed classroom constructs on students' motivations were closely examined. As expected, for girls who perceived the classroom to be low on a particular dimension and who were also situated in a classroom where the environment was observed to be correspondingly low, their motivations fared the worst (low–low group). However, the converse situation, which would theoretically be expected to be the most positive, was not true, in that girls who perceived the classroom to be high on a certain aspect, and were in a classroom that was judged to be correspondingly high, often experienced decreases in their motivation across time (high–high group). These girls still maintained relatively high motivations, but any declines were counter to our expectation. Instead, it was girls with high perceptions who were in classes low on an environmental dimension who tended to show the highest motivations at Time 2 (high–low group).

This effect might be explained by the fact that girls who had already rated the classroom highly at Time 1 had little possibility to rate the class more positively at Time 2, because they were already at or near the top end of the rating scale. This 'ceiling effect', also for the high observed classroom ratings, meant that any variation in Time 2 responses would bias the high–high group's motivations in a negative direction; however, for the high–low group, the combination of high perceptual ratings with low observation ratings gave those students' motivations more possibility to demonstrate increases over time. As well, it could be that students in the high–high group perceived the classroom environment to be particularly positive at the beginning of the year with their new teacher but, as the year progressed, they normalised these positive features, leading to a recalibration of their perceptions by mid-way through the year and lowered perceptions of the classroom environment.

Classrooms with a regard for adolescent perspectives (RfAP) directly affected girls' extrinsic utility value for science. However, this effect was not in the expected direction, with girls in classrooms having low RfAP showing increases in extrinsic utility value over time; but girls in classrooms that were observed to have high RfAP had stable extrinsic utility value for science. Students who perceived low negativity and were in classrooms with low regard for adolescent perspectives (low–low group) had the highest extrinsic utility values at Time 2; however students who were in classrooms with low regard for adolescent perspectives, but perceived high negativity, had the lowest extrinsic utility values for science at Time 2. Therefore, the influence of negativity was in the expected direction, but the effect of regard for adolescent perspectives was not. Pianta et al. (2008) conceptualised regard for adolescent perspectives as encompassing the use of material that is relevant to students, paying attention to students' ideas and opinions and giving students opportunities for decision making. Thus, it was expected that high levels of RfAP would boost students' motivations, but this is not what was indicated by the results. An explanation could lie in differences between observers' ratings and the students' perceptions.

Even though the 'actual' classroom environment could have been rated by observers to be high on a certain dimension, we cannot be sure that the girls' perceptions would match this. It could be that students who perceive RfAP to be low, when they are in a class that has observed high RfAP, would therefore be less likely to show an increase in their motivations. It would be interesting to collect qualitative data from this group to gain further insight as to their perceptions of RfAP within the classroom. In future, using a matched perceptual and observational measure to measure directly parallel constructs, would allow assessing the congruence between perceptions and observations.

## Differences in teacher and student perceptions

As predicted, teachers' perceptions of the classroom environment were more positive than those of the students on some dimensions of teacher style. In most classrooms, students rated their teachers significantly lower on dimensions of relatedness and structure, which might be particularly problematic because these two dimensions had significant influences on students' science motivations. This result is consistent with previous research which revealed that, whether it is the preferred or perceived actual classroom environment that is being investigated, teachers report a better situation than the students over a range of classroom dimensions (Dorman 2008; Fraser 1982; Raviv et al. 1990; Sinclair and Fraser 2002). Sinclair and Fraser (2002) demonstrated how these perceptual differences could be used in a constructive manner to develop more beneficial classroom environments. Teachers were provided with results for the perceptual difference and given guidance with strategies and action plans to effect change and boost students' perceptions. Results demonstrated that teachers can promote positive perceptual change in their classrooms, which can influence students' motivations.

