



Student perceptions of teacher messages about the value of science in the classroom

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ABSTRACT

Aim: Teachers are uniquely positioned to shape students' motivational beliefs, yet research examining perceived classroom messages that explicitly convey the value of what students are learning remains scarce.

Background: Drawing on the situated expectancy value theory, we examined how student-perceived teacher messages about the value of science longitudinally related to adolescent students' subjective task values, perceived costs, and expectations of success, achievement, and aspirations.

Sample: Data were collected from 1591 participants aged 11 to 14 years (57.5% female) nested in 65 science classes in England.

Method: Data were collected over four waves. Perceived teacher value messages were collected in the first wave, achievement and aspirations in the second and fourth waves, and expectancy, utility value, and effort cost in the first and third waves.

Results: Class-aggregated perceived teacher value messages positively predicted achievement mediated by utility value, and positively predicted aspirations mediated by expectancy and utility value; class-aggregated effort cost negatively predicted aspirations. Additionally, student-level expectancy and utility value showed positive reciprocal relations with achievement and aspirations; student-level effort cost negatively predicted achievement and aspirations but not vice versa.

Conclusion: When students perceive that teachers explain the value of science, they report greater expectancy and utility value, and show subsequent higher achievement and aspirations.

1. Introduction

Over the past two decades, rapid technological advancements across multiple sectors (e.g., manufacturing, commerce, business, medicine) have intensified the demand for STEM skills. Yet, many countries face a significant shortage of qualified graduates (Xue & Larson, 2015), with substantial financial costs for employers and reduced economic competitiveness (STEM Learning, 2018), and reduced capacity for responding to challenges such as climate change (Tasquier et al., 2022). Despite the importance of scientific literacy, many students experience declining interest in science during adolescence (Gaspard et al., 2017), often linked to perceptions of its lack of relevance (Hellgren & Lindberg, 2017). Early secondary education is, therefore, a critical period for understanding the development of science achievement and career aspirations. While teachers' interpersonal and instructional practices are known to influence student motivation (Roorda et al., 2011), little

research has examined how classroom messages that communicate the value of science relate to students' motivational beliefs (e.g., Schmidt et al., 2019). Grounded in Situated Expectancy Value Theory (Eccles & Wigfield, 2020), the present study addresses this gap by investigating whether students' perceived teacher value messages positively predict the motivational beliefs of students and their subsequent achievement and aspirations in the first three years of secondary education.

1.1. Science attitudes in adolescence

In England, like many European countries and beyond (e.g., Potvin & Hasni, 2014), positive attitudes towards science and aspirations to study higher-level science, or develop a career in science, decline for many, although not all, students as they progress through secondary school (Barmby et al., 2008; Wang et al., 2016). Gradual declines in students choosing to study science subjects in upper secondary education (Scott

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et al., 2024) and in undergraduate education (Hamlyn et al., 2024) have been observed since the 2000s. The reasons are varied and complex; however, perceived teacher instrumental and emotional support is one of the most profound influences in boosting science motivation and aspiration in adolescents (Regan & DeWitt, 2015). In England, students take compulsory generic science classes for the first three years of secondary education (aged 11 to 14 years), before choosing which subject options to study for secondary school-exit examinations (General Certificate of Secondary Education: GCSE) in the final two years (aged 14 to 16 years). A key requirement for studying science subjects in upper secondary education (aged 16 to 18/19 years) or beyond is a GCSE in a corresponding single science subject (e.g., Chemistry, Physics, Biology, or Design and Technology). The first three years of secondary education are critical in keeping future pathways to science study or careers open. SEVT has emerged as one of the most prominent theories used to study science choice, engagement, aspirations, and achievement (Bøe & Henriksen, 2015).

1.2. Situated Expectancy Value Theory

Situated Expectancy Value Theory (SEVT: Eccles & Wigfield, 2020; Wigfield & Eccles, 2020) is an influential theory of educational achievement and choice that combines dynamic relations between contextually sensitive developmental and socio-cultural influences with socio-cognitive task appraisals. Developmental and socio-cultural influences include distal (e.g., personal temperament, social roles) and proximal influences (e.g., achievement experiences and socializers' behaviors) that shape task appraisals. Socio-cognitive task appraisals in SEVT concern expectancy of success (hereafter referred to as expectancy for brevity), subjective task values (STVs), and cost. Expectancy refers to beliefs about the probability of success on a forthcoming task or activity. Tasks can be valued because they are interesting and enjoyable (intrinsic), allow someone to express their actual or desired identity (attainment), and are useful in achieving current or future goals (utility). The drawbacks associated with a particular activity include the effort required, missed opportunities to engage in alternative valued tasks, and personal and social consequences of failure.

Of the three STVs, utility value is often cited by students as an important reason for choosing to study science subjects in upper secondary education (Lyons, 2006; Miller et al., 2006). In addition, as utility value is more task-extrinsic in nature, it is more receptive to situational influences, such as teacher communication of value, than intrinsic or attainment value (Hulleman et al., 2010; Perez et al., 2022). Intrinsic and attainment values, rooted in one's core interests and identity, involve internal processes that differ between individuals over phases of development (Eccles, 2009). They may require sustained authentic engagement, personalization of learning, and identity changes to develop (Rosenzweig et al., 2022). Similarly, missed opportunities and psychological costs (e.g., fear of failure) are more task-intrinsic, derived from personal hierarchies of importance rooted in personal and collective identity, whereas effort cost is more closely linked to perceived task difficulty (Eccles, 2009; Wang & Eccles, 2013). As such, we specifically focused on utility value and effort cost as being more responsive to perceived teacher value messages than other STVs and costs.

1.3. Teacher communication of task value

Teachers play a pivotal role in developing their students' subject competencies, academic achievement, and motivation (Burroughs et al., 2019). Numerous aspects of teachers' social and instructional style (e.g., trust, concern, and warmth) can be influential (e.g., Jansen et al., 2022; Roorda, Koomen, Spilt, & Oort, 2011). One important teacher practice that has not been widely studied concerning motivation is the communication of the value of academic tasks, activities, and domains to students. Theoretically, the proposition that teachers value messages could

shape students' utility value, as well as effort cost and expectancy, is highly plausible. As agents of socialization, teacher behavior helps shape students' achievement-related experiences, thereby impacting students' appraisals of STVs and cost (Brophy, 1999; Harackiewicz & Priniski, 2018).

