Achievement goals and classroom goal structures: Do they need to match?

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ABSTRACT
It is often assumed that students’ personal achievement goals are most beneficial when they match the goal structures of the classroom, but interaction between achievement goals and goal structures is not well researched. In this study, we aim at providing a nuanced picture of the direct, interaction, and nonlinear effects of achievement goals and goal structures on test performance and autonomous motivation. We used multiple linear regressions, including interaction and quadratic terms, in combination with response surface methodology to analyze questionnaire data from students in Grades 6-10. We found no evidence for a general match effect, and only weak indications of interactions between achievement goals and goal structures. Thus, the match between classroom goal structures and students’ personal goals may be less important for students’ motivation and achievement than previously assumed. Still, based on our results we recommend a focus on mastery structures in the classroom.

Introduction
Achievement goals constitute the competence-related purposes behind engagement in achievement behavior (Elliot & Hulleman, 2017). The two most basic achievement goals, mastery and performance goals, thus represent two different forms of competence-related purposes. Students with mastery goals define competence in relation to themselves and the task at hand and strive to develop this competence, while students with performance goals define competence in relation to others and strive to demonstrate their competence. Although these goals are internal, personal constructs, they are affected by the implicit and explicit goals that are expressed through the classroom instructional practices. The specific aspects of the instructional practices that emphasize certain achievement goals are known as classroom goal structures.

Research has shown direct links from both achievement goals and classroom goal structures to outcomes such as academic achievement and motivation, but also indirect links from goal structures via students’ achievement goals (Murayama & Elliot, 2009). However, a largely neglected question is whether the effect of students’ achievement goals is dependent on the classroom goal structures. It is often assumed that students’ achievement goals are most advantageous when they match the classroom goal structures (Linnenbrink & Pintrich, 2001). However, the results of the few studies conducted are inconclusive, and there are methodological limitations that may have interfered with the possibility to detect certain types of match patterns. For example, nonlinear effects need to be included to investigate a general match effect, that is, an “optimal” effect when goals and structures have the same values (cf. Chatzisarantis et al., 2016). Nevertheless, we have not found any studies that included nonlinear relations when studying interactions between achievement goals and classroom goal structures. Therefore, to expand the current knowledge about interactions between achievement goals and classroom goal structures, studies applying new types of analyses are needed. The knowledge about interactions between achievement goals and goal structures is not only essential for our understanding of the merits of mastery and performance goals for educational outcomes, but also to guide educators toward productive instructional practices (Linnenbrink, 2005).

With this study, we investigate the interplay between achievement goals and goal structures in the prediction of students’ autonomous motivation and test performance, two commonly desired educational outcomes, within the school subject chemistry. As an expansion of previous research, we include nonlinear relations together with interactions. Our study also takes into account that students may simultaneously hold both mastery and performance goals, and that learning situations may comprise varying levels of performance and mastery supportive elements at the same time. Hence, the ecological validity of our study is high and the results highly relevant for instructional practice.

Achievement goals
Although there are different views about the nature of achievement goals, there is consensus that achievement goals concern competence and can be defined as the purpose...
behind engagement in achievement behavior (Elliot & Hulleman, 2017). However, purpose can refer to either the aim or the reason for behavior, that is, what you want to accomplish or why you want it, respectively. This duality has resulted in different conceptualizations of achievement goals. Some theorists have viewed achievement goals as pure aims, others as reasons, and still others as a combination of the two. The distinction between aim and reason is paralleled by others as reasons, and still others as a combination of the two. The distinction between aim and reason is paralleled by Elliot and Hulleman (2017) standard and standpoint subcomponents of achievement goals. Standards represent references for the evaluation of competence: task-based, self-based, or other-based standard. In contrast, the standpoint subcomponent (identical to reason in Senko & Tropiano, 2016) concerns whether individuals strive to develop or to demonstrate competence. The different standards and standpoints boil down to two separate goal constructs, mastery goals and performance goals. These two goals make up the dichotomous achievement goal model (Elliot & Hulleman, 2017). In this model, a mastery goal is associated with an absolute (task-based) or intrapersonal (self-based) standard for competence evaluation and a standpoint of developing knowledge. Performance goals are associated with a normative standard for competence evaluation and a standpoint of demonstrating competence (Ames, 1992; Elliot & McGregor, 2001).

Expanding the dichotomous achievement goal model, an approach and avoidance distinction has been added for performance goals. Approach and avoidance goals differ in the valence of the goals: seeing the chance of success and approaching it or seeing the risk of failure and avoiding it (Elliot & Harackiewicz, 1996). This expansion resulted in the trichotomous model separating mastery, performance-approach, and performance-avoidance goals (e.g., Elliot, 1999; Elliot & Church, 1997). Mastery goals have also been divided into mastery-approach and mastery-avoidance goals, leading to the 2 × 2 goal framework (Elliot & McGregor, 2001). Along with the addition of mastery-avoidance goals, the 2 × 2 framework excludes the standpoint subcomponent and defines achievement goals exclusively on the standard of competence evaluation (Elliot & Hulleman, 2017).

Despite empirical support for the 2 × 2 framework (Elliot & McGregor, 2001; Elliot & Murayama, 2008), three goals; performance-approach, performance-avoidance, and mastery-approach, have “produced the most solid empirical base” (Lau & Nie, 2008, p. 15). Moreover, removing the standpoint subcomponent of achievement goals, as in the 2 × 2 model, may hamper their predictive ability. Researchers therefore have argued that neither the standard nor standpoint subcomponent is superior on theoretical grounds (Senko & Tropiano, 2016) and that studying them together could be fruitful, capitalizing on their respective strengths (Korn et al., 2019). Moreover, Elliot and Hulleman (2017) pointed out that combining the standard and standpoint components of performance goals could accentuate the negative implications of performance goals and therefore, through reduced satisficing (Podsakoff et al., 2003), lead to increased predictive power. We adopt a trichotomous achievement goal model in this paper, including both the standard and standpoint subcomponents of performance-approach, performance-avoidance, and mastery-approach goals (henceforth termed mastery goals). Thus, our model is similar to the 2 × 2 standpoints and standards achievement goal model recently proposed by Korn et al. (2019), but without mastery-avoidance goals.

Goal structures

According to contemporary social-cognitive perspectives of achievement goals, individuals’ goals are malleable and affected by the social context (Kaplan et al., 2012). Classroom goal structures, that is, instructional practices that emphasize certain achievement goals in the classroom (Ames, 1992), are important aspects of that context. Arguably, it is students’ perceptions of classroom goal structures, rather than “objective” measures of the structures, that are most critical for understanding students’ behavior (Ames, 1992; Meece et al., 2006).