## Implications and contributions to the research field

The present study has made a useful contribution to the classroom environment and motivation literatures by specifically investigating what motivates girls in junior high school science classrooms, including measures across time, as well as student-perceived, teacher-perceived and observed classroom features. Expectancy-value theory (Eccles 2005; Eccles et al. 1983) provided a sound theoretical model on which to base the current study. Results demonstrated that investigating different types of expectancies and values is important because distinct motivations are influenced by different factors. The flow-on effect of early disengagement from science is that girls opt out of science and mathematics, which diminishes their career options and contributes to the gender imbalance in STEM-related vocations. Research has demonstrated that equipping teachers with support and strategies to target specific dimensions of classroom environment helps them to effect positive change (Sinclair and Fraser 2002). Thus, teachers might be able to combat this trend if they know which classroom features are needed to foster girls' particular motivations in science. For example, girls' extrinsic utility values for science can be directly enhanced by provision of an environment that draws links to adolescent perspectives and provides them with opportunities for decision-making. If girls perceive the environment to be structured, they are more likely to be motivated by other positive aspects of the classroom environment. Further, creating an environment of relatedness is a protective factor for girls' intrinsic interest in science. Each of these results provides support for the importance of autonomy and relatedness as proposed by SDT (Deci and Ryan 2010);

teachers can utilise these findings to build upon students' classroom experiences and motivations for learning.

Results highlight the importance of using HLM for analysing data that have an inherent hierarchical structure. Modelling this nested structure allowed valid analysis of the relationships between classroom environment and student motivations. However, there was some under-utilisation of possibilities afforded by HLM because of the study design. Because there were only two time points, there were insufficient degrees of freedom to estimate random slopes, and therefore the present analysis could only estimate fixed effects for changes over time. Further, high correlations among factors of each of the student-reported TSS and CLASS-S meant that all factors were not entered simultaneously because of multicollinearity. This turned out not to be problematic for most motivations because only one CLASS-S dimension significantly affected each motivation factor. However, in the case of extrinsic utility values, the unique effects of each predictor could not be determined.

## Improvements and future directions

The present study demonstrated the utility of gaining multiple perspectives of the same classroom environment. Students reported their motivations and perceptions of their classroom environment; teachers reported their own perceived teaching style; and independent observers rated the classroom on important aspects of learning environments. Each of these measures captured important information to provide a rich, multifaceted picture of the classroom environment. Research has also highlighted the importance of peer interactions when considering student outcomes and classroom environment (Fredricks et al. 2004). Marsh et al. (2008) investigated multiple classrooms taught by the same teacher and found that student perceptions of the classroom environment were more a function of the particular group of students than the teacher who taught the class. The composition of students within a class and the manner in which they interact with each other contributes to the classroom environment that is created (Fredricks et al. 2004). Future research could examine this area through student reports of peer interactions, which would add a further useful perspective to the measurement of classroom environment.

Improvements could be made to the study design. The sample would benefit from the involvement of male teachers and male participants because this would allow gender comparisons between male and female students and teachers, contributing potentially valuable results to gender discrepancies identified in previous studies. An expanded range of subject domains beyond science would allow identification of differential effects particular to boys or girls in specific learning domains. An even distribution of classrooms across different schools would allow comparison between coeducational and single-sex schools, and between government and independent schools, each of which could have differing effects. Indeed, there is a wealth of research surrounding which schooling situations are optimal for girls and boys. The general consensus is that girls achieve best in cooperative learning environments, whereas boys perform better in competitive environments (Gurian and Ballew 2003). It would be interesting to investigate the effects of other classroom environment dimensions on boys' and girls' motivations across different learning domains and types of learning contexts.

Extending the data collection period across a full academic year with three time points would provide a fuller picture of students' classroom experiences and allow the estimation of random effects for changing motivations. Adding students' achievement grades would also provide a useful objective measure, which could impact on students' ability perceptions and other motivations. (The present study planned to include students' grades, but the nature of the tests and assignments completed by students across classes was too varied to allow such comparisons.) Despite these limitations and scope for improvement, the current findings demonstrate the detailed analyses that can be conducted using HLM to examine the motivational impacts of multiple features of students' classroom experiences.

## Conclusion

The analysis of the perceptual and observed classroom environments that shape students' expectancies and values for science showed that girls' perceptions were particularly influential. Specifically, perceptions of structure were related to their extrinsic utility value and attainment importance value of science; perceptions of relatedness affected their intrinsic interest for science; and perceptions of classroom negativity were detrimental to their ability expectancies. Observed classroom environment features also affected students' motivations, but this occurred indirectly via girls' own perceptions of the classroom environment. These relationships existed over and above the impact of prior expectancies and values, which were controlled for within the HLM analyses. These results could be fruitfully utilised by teachers to enhance particular aspects of the classroom environment that promote girls' science motivations. Such efforts could increase the likelihood of girls continuing to study science throughout secondary school and university, with implications for addressing the gender imbalance in science-related professions.

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