In Acee et al.'s (2018) value reappraisal model (VRM), task-value messages prompt students to consider reasons why academic tasks could have personal relevance. The cognitive-affective responses (e.g., positive feelings towards a task, lesson, or subject) elicited by this (re) appraisal have the potential to foster attitude change, including task values and costs, perceived competence, and instrumental reasons for task engagement as a function of depth, valence, and relevance. These motivational beliefs, in turn, influence academic outcomes, including effort, persistence, achievement, and choice.

Interventions that incorporate written value messages into instructions or materials have been shown to increase students' perceived task value, interest, and effort in undergraduate statistics (Acee, 2023; Acee & Weinstein, 2010) and mathematics courses (Canning & Harackiewicz, 2015; Shechter et al., 2011). Similar interventions, when implemented with secondary school students and delivered by either researchers (Gaspard, Dicke, Flunger, Brissou, et al., 2015) or teachers (Gaspard et al., 2021), have also effectively enhanced students' utility value by highlighting the relevance of mathematics to education, careers, and everyday life.

While intervention studies evidence the theoretical principle that direct communication of value messages can positively impact utility values and other motivational beliefs, there are few naturalistic studies (e.g., Parrisius et al., 2020; Schmidt et al., 2019). Consequently, there is limited understanding of the deployment of value messages by teachers, how they are perceived, and their effects on students. Value messages delivered by teachers during regular instruction may be more effective than written interventions due to the personal connection and ongoing influence teachers have (Bainbridge Frymier & Shulman, 1995). Focusing on students' perceived relevance support in a large longitudinal study, Parrisius et al. (2020) found that teachers who provided rationales for studying mathematics during class can positively impact secondary school students' utility value. However, Parrisius et al.'s (2020) focused specifically on utility value messages and did not assess downstream outcomes such as achievement or aspirations.

Unlike one-time interventions, naturalistic studies can capture how teachers repeatedly emphasize the value of science over time in their classrooms. Indeed, Schmidt et al. (2019) found that, in middle school science lessons, the increased frequency of messages about the relevance of science learning activities was associated with students' increased perceptions of science utility. Schmidt et al. (2019) provided an important first step by examining teacher value messages in naturalistic classroom settings with early adolescent students. However, despite employing a rigorous mixed-methods design, their study was constrained by a small sample of four teachers across two schools and did not examine students' perceptions of these messages.

Building directly on this foundational work, the present study addresses these limitations through the first large-scale, naturalistic investigation of how students' perceptions of teacher value messages relate to motivational beliefs (utility value, expectancy, and cost) and, in turn, to achievement and aspirations. By focusing on early adolescence, a pivotal developmental period for the formation of science motivation and future-oriented goals, this study captures a critical window for understanding how classroom experiences shape longer-term educational trajectories.

Theoretically, this study advances SEVT and VRM by empirically testing key, yet largely unexamined, mediational pathways linking socio-cultural classroom influences to students' socio-cognitive motivational processes and educational outcomes. Specifically, we examine students' perceptions of teachers' value messages as proximal classroom cues that shape motivational beliefs, which subsequently predict achievement and aspirations. In line with the VRM framework (Acee

et al., 2018) and teachers' authentic instructional practices, where multiple forms of relevance are typically communicated simultaneously rather than in isolation (Schmidt et al., 2019), we adopt a "broad" conceptualization of perceived teacher value messages. Rather than isolating discrete facets of relevance, we assess students' perceptions of overarching messages about why science is important, useful, valuable, and interesting.

We focus on students' perceptions of instructional practices as these are particularly consequential for learning and motivation (e.g., Held & Mori, 2024; Robinson, 2023). Methodologically, our reliance on aggregated student reports also enhances measurement reliability through using multiple informants (e.g., Lüdtke et al., 2009). Extending prior work beyond utility value, we further examine how perceived value messages relate to expectancy and effort cost, recognizing that value messages not only convey relevance but also signal the worth of investing effort and engaging deeply with scientific content (e.g., Durik et al., 2015; Rosenzweig et al., 2020). Through these pathways, value messages may foster learning gains, strengthen competence beliefs, and elevate future expectations (Hulleman et al., 2010). From a practical perspective, this study has the potential to identify if perceived teacher value messaging can promote student motivation, achievement, and aspirations in science. By demonstrating how perceived everyday classroom communication can shape motivational processes and educational outcomes, the findings offer actionable insights for teachers seeking to support students during a formative stage of motivational development.

1.4. Expectancy, utility value, effort cost, achievement, and aspirations

Guided by SEVT, a substantial body of research has established that expectancy and utility value are positively associated with achievement and educational choices, whereas effort cost is negatively related to these outcomes (e.g., Guo et al., 2015; Jiang et al., 2018; Lauermann et al., 2017; Meyer et al., 2019). Despite this progress, existing research has rarely examined expectancy, value, and cost as predictors of both achievement and educational aspirations, limiting our understanding of how these motivational components shape students' performance and future-oriented decisions. Moreover, although longitudinal studies incorporating autoregressive controls have strengthened directional inference for relations between expectancy and subjective task values with achievement and aspirations (e.g., Lauermann et al., 2017; Marsh et al., 2005), comparable designs that integrate effort cost are lacking. The present study advances SEVT research by examining the contributions of expectancy, utility value, and effort cost to achievement and aspirations while controlling for prior levels of both outcomes. This approach allows for a more robust test of motivational processes and clarifies the role of effort cost, an increasingly recognized component of SEVT.

SEVT emphasizes that relations between motivational beliefs, achievement, and educational choices are recursive rather than unidirectional (Eccles & Wigfield, 2020; Wigfield & Eccles, 2020). Achievement provides feedback about learning and development that shapes students' self-beliefs (Marsh et al., 2022), while aspirations can influence values by contributing to the development of self-identity (Verhoeven et al., 2019). Accordingly, prior studies have documented positive longitudinal relations from achievement and aspirations to expectancy and value in mathematics (Lauermann et al., 2017; Marsh et al., 2005); however, such research remains limited, particularly studies that incorporate effort cost or focus specifically on the science domain. As such, our study makes an additional important contribution to SEVT by examining relations from achievement and aspirations to subsequent expectancy, utility value, and effort cost in science.