In contrast to achievement goals, the dimensionality of classroom goal structures has remained largely undebated, with mastery structures supporting mastery goals and performance-approach structures (often focusing on the approach dimension, see Linnenbrink, 2005) supporting performance goals as the two dominating constructs. To characterize classroom goal structures, researchers frequently use the TARGET framework (e.g., Lüftenegger et al., 2017; PALS; Midgley et al., 2000), focusing on aspects such as; scope for autonomy in learning, characteristics of the task (e.g., understanding vs. memorizing), temporal conditions for learning, reference for assessing learning (i.e., self-based or other-based) and nature of evaluation (private vs public). For example, mastery goal structures can be characterized by opportunities for students to choose between different learning activities or approaches, recognition of individual progress rather than between-student comparisons, feedback given privately, and adequate time given for development of understanding. In contrast, performance goal structures include encouragement of competition between students (e.g., by publicly praising successful students), evaluation of competence relative to other students, limiting possibilities for students to regulate their own learning, and allowance of too little time for development of thorough understanding of the content.

Attempts have been made to measure performance-approach and performance-avoidance structures separately, but the performance-avoidance scale have often been excluded due to low reliability or low variance between classrooms (Kaplan et al., 2002; Murayama & Elliot, 2009; Wolters, 2004). Therefore, we only included mastery and performance structures, both with approach focus, in this study. Hereafter, the label performance structures will be used for performance-approach structures.

Achievement goals and goal structures as predictors of student outcomes

In the following paragraphs, we review results concerning both academic achievement and intrinsic motivation as outcomes of goals, goal structures, and their interactions.
Although intrinsic motivation dominates as an outcome in most previous studies, which is the reason we review those results, we are interested in to what extent students feel self-determined in their learning. Hence, we have used the broader construct of autonomous motivation. Autonomous motivation captures not only the ‘ultimate’ reason for self-determined behavior, that is, doing something because of the enjoyment it brings, but also reasons that relate to the identification and integration of more instrumental personal values. However, both intrinsic and autonomous motivation build on the individuals’ identification of a personal value of the activity and hence reflect the level to which a behavior is self-determined. Therefore, we argue that results pertaining to the relationship between achievement goals, goal structures, and intrinsic motivation is relevant for our study.

Direct effects
Murayama and Elliot (2009) presented an analytical framework for studying the joint influence of achievement goals and goal structures on outcome variables (Figure 1). In this framework, they posited a direct effect model, where both achievement goals and goal structures directly affect the outcome (Figure 1A). Studies have shown that both achievement goals and goal structures have direct effects on, for example, intrinsic motivation and achievement, (see Murayama & Elliot, 2009, for a more comprehensive review including effects on other outcomes). Throughout this text, we use the term effect to indicate predictive relations, not causality, in line with Murayama and Elliot.

Intrinsic motivation often correlates positively with mastery and performance-approach goals and negatively with performance-avoidance goals (Elliot & Harackiewicz, 1996; Elliot & Murayama, 2008; Grant & Dweck, 2003; Murayama & Elliot, 2009). There is less research on direct effects of goal structures on intrinsic motivation, but mastery structures seem to follow the same pattern as mastery goals (Murayama & Elliot, 2009; Skaalvik & Skaalvik, 2013), while performance structures have a more negative pattern (Murayama & Elliot, 2009; Skaalvik et al., 2017).

Turning to the relationship with achievement, Linnenbrink-Garcia et al. (2008) review of over 90 studies showed that both mastery goals and performance-approach goals are more often positively correlated with achievement than negatively. Also, mastery goals seem to be more adaptive than performance-approach goals for younger students (Linnenbrink-Garcia et al., 2008), when solving challenging tasks (Linnenbrink-Garcia et al., 2008, Grant & Dweck, 2003), and for long-time retention of information (Elliot & McGregor, 1999). Performance-avoidance goals generally correlate negatively with achievement (Hulleman et al., 2010). Similar to the relation between goal structures and intrinsic motivation, Lau and Nie (2008) demonstrated that mastery structures correlated positively with test performance, while performance structures correlated negatively. However, neither mastery nor performance goal structures predicted course grade significantly when controlling for personal achievement goals in Wolters (2004).

Indirect effects
According to the indirect effect model of Murayama and Elliot (2009), goal structures affect student outcomes via the adoption of achievement goals, which in turn are the proximal predictors of the outcomes (Figure 1B). Examples of studies showing indirect effects of goal structures on intrinsic motivation and achievement include Bergsmann et al. (2013), Church et al. (2001), Mouratidis et al. (2018), and Roesser et al. (1996). Because the abundance of evidence for the indirect effects of goal structures, they are not examined in this study.

Interaction effects
In the interaction effect model of Murayama and Elliot (2009), the effect of achievement goals on outcomes varies as a function of the goal structures (Figure 1C). In line with general person-environment fit research (Eccles & Midgley, 1989; Hunt, 1975), theorists have proposed that a match between students’ personal achievement goals and the classroom goal structures should lead to the most positive outcome pattern (Harackiewicz & Sansone, 1991; Linnenbrink & Pintrich, 2001). As an expansion of this general hypothesis, Murayama and Elliot (2009) presented more detailed hypothetical patterns for how the interaction between goals and goal structures may influence outcomes. In the following paragraph, these hypothetical patterns will be presented.
First, the match hypothesis states that matching goal structures either can lead to accentuation of the basic pattern of the goals or positivity, that is, produce the optimal pattern (cf. the two reinforcing patterns of Lau & Nie, 2008). Second, three mismatch hypotheses were presented: vitiations, mitigation, and exacerbations. A vitiations effect is present if a beneficial effect of an achievement goal is weakened when there is a mismatch between classroom goal structures and personal achievement goals (cf. a dampening effect in Lau & Nie, 2008). The opposite effect, mitigation, is present if a detrimental effect is weakened by the mismatching structure (cf. a buffering effect in Lau & Nie, 2008). Finally, a detrimental effect could be strengthened by the mismatch, labeled exacerbation effect.

Although investigation of person-environment interactions in educational research have been called for since the 1970s (e.g., Hunt, 1975), there are surprisingly few studies on this subject. We have only found six studies that examine interactions between achievement goals and goal structures, and the results are inconclusive. To start with, Linnenbrink (2005) found no significant interactions between environmental goal conditions and students’ mastery or performance-approach goals in the prediction of test results, academic self-efficacy, interest, utility value, emotional wellbeing, help-seeking, or cognitive engagement. However, other studies have showed positive match effects. For example, in Wolters’ (2004) study, mastery goal structures accentuated the positive effect of students’ mastery goals on effort, although no interaction effects were found on engagement, use of learning strategies, or course grade. Furthermore, Muis et al. (2013) found that for students high in mastery goals, mastery feedback was more beneficial for metacognitive self-regulation than other conditions, also supporting a match hypothesis. Again, the effect was limited as no match effect was evident for course grade, self-efficacy, or test anxiety.

In the above cited results of Wolters (2004) and Muis et al. (2013), a match led to beneficial effects. However, if a match hypothesis is formulated as accentuation of an achievement goal’s basic pattern, negative effects are also expected to be accentuated by a match. This type of negative match effect is evident in both Lau and Nie (2008), Murayama and Elliot (2009), and Wolters (2004). In all these studies, the maladaptiveness of performance-avoidance goals was accentuated in performance structures.

There are also examples of mismatch effects. Murayama and Elliot (2009) showed that the positive correlation between performance-approach goals and intrinsic motivation was weaker when students perceived a strong mastery goal structure than at weaker mastery structures. This is an example of a vitiations effect. Still, the evidence of mismatch effects between performance goals and mastery structures are weak, considering that neither Linnenbrink (2005), Wolters (2004), nor Lau and Nie (2008) found any significant interactions between them.

Finally, there are results that are difficult to sort into match or mismatch hypotheses. For example, Newman (1998) found that students with at least moderate levels of performance-approach goals showed a more positive help-seeking pattern under mastery goal conditions than under performance goal conditions. Because Newman did not include a control group, it is unclear whether this result indicates that mastery structures mitigated the negative effects of performance goals (mismatch) or that performance structures accentuated negative effects of performance goals (match) on help seeking behavior.

To summarize, when interaction effects have been found, a match between personal goals and classroom goal structures seem to have strengthened, and a mismatch reduced, the effect of the goal. These effects seem to be independent of whether the effect is positive or negative. There is some, though ambiguous, evidence of match, mitigation, and vitiations effects, while the empirical support for exacerbations effects is limited. It should be noted that this literature review has focused on significant results, but many of the possible interactions were insignificant in the reviewed studies. The limited research, and the inconsistent results, on interactions between goal structures and achievement goals warrants further studies in its own right. However, these interactions may also have contributed to the current ambiguity regarding the respective merits of mastery and performance-approach goals for learning (e.g., Meece et al., 2006; Senko, 2016). Hence, better awareness of interaction patterns will also be valuable in the design, interpretation, and comparison of future studies on the role of achievement goals for learning.

**Interactions between achievement goals and interactions between goal structures**

Beside interactions between achievement goals and goal structures, goals may interact with goals and structures with structures (Barron & Harackiewicz, 2001). For example, Darnon et al. (2010) showed that students’ adoption of performance-approach goals interacted with the link between mastery goals and tendency to search for social comparison information. Moreover, Federici et al. (2015) showed that the degree of perceived performance structure moderated the relationship between mastery structures and personal mastery goals. Our main focus in this article is the interaction between achievement goals and goal structures, but interactions between goals and between goal structures are also considered.

**Self-determination theory**

One of the outcomes included in the present study, autonomous motivation, stems from self-determination theory (SDT; Ryan & Deci, 2000). SDT distinguishes between intrinsic motivation, which refers to doing an activity because it is interesting or enjoyable in itself, and extrinsic motivation, which refers to doing something because it leads to a separable outcome that is external to the activity (e.g., a good grade). There are several types of extrinsic motivation, called regulatory styles. The regulatory styles differ in the degree to which the motive for a behavior has been
internalized by the individual (Figure 2). As an alternative to the five regulatory styles presented in Figure 2, Deci and Ryan (2008) distinguish between controlled (external and introjected regulation) and autonomous motivation (identified, integrated and intrinsic regulation). This later model has shown adequate fit in factor analytical studies (Chemolli et al., 2015; Ulstad et al., 2016), high persistence (Pelletier et al., 2001), goal progress (Koestner et al., 2008) and positive affect (Linnenbrink-Garcia et al., 2016). For the present paper, we focus on autonomous motivation as an outcome of the interaction between achievement goals and goal structures because this is the desired outcome of teaching.

**Present study**

Previous research has relied on hierarchical linear modeling (HLM) to study the joint influence, including interaction, of achievement goals and goal structures on students’ outcomes (e.g., Lau & Nie, 2008; Murayama & Elliot, 2009; Wolters, 2004). In this paper, we propose an alternative approach to study these relationships: polynomial regressions in combination with response surface methodology. Previous research applying traditional HLM to study interactions between achievement goals and goal structures has been highly informative. However, polynomial regressions interpreted through response surfaces offer a more detailed and integral graphical representation of the predictors’ relationship with each other and with educational outcomes. While graphical output from HLM typically shows linear relations between one predictor and the outcome variable, given a specific level of a second predictor, response surfaces display the estimated outcome for all possible combinations of the two predictors. This may be important to capture deviations from the general trend in the data. Moreover, polynomial regressions allow nonlinear relations that may play an important role in the interplay between predictors. Chatzisarantis et al. (2016) argued that neglecting nonlinear relationships may preclude detection of certain types of interaction patterns. This in turn may explain the weak empirical support for combined effects of achievement goals on academic achievement in extant research. Nonlinear terms in regression analyses allow optimal outcomes at any combination of the predictors. In contrast, purely linear models assume that the effect of a predictor has its maximum value at either the highest or the lowest value of the other predictor. If, for example, a general match hypothesis is true, outcomes are optimal when achievement goals and goal structures are at similar levels. Goal endorsement at both higher and lower levels than the optimal leads to less beneficial outcomes. Thus, regression analyses testing this hypothesis require nonlinear terms.

Chatzisarantis et al. (2016) demonstrated a nonlinear relationship between performance goals and academic achievement, and a combined effect of mastery and performance goals that went unnoticed in a model without nonlinear effects. Sideridis and colleagues have recently shown nonlinear relationships between achievement goals and help-seeking (Sideridis & Stamovlasis, 2016), and between goal “climate” and academic achievement (Sideridis et al., 2016). However, as far as we have been able to discern, no previous studies have combined nonlinear terms and interactions to investigate the relationship between goal structures, achievement goals, and student outcomes. In this article, we set out to do exactly this in the prediction of students’ autonomous motivation and their performance on a chemistry test.

The research questions that guided our study were the following. For the prediction of autonomous motivation and test performance,

- What impact does the match between students’ achievement goals and perceived goal structures have?
- What is the nature of the interactions, if any, between achievement goals and perceived goal structures?
- What nonlinear relations between achievement goals, goal structures, and outcomes can we identify?