By employing multilevel analyses that reflect the inherently classroom-based nature of perceived teacher value messages and motivational climates (Lüdtke et al., 2009; Marsh et al., 2012), this study extends SEVT and VRT beyond the individual student level. Specifically,

we examine bidirectional relations between expectancy, utility value, and effort cost, and achievement and aspirations at both the student (L1) and classroom (L2) levels. While classroom-level associations between academic self-concept, a self-belief that underpins expectancy, and achievement have been widely studied at the classroom level (e.g., Marsh & Seaton, 2015), classroom-level analyses of STVs, cost, and expectancy are lacking (e.g., Cambria et al., 2017). By addressing this gap, the present study provides theoretically meaningful insights into how shared motivational climates operate within science classrooms, with the potential for practical guidance for enhanced motivation, achievement, and aspirations, not only at the individual level but also through classroom-wide instructional practices.

1.5. Aim of the present study

We aimed to examine the associations among perceived teacher value messages, expectancy, utility value, effort cost, achievement, and aspirations in science. More specifically, we examined (a) how perceived teacher value messages predicted expectancy, utility value and effort cost after an approximate five-month interval (controlling for prior expectancy, utility value and effort cost), (b) how achievement and aspirations predicted expectancy, utility value and effort cost after an approximate four-month interval (controlling for prior expectancy, utility value and effort cost), (c) how expectancy, utility value and effort cost predicted achievement and aspirations after a two week interval (controlling for prior achievement and aspirations), and (d) if the perceived teacher value messages showed indirect relations with achievement and aspirations, mediated by expectancy, utility value and effort cost.

Perceived teacher value messages were measured concurrently with prior expectancy, utility value, and effort cost, while baseline science achievement and aspirations were assessed two weeks later. Although the model arrangement would be neater if perceived teacher value messages were measured after baseline achievement and aspirations, data collection was scheduled this way to accommodate school timetables. It still allows for estimation of the effects of baseline motivational beliefs (i.e., expectancy, utility value, and effort cost), achievement, and aspirations (see Supplementary Materials; Fig. S1). Subsequent expectancy, utility value, and effort cost were measured five-months after baseline assessment, which was considered appropriate based on previous naturalistic messaging studies (e.g., Putwain et al., 2017). A second assessment of science achievement and aspirations took place two weeks later.

Hypothesized relations were tested in three multilevel structural equation models (ML-SEMs), one each for expectancy value, utility value, and effort cost, with all baseline variables correlated (see Fig. 1). Items used to measure perceived teacher value messages were phrased as "our class" rather than "to me," reflecting students' perceptions of a shared classroom environment and constructed from aggregated individual student responses (see Morin et al., 2014). Although not our principal research question, we conceptualized variation in students' perceptions of teacher value messages at L1 through class mean-centered student reports representing the extent to which a student was more (or less) receptive to such messages compared with a typical classmate (e.g., as a function of prior value, competence, or affiliation with the teacher; see Schmidt et al., 2019).

We tested the following hypotheses:

Hypothesis 1. Perceived L2 teacher value messages will positively predict expectancy and utility value and negatively predict effort cost, after controlling for the initial levels of expectancy, utility value, and effort cost.

Hypothesis 2. L1 and L2 achievement and aspirations will positively predict expectancy and utility value, and negatively predict effort cost, after controlling for the initial levels of expectancy, utility value, and effort cost.

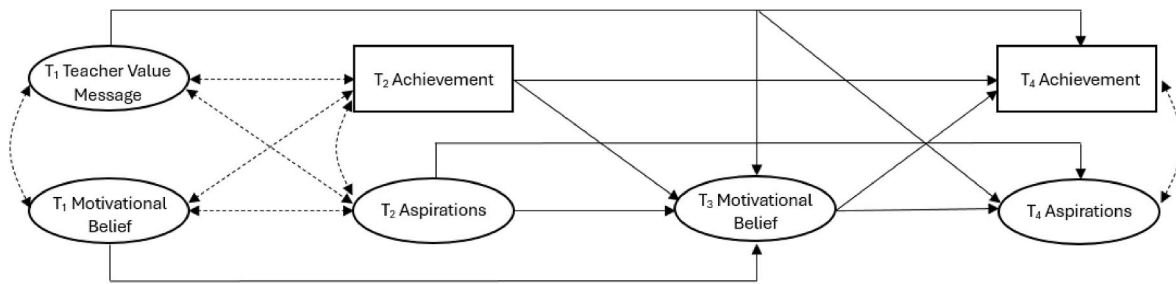


Fig. 1. Hypothesized multilevel structural equation model. Note. Dotted lines represent correlations, and solid lines represent structural paths.

Hypothesis 3. L1 and L2 expectancy and utility value will positively, and effort cost negatively, predict achievement and aspirations, after controlling for the initial levels of achievement and aspirations.

Hypothesis 4. Perceived L2 teacher value messages will positively and indirectly predict achievement and aspirations, mediated by higher expectancy and utility value, and lower effort cost.

2. Method

2.1. Participants, procedure, and missing data

Data were collected in England in schools during a science lesson over four waves. In the first wave, participants completed an online questionnaire covering perceived teacher value messages, expectancy, utility value, effort cost in school science, and demographics. After a five-month interval (the third wave of data collection), participants completed another online questionnaire measuring expectancy, utility value, effort cost, and demographics. In the second and fourth waves, scheduled approximately two weeks after the first and third, participants completed a 30-min online science test followed by survey questions for science aspirations. Separate tests were used at the second and fourth waves. The study was approved by an institutional research ethics committee (reference: 19/EHC/001). Schools working in partnership with the first and second authors' institution (typically a diverse sociodemographic region) were invited to participate in the study. Written permission was provided by the Head Teacher of the five participating schools, and consent was sought from parents/carers (opt-out) and participants (opt-in).