**Method**

**Participants and procedure**

The data for the present study were drawn from a larger study to which all students in Grades 5–11 in two municipalities in Sweden were invited. The students responded to an online self-report questionnaire under teachers’ supervision. The questionnaire contained several instruments assessing, for example, students’ interest, self-concept, epistemic beliefs, and perception of classroom environment pertaining to their chemistry studies. The subject of chemistry was chosen solely because the participating researchers’ subject, pedagogical, and didactical competence is in this subject. We do not consider this subject especially suitable to study, for other than the pragmatic reasons mentioned above, nor do we expect students’ achievement goals to have different implications for learning in chemistry than in other subjects. For this particular study, we concentrated on students in Grades 6–10, and on the instruments assessing achievement goals, goal structures, autonomous, and a chemistry test. All students attended municipality-governed public schools, but students in specific programs for
students who had recently immigrated to Sweden or in programs for students with learning disabilities were excluded. In Grades 6–10, 1648 students (43% females, 46% males, 11% undefined) responded to the questionnaire. After data cleaning (described below) and listwise deletion for achievement goals and goal structures, 909 (45% females, 46% male, 9% undefined) remained. Table 1 displays the sample sizes for each grade, after data cleaning, and what school level the grades belong to. Grade 10 (upper secondary level) is not compulsory in Sweden, but most students (98% year 2015; Skolverket, 2016) transition directly from lower to upper secondary school.

Cleaning procedure

The responses of some participants contained long strings of identical answers, leading to positive correlations between all constructs, even those hypothesized to be negatively correlated. As long strings of identical answers imply careless responses, threatening the validity of the data (Meade & Craig, 2012), we cleaned the data according to the length of the strings of identical answers. We defined cutoff values for students’ maximum longest string (Meade & Craig, 2012) as longest string values exceeding 1.5 times the interquartile range above the upper quartile of the full sample. Additionally, we calculated histograms of longest string values to make scree-test like judgements of the appropriateness of these cutoff values (Johnsen, 2005). Cutoff values were calculated for several sets of constructs to allow for the possibility that students provide careless responses in one part of the questionnaire, but valid responses in others. Participants with longest string values exceeding the cutoff value for any of the sets included in this study were excluded from further analyses.

Measures

For all questionnaire items, students responded on a 5-point Likert scale. The questionnaire items specifically targeted students’ goals, beliefs, and perceptions in relation to the chemistry subject. All items used to measure achievement goals, perceived goal structures, and autonomous motivation are presented in Appendix A.

Achievement goals

To measure students’ achievement goals, we used an instrument that combined adapted items from the mastery-approach, performance-approach, and performance-avoidance subscales of the Revised Achievement Goal Questionnaire (AGQ-R, Elliot & Murayama, 2008) and the Patterns of Adaptive Learning Scales (PALS; Midgley et al., 2000). Hence, the instrument included both the standard and the standpoint subcomponent of achievement goals. During the validation of the instrument, we found that performance-approach and performance-avoidance goals were indistinguishable in this sample (their correlation was not significantly different from 1) and the two subscales were therefore collapsed into one general performance goal scale. A high correlation between performance-approach and performance-avoidance goals, showing near-identical predictive patterns, have been found in our own and others’ previous studies on different Swedish samples, using partially different measurement instruments and approaches for analyzing the dimensionality of achievement goals (e.g., Blomgren, 2016; Winberg, Hellgren, & Palm, 2014; Winberg & Palm, 2016). Therefore, this result was not surprising. Confirmatory factor analysis (CFA) supported a two-factor structure, $\chi^2 (52, N = 1121) = 283.1$, root mean square error of approximation (RMSEA) = .063, standardized root mean square residual (SRMR) = .052, comparative fit index (CFI) = .946, and Tucker-Lewis index (TLI) = .932. We also conducted measurement invariance testing (Vandenbussche & Lance, 2000) to verify that the measurement was invariant for the different grades. The data supported scalar invariance over Grades 6-10, $\chi^2 (642, N = 1121) = 696.1$, RMSEA = .068, SRMR = .072, CFI = .924, TLI = .926, and $\Delta$CFI = .008. For more information on the development and validation of the instrument, see Hofverberg and Winberg (2020). Internal consistency indices for both scales were good, Cronbach’s $\alpha = .85$ for mastery goals and Cronbach’s $\alpha = .90$ for performance goals.

Classroom goal structures

According to Koskey et al. (2010), classroom goal structure measures directed at students’ perceptions of the teacher’s goals have higher validity than those measuring students’ perceptions of the classroom environment in large. Therefore, our measure of classroom goal structures is adapted from PALS’ Teacher’s approaches to instruction and Perception of Teacher’s goals (Midgley et al., 2000), consisting of items typically phrased as “My teacher…” Two classroom goal structure subscales were assessed; mastery structures (e.g., “My teacher makes a special effort to recognize my individual progress”) and performance structures (e.g., “My teacher encourages students to compete with each other”). Initially, each subscale comprised five items, but after construct validation through CFA, three mastery structure items and four performance structure items remained. CFA supported the hypothesized two-factor structure, $\chi^2 (13, N = 1117) = 51.1$, RMSEA = .051, SRMR = .037, CFI = .976, and TLI = .961. Scalar invariance over Grades 6-10 was also supported for the goal structures, $\chi^2 (104, N = 1117) = 172.1$, RMSEA = .054, SRMR = .066, CFI = .959, TLI = .958, and $\Delta$CFI = .008. As for the achievement goal scales, internal consistency for both classroom goal

| Grade     | $n$  |
|-----------|------|
| Primary   | 135  |
| 6         | 247  |
| 7         | 187  |
| 8         | 183  |
| 9         |      |
| Upper secondary | 157 |
| Total:    | 909  |
structure scales was good, Cronbach’s α = .80 for mastery structures and Cronbach’s α = .81 for performance structures.

Test performance
The chemistry test assessed the complexity of students understanding of three fundamental chemical concepts: energy, chemical reactions, and structure and composition of matter. For each concept, students answered four grade-specific items and six anchor-items common for all grades. Test items were either in multiple-choice or ordered multiple-choice format (Alonzo & Steedle, 2009), with one scientifically acceptable response and three responses that either represented lower levels of understanding or alternative conceptions. The development and validation of the items are described in Hadenfeldt et al. (2013) and Podschuweit and Bernholt (2018). For the current study, a panel of four chemistry education researchers and three chemistry teachers checked all test response options for correctness, ambiguities, alternative interpretations that could affect between-options relationships, their potential ability to discriminate between levels of understanding, and appropriateness of items for each grade. Items were discussed and revised until consensus among the assessors was reached. Statistical validation of the instrument, by a one-dimensional multigroup generalized partial credit model, supported the validity of the test for Grades 6–10, as described in Höft, Bernholt, Blankenburg, and Winberg (2018). This analysis also generated weighted likelihood estimates that were used as interval scale measures (test scores) of students’ conceptual understanding in the ensuing regressions. Test scores varied between −2.9 and 3.8, with a mean of 0 and a standard deviation of 1.

Autonomous motivation
Students’ autonomous motivation was assessed by 6 items from the Academic Self-Regulation Questionnaire’s (Ryan & Connell, 1989) identified and intrinsic motivation scales. Items were formulated with a common stem, for example, “When I work with tasks during chemistry class, I do it because…” followed by reasons, such as: “it is fun” (intrinsic) and “it is important for me to do well in chemistry” (identified). A single factor CFA model demonstrated acceptable fit for the investigated grades, $\chi^2 (8, N=1117) = 63.5$, RMSEA = .079, SRMR = .031, CFI = .971, and TLI = .946. Scalar invariance over Grades 6–10 for the autonomous motivation model was supported, $\chi^2 (77, N=1117) = 128.9$, RMSEA = .055, SRMR = .071, CFI = .975, TLI = .975 and ΔCFI = .006. The autonomous motivation scale also showed good internal consistency, Cronbach’s α = .88. We used the factor scores, ranging from −2.3 to 1.4, from the scalar invariance model as the outcome variable.

Comparability of constructs over grades
As the data supported scalar invariance for all constructs, comparisons between grades were possible. To further reduce the risk of errors stemming from differences in the factor covariance matrix between grades, we used factor scores from the scalar models of each respective construct for the subsequent analyses (Muthén, 1989; also see forum comments August 3 and August 4 by Muthén, 2016). These factor scores were generated through the regression method (Muthén, 1998–2004).

Rationale for not aggregating scores to class-level
With data consisting of individual students clustered in classes, which are clustered in schools, multi-level analyses must be considered. Particularly students’ perceptions of classroom goal structures should, intuitively, be more similar within the same class than between classes. However, several studies indicate that variation in perceived goal structure is as high within classes as between classes (e.g., Murayama & Elliot, 2009; Wolters, 2004), and Lam et al. (2015) demonstrated that it may not be appropriate to aggregate individual students’ perceptions of goal structures to classroom level. Even if goal structures describe classroom level features, students may perceive the same classroom goal structure differently, and different students may be treated differently within the same classroom (Ames, 1992; Turner & Patrick, 2004). Furthermore, students’ subjective perceptions of goal structures have been shown to be better predictors of behaviors and outcomes than classroom averages (Ames, 1992; Meece et al., 2006). Hence, there are both theoretical and empirical reasons to treat classroom goal structures as individual-level phenomena in analyses. Still, we tested whether our data showed sufficient reliability on classroom-level for multi-level analyses to be appropriate. To determine the reliability of classroom-level measures of goal structures, we followed Lüdtke et al. (2009) and calculated the intraclass correlations ICC1 and ICC2. ICC1 shows the amount of variance at student-level that can be explained by classroom-level differences, while ICC2 describes the reliability of aggregated classroom-level means. Lam et al. (2015) argue that ICC1 exceeding .1 shows sufficient group-level variability for multilevel modeling, but data with values as low as .05 can be used. ICC2 should exceed .70 to be acceptable. In the present study, mastery structures had ICC1 = .044 and ICC2 = .48, while performance structures had ICC1 = .044 and ICC2 = .48. We found similarly low values for mastery goals, ICC1 = .061 and ICC2 = .551, and performance goals, ICC1 = .034 and ICC2 = .402. Consequently, aggregation to classroom-level was deemed inappropriate for these constructs and all analyses were conducted on individual-level only.

Predicting test performance and autonomous motivation
Before conducting any regressions, we rescaled all the predictors’ factor scores to a 5-point scale and then centered the scales on the midpoint. This procedure aids interpretation and decreases multicollinearity (Aiken & West, 1991).
We only included students with complete data on all variables in the regressions.

**Regressions with mastery and performance constructs separately**

The first step in the prediction of test performance and autonomous motivation was to regress them individually on either performance goals and performance structure or mastery goals and mastery structures. In these regressions, we included quadratic predictor terms and the interaction between achievement goals and goal structures, resulting in the following regression equation:

\[ Z = b_0 + b_1X + b_2Y + b_3X^2 + b_4XY + b_5Y^2 + e \]

\( Z \) represents the outcome variable (test performance or autonomous motivation), \( X \) represents students’ achievement goals (mastery or performance goals), \( Y \) represents goal structures (mastery or performance structures), \( X^2 \) and \( Y^2 \) are quadratic expressions of the predictors, \( XY \) represents the interaction between achievement goals and goal structures, and \( b_0 \) through \( b_5 \) are regression coefficients. We plotted the results of the regressions in a three-dimensional space representing achievement goal (\( X \)), goal structure (\( Y \)), and outcome variable (\( Z \)). For more information about these plots, see Interpreting response surfaces.

Beside the factor scores of classroom goal structures and personal achievement goals, we included students’ grade (school year), sex, and socio-economic status (SES) as control variables in all regressions. Grade was collected from databases, sex was self-reported, and the SES indicator represented the self-estimated number of books in students’ homes. Initially, we intended to include items assessing the mothers’ and fathers’ educational level in a composite measure of SES. However, we noticed that many students had difficulties answering these items as they were not aware of their parents’ educational attainments. Moreover, the number of books at home correlated more strongly than mothers’ and fathers’ educational level with the extent to which students watched or read about chemistry related issues on television, in books, in newspapers/magazines, and on the internet. The number of books at home also correlated higher with students’ perceptions that their parents could explain chemistry well. Hence, we deemed the number of books at home to be a reasonably good indicator of the homes’ attitudes toward chemistry and ability to help the students with their chemistry studies. Therefore, combined with a need to shorten the questionnaire to reduce the burden on students, we decided to omit questions about the parents’ educational level and only use the number of books as a measure of SES.

**Regressions with both mastery and performance constructs simultaneously**

After analyzing mastery goals/mastery structures and performance goals/performance structures as predictors of test performance and autonomous motivation, respectively, we constructed complex models that included both mastery and performance goal constructs simultaneously. Thus, these analyses contained four predictors, resulting in a large number of possible interactions and quadratic terms. To reduce the large number of terms, we studied zero-order correlations between all possible two-way interactions and quadratic terms and the two respective outcomes. We only included interactions and quadratic terms that had significant zero-order correlations with each respective outcome in the following analyses. Based on recommendations to focus on mastery in the classroom (e.g., Pintrich, 2000), we chose to focus on the mastery constructs in the surface plots illustrating these complex regressions.

**Interpreting response surfaces**

We present our results through response surface methodology, and to help the reader interpret the figures, a short introduction follows. A response surface is a 3D representation of a regression equation, with two predictors and one outcome on the three axes (e.g., Figure 3). In this article, the right axis represents level of goal endorsement, increasing from left to right, and the left axis represents level of perceived goal structure, increasing from right to left. The outcome variable, test score or autonomous motivation, is represented by the vertical axis.

Interactions would result in surfaces where the slope along, for example, the achievement goal axis differ at different levels of goal structures. Nonlinear relations can be seen as curvatures in the surface. Such curvatures will, for example, be evident if what we call a general match hypothesis is true. A general match hypothesis entails that matching values on both predictors are the most beneficial combination, disregarding the absolute values of the predictors. Such a match effect should be visible as a ridge in the response surface, diagonally from the near corner to the far (also referred to as the line of congruence) where goals and structures take on similar values (Shanock et al., 2010). Along the perpendicular line, the line of incongruence, effects of the level of difference between the two predictors can be studied. The slopes and curvatures along the line of congruence and of incongruence were investigated through calculations of surface values. For descriptions of these values, see Shanock et al. (2010), and for formulas of surface values and corresponding significance tests, see Appendix B.