Across the four waves of data collection, a total of 1,591 participants were recruited for the study from five secondary schools, with 62 science classes participating ($M = 22.3$ participants per class, $SD = 6.54$). Participants were in the first three years of secondary education, aged 11-14 years ($M = 12.4$, $SD = .87$, at T₁): 594 participants in year 7, 622 participants in year 8, and 186 participants in year 9 (189 missing data responses). The breakdown of self-reported demographic variables at T₁ and T₃ is shown in Table 1. The proportion of gender, ethnicity, and free school meal (FSM) eligibility was similar in both waves. In the school year in which data were collected (2022-23), 51.3% of all secondary school students in England were male, 34.8% were from minority ethnic backgrounds, and 22.7% were eligible for FSM (Department for Education, 2023). Our sample was broadly representative of ethnicity but contained a greater proportion of students eligible for FSM. The overrepresentation of female participants arose from one participating school being a girls' school.

In total, 24.4% of data points were missing. Little's omnibus test, including all study variables (i.e., T₁ utility value, expectancy, effort cost and perceived teacher value messages, T₂/T₄ achievement and aspirations, and T₃ utility value, expectancy, effort cost, as well as covariates), showed that missing completely at random (MCAR) could not be assumed, $\chi^2(107) = 196.95$, $p < .001$. Participants with lower T₃ expectancy and utility value, and higher effort cost, were less likely to

Table 1 Demographic characteristics of participants at T₁ and T₃.

	Wave 1	Wave 3
<i>Gender</i>		
Male	489 (39.4%)	436 (38.1%)
Female	700 (56.5%)	669 (58.5%)
Prefer not to say	29 (2.3%)	24 (2.1%)
Other	22 (1.8%)	14 (1.2%)
<i>Ethnicity</i>		
Black/British Black	130 (10.5%)	89 (9.3%)
Chinese/British Chinese	42 (3.4%)	30 (3.1%)
South Asian/British South Asian	68 (5.5%)	53 (5.6%)
British/European White	814 (65.7%)	647 (67.9%)
Other	118 (9.5%)	83 (8.7%)
Multiethnic	67 (5.4%)	41 (5.4%)
Missing	1	190
Free School Meals	417 (33.6%)	301 (31.6%)
Total	1240	1143

participate in the fourth wave ($ps < .05$). Attrition in multi-wave studies is not uncommon and need not be problematic (Dong & Peng, 2013). Studies have shown that full information maximum likelihood can generate accurate parameter estimates when missing at random (MAR) is assumed and the causes of missingness in data are included in analytic models (Nicholson et al., 2017). Since T₃ expectancy, utility value, and effort cost were included in their respective analytic models, missing data were handled using FIML with MAR assumed. All data, materials, and analytic code have been made publicly available at the Open Science Framework and can be accessed at: <https://osf.io/s4tbd/>. The study was not preregistered.

2.2. Measures

Self-report measures for expectancy, utility, effort cost, and aspirations were measured on a five-point response scale (1 = "Strongly disagree", 3 = "Neither", and 5 = "Strongly agree"). Science aspirations were measured on a four-point scale (1 = "Strongly disagree" to 4 = "Strongly agree" with no mid-point response). All scale items are listed in the Supplementary Materials.

We measured expectancy using four items from the Grade 8 version of the 2019 Trends in International Mathematics and Science Study (TIMSS) Students' Confidence in Science scale (International Association for the Evaluation of Educational Achievement, 2018). We selected the four items (e.g., "I learn things quickly in science") that focused specifically on expectancy and discarded three items that included a comparison with classmates, teacher feedback, and confusion. McDonald's omegas were $\omega = .81$ and $.84$ for T₂/T₄.

We measured utility value using a modified four-item version of Eccles et al.'s (2005) scale. An additional item was included ("Learning science can help with things in everyday life"), and uniform scale response anchors were used for all items to ease participant responding.

Effort cost was measured using Jiang et al.'s (2020) three-item scale (e.g., "It takes too much effort for me to do well in science"). McDonald's omegas were $\omega = .85$ and $.81$ for T_2/T_4 utility value and $\omega = .73$ and $.69$ for T_2/T_4 effort cost.

Perceived teacher value messages were measured by adapting the referent of the value items from the Expectancy-Value-Cost Scale (Kosovich et al., 2015) from the self to the teacher (e.g., "My science teacher tells our class that science is an important subject"). McDonald's omega was $\omega = .85$. Higher-level study and career aspirations in science were measured using the four-item Future-Oriented Science Motivation scale (e.g., "I would like to work in a career involving science") from the 2006 Programme for International Student Assessment (OECD, 2009). McDonald's omegas were $\omega = .89$ and $.90$ for T_2/T_4 .

To measure science achievement, we created two tests from a pool of items designed to test scientific reasoning for students in the first three years of English secondary education. Items assessed knowledge and understanding of how scientific knowledge is generated and grows, and were drawn from previously validated National Curriculum tests that have shown good reliability (Newton, 2009). Each test comprised seven items awarded between five and seven marks, depending on question complexity, resulting in a total score between 0 and 41. McDonald's omegas in the present study were $\omega = .75$ and $.79$ for T_2/T_4 , respectively.

2.3. Analytic plan

Our analyses proceeded in three phases. First, in preliminary analyses, we estimated descriptive statistics, including intraclass correlations (ICCs; Lüdtke et al., 2009) and conducted tests of longitudinal measurement invariance for expectancy, utility value, effort cost, and aspirations. The ICC(1) statistic shows what proportion of variance in the variable is attributable to between-class (L2) variation and can be used to establish if multi-level analyses are warranted. The ICC(2) statistic shows the reliability of the class-level (L2) environment construct, teacher value messages, created from aggregated individual student reports. Second, we estimated a multi-level confirmatory factor analysis (ML-CFA) to generate bivariate correlations. Third, we estimated ML-SEMs to test the paths shown in Fig. 1.