**Results**

We included students’ grade (school year), sex, and SES as control variables in all regressions. In all models, residuals were normally distributed and there were no outliers. Furthermore, cross-validation (Efron & Gong, 1983), CV-ANOVA (Eriksson et al., 2008), and response permutation testing (Good, 2013) indicated that all models were significant, that is, the models did not describe the variation well by chance and they were valid for several random subpopulations in the sample.
Prediction of test performance

Mastery goals and structures

The prediction of students’ performance on the chemistry test by their mastery goals and perception of mastery structures, including interactions and quadratic terms, resulted in a significant regression model, adjusted $R^2 = .196$, $F(8, 622) = 20.17$, $p < .001$. As the slope along the mastery goal axis in Figure 3 illustrates, mastery goals positively predicted test score, while the less steep slope along the mastery structure axis shows that the structures were less important. Despite a nonsignificant quadratic regression coefficient (Table 2), the effect of goal structures seems to be slightly nonlinear, so that students perform best when they have high mastery goal endorsement and perceive a moderately mastery-focused classroom. The slopes along both the line of congruence and of incongruence were significant, but there were no significant curvatures along these lines.

Performance goals and structures

The prediction of test score by performance goals, performance structures, their quadratic terms, and interaction also resulted in a significant model, adjusted $R^2 = .141$, $F(8, 622) = 13.86$, $p < .001$. However, only the control variables grade and SES contributed significantly to the prediction (Table 2). This is reflected in the relatively flat surface in Figure 4, where only weak effects of performance goals and structures are observable. Surface values indicated no

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Table 2. Standardized regression coefficients of all regression models.

| Variable | Mastery model $N=631$ | Performance model | Complex model | Autonomous motivation $N=603$ | Performance model | Complex model |
|----------|------------------------|-------------------|---------------|-----------------------------|-------------------|---------------|
| M        | .252*                  |                   |               | .668*                      |                   |               |
| MS       | .051                   | .037              |               | .071*                      | .182*             | .085*         |
| P        | .045                   | -.007             |               |                            | -.041             |               |
| PS       | -.055                  | -.048             |               |                            | .014              | -.023         |
| $M^2$    | .013                   | .074              |               |                            |                   | .059          |
| $MS^2$   | -.038                  |                   |               |                            |                   |               |
| $P^2$    | -.031                  | .008              |               |                            |                   |               |
| PS$^2$   | -.014                  |                   |               |                            |                   |               |
| P x PS   | .008                   |                   |               |                            |                   |               |
| M x P    | -.122*                 |                   |               |                            |                   |               |
| M x PS   | .036                   |                   |               |                            |                   |               |
| GRADE    | .378*                  | .337*             | .380*         | .043                       | -.085*            | .040          |
| SEX      | .019                   | .041              | .026          | -.054                       | -.016             | -.048         |
| SES      | .141*                  | .177*             | .144*         | -.003                       | .088*             | .005          |
| $R^2$    | .206*                  | .151*             | .221*         | .469*                       | .060*             | .484*         |

Note. $M =$ mastery goals, $MS =$ mastery structures, $P =$ performance goals, $PS =$ performance structures. $p < .05$ for the F-test comparing if the prediction of the regression model is better than using the mean of the outcome.
significant slopes or curvatures. Apparently, students’ performance goals and perceived performance structure had low impact on their results.

**Mastery and performance goals and structures**

The complex model contained both mastery and performance goals, classroom structures, relevant interactions, quadratic terms, and control variables as predictors of test score. The explained variance was slightly higher than for the model with only mastery constructs, adjusted $R^2 = .208$, $F(10, 620) = 17.54, p < .001$. Figure 5 illustrates the complex regression model at different levels of performance goals and performance structures, while control variables are kept at their center values. Note that the range of test scores displayed in Figure 5 represents only the range predicted by the goals and goal structures in this study.

In this model, only mastery goals demonstrated a significant, positive, main effect (Table 2), although a weak
The positive effect of mastery structures can be seen in Figure 5. In contrast to Figure 3, mastery structures do not show a nonlinear trend in Figure 5, but the effect of mastery goals seems to increase in an exponential fashion. However, although relatively high, the quadratic mastery goal coefficient was not significant (Table 2). Furthermore, surface values did not indicate any significant curvatures. Neither were the slopes significant, other than at low performance goals (i.e., the three leftmost plots in Figure 5).

The regression coefficient for the interaction between mastery and performance goals was significantly negative (Table 2). This is illustrated in Figure 5 by the decrease in the positive slope along the mastery goal axis as endorsement of performance goals move from low to center to high. To a lesser degree, the same was true when perceived performance structures increased, but the interaction between mastery goals and performance structures was non-significant. Thus, mastery goals had its strongest effect on test score when both performance goals and performance structures were low (see lower left response surface of Figure 5).

**Prediction of autonomous motivation**

**Mastery goals and structures**

Students’ mastery goals and mastery structures, together with interactions and quadratic terms, explained a large proportion of the variance in students’ autonomous motivation, adjusted $R^2 = .461$, $F(8, 594) = 65.45$, $p < .001$. Only the main effects of mastery goals ($\beta = .668, p < .001$) and of mastery structure ($\beta = .071, p = .035$) were significant at $\alpha = .05$ (see Table 2), which is reflected in the flat, slanted response surface in Figure 6. Surface values confirmed that the surface had no significant curvatures.

As the slope along the mastery goal axis differs slightly with the level of mastery structures, the positive effect of increasing mastery goals was more pronounced for students that perceived strong mastery structures than for students that perceived weak. Overall, the influence of mastery goals was considerably stronger than that of mastery structures, further confirmed by a significant positive slope along the line of incongruence, $t(616) = 11.61$, $p < .001$.

**Performance goals and structures**

The regression model with performance structures, performance goals, quadratic terms, and interactions also predicted a significant portion of the variance in autonomous motivation, adjusted $R^2 = .048$, $F(8, 594) = 4.76$, $p < .001$. However, the explained variance was much smaller than in the mastery goal counterparts. Except for control variables, only the regression coefficient of performance goals was significant (Table 2), but even that influence was weak, as illustrated by the flat surface in Figure 7.

**Mastery and performance goals and structures**

The complex mastery, performance, and control variable model predicted autonomous motivation well, adjusted $R^2 = .473$, $F(12, 590) = 46.12$, $p < .001$, but only slightly better than the mastery goal model. The regression coefficients (Table 2) and Figure 8 show that mastery goals were positively related to autonomous motivation. Mastery structures also had a positive effect on autonomous motivation, but the effect was weak and only discernible at high levels of mastery goals. Analogous to the prediction of test scores,
there was a significant negative interaction between mastery goals and performance goals ($\beta = -0.119$, $p = .012$). Thus, performance goals mitigated the effects of mastery goals on autonomous motivation.

Although the surfaces appear linear in Figure 8, and no individual quadratic coefficient were significant (Table 2), surface values indicated small but significant positive curvatures along the lines of congruence and of incongruence.

**Discussion**

In this paper, we set out to add to the largely neglected area of interaction between achievement goals and goal structures, and to extend the previous research by including nonlinear relations in the analyses. There were no indications of a ridge parallel to the line of congruence (which would have indicated an optimal effect for all situations when the value of the goal matched the value of the structure) in any of our
response surfaces. Thus, we saw little support for a general match hypothesis. Neither did we find any statistically significant interaction coefficients between achievement goals and goal structures. These results, together with weak evidence in previous studies (see the section Interaction effects above), speak against the hypothesis that achievement goals are most beneficial in a matching environment (cf. Linnenbrink & Pintrich, 2001). However, there were indications that strong mastery structures strengthened the effect of mastery goals on autonomous motivation (Figure 8), and that a strong performance structure weakened the effect of mastery goals on test score (Figure 5). The first case indicates that a match between goal structure and achievement goal accentuated the basic, beneficial, pattern of mastery goals. Nevertheless, this does not support a general match hypothesis, which would result in positive effects at all points where mastery goals and structures take on similar values, not only at strong mastery structures. The second case indicates a vitiation effect as the mismatch between goal and goal structure reduced the positive influence of mastery goals. However, none of these effects was strong enough to yield significant regression coefficients, possibly because the match/mismatch effect only was prominent at high levels of mastery/performance goals. Overall, the interaction between mastery and performance goals had a stronger effect on both outcomes than interactions between goals and structures (Table 2, Figure 5, and Figure 8). Thus, the combination of personal achievement goals that students pursue seems more important than the combination of goals and classroom goal structures for students’ school achievement and perceived autonomy.

As to the nonlinearity that previous studies have ignored, there were no significant quadratic terms in any of the regressions. Nevertheless, the response surfaces demonstrate nonlinear tendencies, primarily in the prediction of test score (Figure 3 and 5). Surface values also indicated significant curvatures in the prediction of autonomous motivation. It may therefore be too early to abandon the exploration of such effects completely.

**Test achievement**

A combination of high mastery goals, low performance goals, and a weak perceived performance structure was particularly beneficial for students’ achievement on the chemistry test. Interestingly, increasing performance goals (i.e., going from left to right in Figure 5) seemed to counteract the negative effect of low mastery goals. That is, students who were low in both mastery goals and performance goals had lower scores on the chemistry test than students with low mastery goals and high performance goals. However, strong performance goals also reduced the beneficial effects of mastery goals. Hence, having strong performance goals was better than not pursuing any goals, but less beneficial than average levels of mastery goals. Increasingly strong classroom performance structures (going from bottom to top in Figure 5) did not show the same compensatory effects on students with low levels of mastery goals as performance goals did and were detrimental for students with strong mastery goals (a vitiation effect). Thus, performance goals can have positive effects when students lack mastery goals, but performance structures seem to be exclusively detrimental for the development of conceptual understanding in chemistry. These results also show that researchers need to account for both classroom goal structures and “competing” achievement goals when assessing the relative merits of students’ personal achievement goals for academic achievement.

**Autonomous motivation**

In line with previous research, mastery goal endorsement was a strong positive predictor of autonomous motivation. In contrast, performance goals only had a weak main effect that became nonsignificant when we added mastery goals to the regression. However, similar to the prediction of test results, performance goals did play an important role in the bigger picture of the relationship between goals, structures and autonomous motivation. The coefficient for the interaction between performance and mastery goals indicates an overall negative influence of performance goals on the effects of mastery goals (Table 2). However, the response surface in Figure 8 indicates that while performance goals weakened the beneficial effect of mastery goals for students high in mastery goals, they were beneficial for autonomous motivation for students with low mastery goals. The negative effects only occur when both performance and mastery goals are present, and the negative effect of performance goals is the same for all levels of classroom mastery structures. Therefore, it is unlikely that the negative pattern is due to a mismatch between performance goals and mastery structures, or due to performance goals disrupting the match effect between mastery goals and mastery structures. Instead, this is an example of an interaction between the goals themselves. This result challenges previous ideas that a mixture of performance and mastery goals would be optimal for learning in school (cf. Lau & Lee, 2008; Pintrich, 2000) and favors consistency in teachers’ communication of classroom goal structures to exclusively foster mastery goals.

Mastery structures themselves showed an overall significant positive relationship with student autonomous motivation (Table 2), corroborating previous studies (e.g., Murayama & Elliot, 2009; Skaalvik et al., 2017; Skaalvik & Skaalvik, 2013). However, despite the coefficient indicating a direct and independent effect of mastery structures on students’ autonomous motivation (Table 2), the response surface in Figure 8 indicates that mainly students with strong mastery goals benefit from mastery structures. Thus, it seems that mastery structures are not able to generate effects on students’ autonomous motivation “on their own” but require high enough levels of matching achievement goals (i.e., mastery).

**The most beneficial goals?**

Overall, our results point out mastery goals as adaptive for both motivation and test performance, while neither
performance goals nor any goal structures were as important in the prediction of the outcomes. However, our results indicate that this view on the relation between goals, structures, and outcomes might be too simplistic. For example, for students with strong performance goals, higher mastery goals do not necessarily relate to higher test scores or autonomous motivation. Consequently, formulating a general rule for the goals’ effect means over-reducing the complexity of the situation and may not apply to all students and all situations. Still, high endorsement of mastery goals and low endorsement of performance goals showed the most adaptive pattern of outcomes in this study.

**The most beneficial structures?**

In the prediction of test score by only mastery goals, mastery structures, and control variables, moderate mastery structures were slightly more beneficial than weak or strong mastery structures when paired with high mastery goal endorsement. However, that nonlinear trend was not evident when performance constructs were added to the model. Except for this weak effect, we did not find indications that strong mastery structures were detrimental to students’ test performance or autonomous motivation, even when it mismatched the students’ achievement goals. In contrast, performance structures seemed to vitiate the positive effects of mastery goals (Figure 5).

Despite relatively weak support for the direct effect of mastery structures, it is important to remember that goal structures can play an important role as antecedents of achievement goals (Bardach et al., 2019). Hence, all students should benefit from a mastery supporting environment that can, in some cases, lead to better performance but, above all, shift students’ goals toward a higher mastery goal endorsement and thus a more adaptive motivational profile.