The ML-CFA and ML-SEMs were estimated in Mplus v8.11 (Muthén & Muthén, 2018) using the maximum likelihood estimator. Model fit was assessed using the root mean error of approximation (RMSEA), the standardized root mean residual (SRMR), the confirmatory fit index (CFI), and the Tucker-Lewis index (TLI). Good-fitting single-level models typically have RMSEA values $\approx .06$, SRMR values $\approx .08$, and CFI and TLI values $\approx .95$ (Hu & Bentler, 1999). For multi-level models, a between-level SRMR $\approx .08$ is cautiously recommended where the number of L2 units (i.e., classrooms) is > 100 ; between-level SRMR values $> .08$ do not, however, necessarily indicate poor fit when L2 units < 100 (Padgett & Morgan, 2021). Our interpretation of effect size was guided by Orth et al. (2024), whereby $\beta_s > .03$ are considered small, $\beta_s > .07$ are moderate, and $\beta_s > .12$ are strong. A detailed analytic plan is included in

the Supplementary Materials.

3. Results

3.1. Preliminary analyses and descriptive statistics

Expectancy, utility value, effort cost, and aspirations showed residual measurement invariance at T_1 and T_3 (see Supplementary Materials; Table S1), meeting the metric invariance threshold as a precondition for subsequent longitudinal modelling. Descriptive statistics are shown in Table 2. The skewness and kurtosis for all variables were within ± 1.25 . Factor loadings were taken from the measurement models used to test for bivariate correlations. The proportion of between-class variance, i.e., ICC(1) values, were between approximately 4% to 10% for expectancy, utility value, and effort cost, 12% for perceived teacher value messages, 6% and 9% for aspiration, and 44% and 48% for achievement. The ICC (2) statistic (i.e., the reliability of student judgments) of perceived teacher value messages at T_1 was $.75$. The portion of between-class variance, alongside the reliable measurement of perceived teacher value messages, justifies a multilevel analysis of data (see the Supplementary Materials for a more detailed interpretation of the ICCs).

3.2. Bivariate correlations

Model fit for the ML-CFA was: $\chi^2(1067) = 2501.13$, RMSEA = $.031$, SRMR-W = $.041$, SRMR-B = $.148$, CFI = $.924$, and TLI = $.911$. The SRMR statistic for the L2 portion of the model was higher than is typically desirable. However, interpretation of fit indices must be balanced against model complexity and the number of L2 units. When considered alongside the RMSEA, CFI, and TLI (which refer to L1 and L2), and other model parameters (e.g., factor loadings, variance explained, and standardized residuals), we considered the model to show a reasonable fit. Coefficients are shown in Table 3. Perceived teacher value messages were positively correlated with expectancy and utility value and negatively correlated with effort cost in the L2 portion of the model. At the student (L1) and class (L2) levels of the model, expectancy and utility value positively and effort cost negatively correlated with achievement and aspirations.

3.3. Multi-level structural equation models

The model fit for the expectancy model was: $\chi^2(380) = 905.71$, RMSEA = $.031$, SRMR-W = $.047$, SRMR-B = $.092$, CFI = $.952$, and TLI = $.942$, for the utility value model: $\chi^2(380) = 874.88$, RMSEA = $.030$, SRMR-W = $.036$, SRMR-B = $.104$, CFI = $.958$, and TLI = $.948$, and for the effort cost model: $\chi^2(303) = 574.32$, RMSEA = $.025$, SRMR-W = $.036$, SRMR-B = $.098$, CFI = $.969$, and TLI = $.961$. Standardized regression coefficients are shown in Tables 4 and 5, and tests of L2 indirect relations from T_1 teacher value messages to T_4 achievement and aspiration, mediated by T_3 expectancy, utility value, and effort cost, are

Table 2
Descriptive statistics for study variables.

	Range	Mean	SD	ICC1	Skewness	Kurtosis	Factor Loadings	
							Within	Between
T ₁ Perceived Teacher Value Messages	4 - 20	16.39	3.29	.12	-1.06	1.25	.62 - .85	.70 - .92
T ₁ Expectancy	4 - 20	12.33	3.62	.04	-.08	-.50	.63 - .76	.75 - .93
T ₁ Utility Value	4 - 20	14.96	3.67	.05	-.61	-.09	.73 - .76	.64 - .95
T ₁ Effort Cost	3 - 15	8.62	2.65	.06	-.06	-.27	.41 - .76	.46 - .97
T ₂ Achievement	0 - 41	22.57	8.37	.44	-.66	-.17	—	—
T ₂ Aspirations	4 - 16	9.31	3.09	.06	.24	-.47	.76 - .85	.77 - .91
T ₃ Expectancy	4 - 20	12.27	3.53	.07	-.20	-.25	.62 - .77	.78 - .91
T ₃ Utility Value	4 - 20	14.72	3.76	.10	-.61	.01	.70 - .81	.90 - .97
T ₃ Effort Cost	3 - 15	8.51	2.70	.09	.18	-.26	.45 - .81	.17 - .97
T ₄ Achievement	0 - 41	22.68	8.62	.48	-.64	-.35	—	—
T ₄ Aspirations	4 - 16	9.37	3.24	.09	.17	-.64	.75 - 85	.91 - .94

Table 3

Bivariate correlations between study variables from the ML-CFA (student-level above, and class-level below, the diagonal).

	1	2	3	4	5	6	7	8	9	10	11
1. T ₁ PTVM	—	.18	.34	.01	.16	.12	.10	.22	-.03	.05	.13
2. T ₁ EX	.52	—	.53	-.53	.27	.53	.76	.42	-.39	.25	.45
3. T ₁ UV	.59	.71	—	-.19	.19	.63	.36	.66	-.17	.16	.49
4. T ₁ EFC	-.50	-.71	-.43	—	-.21	-.20	-.41	-.17	.72	-.20	-.19
5. T ₂ ACH	.50	.61	.61	-.67	—	.19	.27	.26	-.16	.47	.22
6. T ₂ ASP	.49	.75	.75	-.31	.54	—	.43	.55	-.16	.16	.69
7. T ₃ EX	.61	.45	.45	-.43	.53	.44	—	.57	-.51	.36	.64
8. T ₃ UV	.72	.70	.70	-.56	.62	.53	—	—	-.17	.31	-.31
9. T ₃ EFC	-.57	-.53	-.56	.82	-.70	-.28	-.58	-.62	—	-.26	-.20
10. T ₄ ACH	.44	.73	.73	-.48	.89	.51	.54	.63	-.68	—	.22
11. T ₄ ASP	.71	.55	.55	-.64	.54	.64	.73	.85	-.57	.49	—

Note. PTVM = perceived teacher value message, EX = expectancy, UV = utility value, EFC = effort cost, ACH = achievement, and ASP = aspiration. **Bold** coefficients: $p < .05$.

Table 4

Standardized coefficients from the student (L1) portion of the ML-SEM

Path/Correlation	Expectancy Model		Utility Value Model		Effort Cost Model	
	β	SE	β	SE	β	SE
<i>Autoregressive Paths</i>						
T ₁ MB → T ₂ MB	.43	.04	.49	.05	.72	.04
T ₂ ACH → T ₄ ACH	.40	.04	.42	.04	.44	.04
T ₂ ASP → T ₄ ASP	.56	.04	.47	.04	.66	.03
<i>T₂ Achievement and Aspiration to T₃ Motivational Belief</i>						
T ₂ ACH → T ₂ MB	.14	.04	.13	.04	-.01	.04
T ₂ ASP → T ₂ MB	.30	.04	.22	.05	-.01	.04
<i>Perceived Teacher Value Messages to Motivational Belief, Achievement and Aspiration</i>						
T ₁ PTVM → T ₂ MB	-.02	.04	.01	.04	-.03	.04
T ₁ PTVM → T ₄ ACH	-.04	.04	-.06	.04	-.02	.04
T ₁ PTVM → T ₄ ASP	.02	.04	-.02	.04	.05	.04
<i>T₃ Motivational Belief to T₄ Achievement and Aspiration</i>						
T ₃ MB → T ₄ ACH	.26	.04	.42	.04	-.19	.04
T ₃ MB → T ₄ ASP	.28	.04	.39	.04	-.10	.04
<i>Baseline/Outcome Correlations</i>						
T ₁ TVM & T ₁ MB	.18	.03	.34	.03	.01	.04
T ₁ TVM & T ₂ ACH	.16	.04	.16	.04	.16	.04
T ₁ TVM & T ₂ ASP	.12	.04	.12	.04	.13	.04
T ₂ ACH & T ₂ ASP	.18	.04	.19	.04	.19	.04
T ₁ MB & T ₂ ACH	.28	.04	.19	.04	-.22	.04
T ₁ MB & T ₂ ASP	.54	.03	.63	.03	-.23	.04
T ₄ ACH & T ₄ ASP	.02	.05	.03	.05	.11	.04

Note. PTVM = perceived teacher value message, MB = motivational belief, ACH = achievement, and ASP = aspiration. **Bold** coefficients: $p < .05$.

shown in Table 6. For comparative purposes, models including socio-demographic variables (i.e., gender and socioeconomic status) are included in the Supplementary Materials. The main analyses reported here remain unchanged in these models with covariates.

3.3.1. Perceived teacher value messages on expectancy, utility value, and effort cost

Our first hypothesis concerned whether perceived teacher value messages predict students' expectancy, utility value, and effort cost. Where students perceived that teachers conveyed the relevance of the material (i.e., the L2 portion of the model), they reported higher average expectancy and utility value, beyond prior levels, with large effect sizes. The (negative) relation with effort cost was in the expected direction but was not statistically significant. These findings partially support Hypothesis 1. Perceived teacher value messages in the L1 portion of the model (i.e., students who more or less strongly agreed that their teachers communicated the value of sciences relative to their classmates) were unrelated to motivational beliefs, after controlling for their prior beliefs.

3.3.2. Achievement and aspirations on expectancy, utility value, and effort cost

Our second hypothesis concerned whether achievement and

Table 5

Standardized coefficients from the class (L2) portion of the ML-SEM

Path/Correlation	Expectancy Model		Utility Value Model		Effort Cost Model	
	B	SE	β	SE	β	SE
<i>Autoregressive Paths</i>						
T ₁ MB → T ₂ MB	.67	.18	.41	.17	.56	.12
T ₂ ACH → T ₄ ACH	.84	.07	.78	.07	.82	.08
T ₂ ASP → T ₄ ASP	.34	.13	.27	.12	.51	.12
<i>T₂ Achievement and Aspiration to T₃ Motivational Belief</i>						
T ₂ ACH → T ₂ MB	.02	.15	.19	.11	-.23	.15
T ₂ ASP → T ₂ MB	-.15	.19	-.03	.16	.07	.12
<i>Perceived Teacher Value Messages to Motivational Belief, Achievement and Aspiration</i>						
T ₁ PTVM → T ₂ MB	.29	.14	.39	.12	-.22	.12
T ₁ PTVM → T ₄ ACH	.01	.09	-.08	.10	-.02	.10
T ₁ PTVM → T ₄ ASP	.22	.13	.15	.14	.26	.16
<i>T₃ Motivational Belief to T₄ Achievement and Aspiration</i>						
T ₃ MB → T ₄ ACH	.12	.12	.28	.10	-.13	.11
T ₃ MB → T ₄ ASP	.47	.14	.56	.14	-.29	.13
<i>Baseline/Outcome Correlations</i>						
T ₁ TVM & T ₁ MB	.52	.11	.62	.09	-.49	.11
T ₁ TVM & T ₂ ACH	.51	.11	.51	.11	.52	.11
T ₁ TVM & T ₂ ASP	.51	.12	.49	.12	.47	.13
T ₂ ACH & T ₂ ASP	.49	.12	.44	.12	.44	.13
T ₁ MB & T ₂ ACH	.58	.10	.55	.11	-.67	.08
T ₁ MB & T ₂ ASP	.69	.10	.72	.09	-.16	.16
T ₄ ACH & T ₄ ASP	.04	.19	-.16	.18	.03	.19

Note. TVM = teacher value message, EVB = MB = motivational belief, ACH = achievement, and ASP = aspiration. **Bold** coefficients: $p < .05$.

Table 6

Tests of standardized indirect relations from L2 T₁ perceived teacher value messages to L2 T₄ achievement and aspiration, mediated by L2 T₃ expectancy, utility value, and effort cost.

Mediator	Achievement			Aspiration		
	β	SE	95% CIs	β	SE	95% CIs
Expectancy	.04	.04	-.03, .10	.14	.08	.01, .26
Utility Value	.11	.06	.02, .20	.21	.09	.07, .36
Effort Cost	.03	.03	-.02, .08	.06	.05	-.01, .14

aspirations predict expectancy, utility value, and effort cost. Students with greater achievement and aspirations relative to their classmates (i.e., the L1 portion of the model) reported higher expectancy and utility value with large effect sizes, beyond prior levels. Student-level achievement and aspirations were unrelated to effort cost. Class-average achievement and aspirations (i.e., the L2 portion of the model) were unrelated to class-average expectancy, utility value, and effort cost. These findings offer partial support for Hypothesis 2.

3.3.3. Expectancy, utility value, and effort cost, on achievement and aspirations

Our third hypothesis concerned whether expectancy, utility value, and effort cost predict subsequent achievement and aspirations. Students who reported higher expectancy, utility value, and lower effort cost than their classmates (i.e., the L1 portion of the model) showed higher achievement and aspirations, beyond prior levels, with mainly large effect sizes (an exception was the moderate negative relation from effort cost to achievement). In addition, classes with higher average utility value (i.e., the L2 portion of the model) showed higher achievement beyond prior levels, with a large effect size; classes with higher average expectancy and utility value, and lower effort cost, showed higher aspirations, beyond prior levels, with large effect sizes. These findings offer strong, if not unequivocal, support for [Hypothesis 3](#).

3.3.4. Relations from perceived teacher value messages to achievement and aspirations

Our fourth hypothesis concerned whether perceived teacher value messages would predict achievement and aspirations indirectly, through their relations with expectancy, utility value, and effort cost. Classes where teachers were strongly perceived to provide value messages (i.e., the L2 portion of the model) showed greater achievement mediated by higher class-average utility value with a large effect size, and greater aspirations mediated by higher class-average expectancy (a moderate effect size) and utility value (a large positive effect size). There were no statistically significant direct relations from perceived teacher value messages to achievement and aspirations. These findings offer partial support for [Hypothesis 4](#).

4. Discussion

The aim of this study was threefold. First, it examined how class-level (L2) perceived teacher value messages about science were related to students' subsequent expectancy, utility value, and effort cost. Second, it explored the reciprocal relations between student-level (L1) and class-level (L2) expectancy, utility value, and effort cost, and science achievement and aspirations. Third, it investigated whether there were indirect relations between L2 perceived teacher value messages about science and class-average science achievement and aspirations, mediated by class-average expectancy, utility value, and effort cost. In summary, L2 perceived teacher value messages showed strong positive relations with expectancy and utility value. Higher L1 expectancy and utility value, and lower effort cost, predicted higher achievement and aspirations; higher L2 utility value predicted higher achievement; higher L2 expectancy and utility value, and lower effort cost, predicted higher aspirations. L2 perceived teacher value messages predicted greater achievement mediated by higher utility value, and higher aspirations mediated by higher expectancy and utility value.

4.1. Perceived teacher value messages predict students' beliefs

Based on the processes outlined in SEVT ([Eccles & Wigfield, 2020](#)) and VRT ([Acee et al., 2018](#)), alongside findings from intervention studies (e.g., [Gaspard et al., 2021](#); [Shechter et al., 2011](#)) and naturalistic studies of the classroom environment (e.g., [Parrisius et al., 2020](#); [Schmidt et al., 2019](#)), we reasoned in [Hypothesis 1](#) that perceived teacher value messages would relate to students' beliefs about science. Directly providing students with broad reasons why science is important, valuable, useful, and interesting would prompt them to (re) appraise the relevance to their lives and their science career options. Our findings supported this reasoning with large effect sizes; in classes where students strongly agreed that their teachers communicated the value of science, the average student utility value was higher. As such, they are consistent with and build on utility value and value reappraisal intervention studies and extend the nascent naturalistic studies showing the benefit of discussing the relevance of science with students in early

secondary education. Importantly, our findings indicate that students' shared perceptions of teachers' value messages to the class (the L2 construct), rather than individual differences in students' receptivity to those messages (the L1 construct), are critical for predicting subsequent expectancy and utility value.

To the extent that messages are perceived, our findings suggest that providing reasons for how science may link to students' everyday lives and contribute to their ambitions can lead to an increase in the students' judgements about the importance of school science and a greater willingness to engage and exert effort in lessons and learning science ([Hulleman & Harackiewicz, 2021](#); [Simon et al., 2020](#)). Greater engagement and effort can result in learning gains and competence development, which underpin expectancy of success. Our finding that perceived teacher value messages were also positively associated with higher expectancy may reflect these mechanisms and is consistent with utility value intervention studies that have boosted expectancy ([Hulleman et al., 2017](#); [Rosenzweig et al., 2022](#)). That perceived teacher value messages were not associated with lower effort cost suggests that broad perceived messages about the importance and usefulness of science alone are insufficient to reduce cost. Additional messages may be needed that are more task- or lesson-specific, or that address task difficulty.

4.2. Expectancy, utility value, and effort cost are key drivers of achievement and aspiration

There is widespread evidence that expectancy, utility value, and effort cost impact achievement and educational decisions (e.g., [Lauer-mann et al., 2017](#); [Meyer et al., 2019](#)). However, studies that include both achievement and aspirations as outcomes and control for prior achievement and aspirations are rare. Moreover, few studies model relations at the student (L1) and classroom (L2) levels (e.g., [Cambria et al., 2017](#)). Thus, our findings make a novel contribution to this oft-studied question. Our student-level results support the SEVT proposition that expectancy and utility value lead to greater, and effort cost to lower, achievement and aspirations with large effect sizes (effort cost excepted with a moderate effect size). Moreover, they support previous findings from samples of secondary school students (e.g., [Guo et al., 2015](#); [Jiang et al., 2018](#)). Students with stronger competence beliefs in science and who value science invest greater time and effort in, think more deeply about, and are more emotionally invested in their science courses (e.g., [Putwain et al., 2019](#); [Wang & Eccles, 2013](#)). Consequently, student learning and achievement are enhanced, and motivation to study higher-level science courses and pursue science careers is higher. L2 findings showed classes with higher mean expectancy and utility value and lower mean effort cost reported higher mean aspirations with large effect sizes. Moreover, classes with a higher mean utility value showed stronger achievement with a strong effect size. Expectancy and effort cost were in the expected direction but did not reach statistical significance. This is likely an artefact of strong stability paths with prior achievement coupled with the less-than-ideal number of L2 units. Nonetheless, findings further evidence that the foundational motivational drivers of achievement and aspirations proposed in SEVT apply to classrooms as well as individuals.

4.3. Achievement and aspirations impact expectancy, utility value, and effort cost

In SEVT, it is expected that educational achievement and choices would also shape subsequent motivational beliefs ([Eccles & Wigfield, 2020](#)), but few studies have examined these relations. We found partial support at the student level; higher achievement and aspirations were related to stronger expectancy and utility value with large effect sizes. Higher achievement provides feedback that reinforces competence beliefs and purpose, thereby leading to stronger expectations for future achievement and connections with the real-world usefulness of science.

Higher aspirations can strengthen goals and provide reasons why a subject (or lesson or task) is important. This leads to greater utility value and is associated with stronger effort intentions, thereby raising expectations of success (e.g., Horowitz et al., 2018). Our findings extend those of Lauermann et al. (2017), who found mathematics aspirations predicted utility value in secondary school students, as we included achievement and analyzed these associations in the domain of science. Conceptually, higher achievement and aspirations would signal that effort was justified and worthwhile, but we did not find support for this proposition. Effort cost may be more strongly influenced by task difficulty and effort attributions (e.g., Hong & Lin-Siegler, 2012).

One of the few studies to examine relations at the class level found that achievement positively predicted academic self-concept (a self-belief that underpins expectancy) and utility value and negatively predicted L2 global cost in mathematics (Cambria et al., 2017). Although we found L2 bivariate correlations in the expected direction, we did not find evidence that class-level achievement or aspirations were linked to subsequent class-mean motivational beliefs. Cambria et al.'s (2017) study, however, did not include relations with prior motivational beliefs, which may account for the discrepancy between their findings and those of the present study.

4.4. Perceived teacher value messages extend to science achievement and aspiration

L2 perceived teacher value messages were related to expectancy and utility value as expected. In turn, expectancy was related to subsequent aspirations, and utility value was related to subsequent achievement and aspirations. These findings extend previous work showing how (perceived) teacher value messages are related to task values in science (Schmidt et al., 2019) and mathematics (Parrisius et al., 2020).

This links key mechanisms described in SEVT (Eccles & Wigfield, 2020): students' perceptions of socializer behavior (a sociocultural influence) with their expectancies and subjective task values (socio-cognitive influences on educational choice and achievement). Additionally, our study provides naturalistic evidence for the proposition in VRT (Acee et al., 2018) that perceived teacher value messages relate to motivational beliefs and subsequent educational outcomes. Teachers are instrumental in establishing the collective motivational climate in their classrooms. As such, they are in an influential position to influence their students' beliefs about competence and the relevance, importance, and drawbacks of subjects and specific learning activities and tasks (Acee et al., 2018; Brophy, 1999). Ultimately, these beliefs impact student outcomes, including engagement (e.g., Wang, Degol, Amemiya, Parr, & Guo, 2020), achievement, and aspirations (e.g., Lauermann et al., 2017).

4.5. Limitations and recommendations for future studies

While our study used a longitudinal design, employed rigorous analyses, and contributed novel findings, there are two key limitations to highlight. First, we focused on a broad conceptualization of perceived teacher value messages, which were measured at the generic subject level to maintain an appropriate level of matching specificity (Swann et al., 2007) to students' science expectancy, utility value, and effort cost. While this general approach is a useful starting point, it does not establish how perceived teacher value messages may take time to embed, or gather momentum over a series of lessons, or coverage of a topic. Moreover, teachers may emphasize the value of science in different ways for different topics or tasks; in some topics or tasks, it may be more appropriate to emphasize utility value, others intrinsic value, and so on. Future studies could, therefore, use a time series approach and explore how messages are contextualized for different topics or lessons.

Second, our study measured perceived teacher value messages from students' reports. Key advantages of student reports are measuring

student perceptions and the assessment of reliability from multiple observer ratings (Lüdtke et al., 2009). Student, teacher, and independent observer reports all show potential biases (see Supplementary Materials). Nonetheless, it would be useful to establish how potentially more objective measures (i.e., judged by independent raters) are related to students' motivational beliefs. Future studies should incorporate data from multiple sources (i.e., students and independent observers) to validate student-reported messages and better understand the extent and impact of potential reporting biases.

4.6. Recommendations for educational practice

The foremost implication of our findings is that students' aspirations to pursue science further may be supported when teachers are perceived to communicate messages about the value of science. To the extent that messages are perceived, the time teachers spend in lessons explaining the importance, relevance, and utility of science is not wasted. Students positively respond to this perceived communication of the value and relevance of science in ways that ultimately shape their beliefs about science and their subsequent aspirations. Therefore, we recommend that teachers, individually and in their subject teams, consider carefully exactly how the relevance, importance, and utility of science can be emphasized alongside curriculum content. This could involve highlighting different types of scientific careers, highlighting examples of people who have developed scientific careers from similar backgrounds to those of students, and how a scientific approach to issues important to students' lives can be informative. Moreover, teachers can use student voice approaches (e.g., Conner, 2022) to check that value messages were perceived by students as intended.

4.7. Conclusion

When students perceive that teachers strongly explain the value of science, they feel more confident in their abilities and see science as more useful. This perception of utility is linked to higher achievement and, together with expectancy beliefs, supports aspirations to study advanced science and pursue scientific careers. Encouraging teachers to incorporate explicit messaging of the values of science is a promising and affordable way to boost students' motivation, achievement, and long-term science aspirations.

CRedit authorship contribution statement

David W. Putwain: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Andrea Mallaburn:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Hanna Gaspard:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization.

Declaration of competing interest

We have no known conflict of interest to disclose. All data, materials, and analytic code, have been made publicly available at the Open Science Framework and can be accessed at: <https://osf.io/s4tbd/>. The study was not preregistered. This project was funded by an award made to the first two authors by the British Academy (SRG22\220016).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.learninstruc.2026.102365>.

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