**Limitations**

In this study, we have focused on individual-level goal structures rather than classroom-level. Although this is preferable to better understand how the environment influences each students’ motivation and performance, it makes it more difficult to make recommendations on classroom-level based on our results (Lüdtke et al., 2009). We assume that the measured goal structures represent subjective perceptions of each student, relatively independent of the objectively observable classroom environment that the teachers construct. Furthermore, we assume that it is this perceived structure which in turn affect students’ cognitive, behavioral, and affective outcomes. Hence, the link from our results to possible development of the teachers’ practice in the classroom is weakened. Still, research has shown that instructional approaches based on frameworks like TARGET increase the probability that students adopt mastery goals (Lüftenegger et al., 2014), despite individual differences in students’ perceptions of the learning environment.

Earlier research has shown differential correlations for performance-avoidance and performance-approach goals with intrinsic motivation (e.g., Elliot & Harackiewicz, 1996). It is possible that the comparatively low effect of our combined performance goal measure is a result of positive and negative effects canceling each other. Still, approach and avoidance goals could not be structurally separated in this sample, so it is possible that the muddled effect is not a limitation of this study, but a characteristic of the students in our sample.

An issue related to the wide span of grades included in this study is that the predictive patterns may vary over grades, despite the goal models being invariant. For example, Linnenbrink-Garcia et al. (2008) found that mastery goals are more beneficial for achievement for younger students than for older, and Givens Rolland (2012) meta-analysis showed similar results for mastery structures. We do not investigate such variations in the present study.

**Implications and directions for future research**

On a methodological note, we saw that reliance on only linear regression coefficients may be misleading. In our case, the interaction coefficient underestimated both the negative influence of performance goals on students with strong mastery goals and the positive influence on students with low mastery goals. In addition, the interaction between mastery goal structures and mastery goals was not significant in the regression coefficients, possibly because the interaction effect was not equal at all levels of students’ mastery goals. Hence, the use of response surfaces or similar methods to reveal nuances that might be hidden in individual regression coefficients is warranted, especially in more complex and logically valid regression models.

It is possible that interactions and nonlinear effects are present in individual grades within our sample and that such effects have been canceled out, or obscured, when all grades are combined. Thus, differences in predictive patterns between age groups should be explored.

**Conclusions**

To summarize, this study has expanded the current knowledge about the interplay between achievement goals and goal structures. Despite including nonlinear terms, allowing us to detect interactions not examined in previous studies, and accounting for the existence of mastery goals and structures in parallel with performance goals and structures, we see little support for a general match hypothesis. Instead, we found that match effects between mastery goals and goal structures seem to increase with increasing levels of mastery goals. For educational practice, our study lends additional support to the beneficial effects of mastery goals, and the detrimental effects of performance goals (comprising both the standard and standpoint components) and performance structures, for high achievement and autonomous motivation in chemistry. As mastery structures are related to the adoption of mastery goals (Bardach et al., 2019), emphasizing mastery goals in the classroom still seems to be a viable way to improve students’ autonomous motivation and learning. However, students may be less sensitive to an
environment that does not match their personal achievement goals than previously assumed.

Notes

1. Based on zero-order correlations, the relevant interactions were those between mastery goals and performance goals and between mastery goals and performance structures, and the only relevant quadratic term was that of the mastery goals.

2. Based on zero-order correlations, the relevant interactions were those between mastery goals and mastery structures, between mastery goals and performance goals, and between mastery goals and performance structures. Both the quadratic terms of mastery goals and of performance goals were also included.

Declaration of interest

None of the authors have conflicts of interest to declare.

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Appendix A

Items used to measure achievement goals, perceived goal structures, and autonomous motivation.

| Subscale                     | Item                                                                                                                                                                                                 |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mastery-approach             | It is important for me to understand chemistry as well as possible. I strive to develop a broad and deep knowledge in chemistry. My goal is to learn as much as possible in chemistry.                                |
| Performance-approach         | In chemistry, I want to learn things, even if they are not assessed on tests or affect my grades. In chemistry it is important for me to perform better on tests than the other students.                           |
| Performance-avoidance       | In chemistry my goal is to perform better than other students. One of my goals is to show others that I am good at chemistry. It is important to me that I look smart compared to others in my class.               |
|                              | My goal is to avoid doing worse in chemistry than other students. In chemistry, it is important for me to not perform worse than other students on tests. In chemistry, it is important to me that I don’t look stupid. One of my goals in class is to avoid to show that I have trouble understanding |

Table A1. Achievement goal items.

Shanock, L. R., Baran, B. E., Gentry, W. A., Pattison, S. C., & Heggestad, E. D. (2014). Erratum to: Polynomial regression with response surface analysis: A powerful approach for examining moderation and overcoming limitations of difference scores. Journal of Business and Psychology, 29(1), 161–161. https://doi.org/10.1007/s10869-013-9317-6

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Table A2. Goal structure items.

| Subscale                      | Item                                                                 |
|-------------------------------|----------------------------------------------------------------------|
| Mastery structure             | My teacher makes a special effort to recognize my individual progress. |
|                               | My teacher considers how much I have improved when we talk about how I am doing in chemistry. |
|                               | My teacher gives a wide range of assignments, matched to my needs and skill level. |
|                               | My teacher wants me to understand my work, not just memorize it.       |
| Performance structure         | My chemistry teacher gives advantages to students who do the best work. |
|                               | My teacher wants me to understand my work, not just memorize it.       |
|                               | My teacher encourages students to compete with each other.             |

Table A3. Autonomous motivation items.

| Subscale                      | Item                                                                 |
|-------------------------------|----------------------------------------------------------------------|
| Stem: When I work with the tasks I get during chemistry class, I do it because ... | Intrinsic motivation It is fun It enjoy it |
|                               | Identified motivation I want to learn new things It is important for me |
| Stem: When I try to do well during the lessons in chemistry, I do it because ...   | Intrinsic motivation I enjoy doing my schoolwork in chemistry in a good way. It is important to me to try to do well in chemistry. |

Appendix B

Calculating surface values and corresponding significance tests.

Calculations of surface values were based on formulas described by Shanock et al. (2010), and the corrections made in Shanock et al. (2014). For the simple regressions, with only mastery or performance constructs, the regression equations follow the general form:

\[ Z = b_0 + b_1 X + b_2 Y + b_3 X^2 + b_4 XY + b_5 Y^2 + e \]

Where X represents the achievement goal (e.g., mastery goals) and Y the goal structure (e.g., mastery structure). Formulas for the relevant linear combinations of coefficients are found in Table B1. Control variables (grade, sex, and SES) are left out because they do not affect the slopes or curvatures, only the intercept of the response surfaces.

For the complex models, including both mastery and performance constructs, formulas are a bit more complicated. The principle can be described by applying it to the following, hypothetical, regression equation:

\[ Z = b_0 + b_1 X + b_2 Y + b_3 X^2 + b_4 XY + b_5 Y^2 + b_6 W \]

Where X represents the achievement goal (e.g., mastery goals) and Y the goal structure (e.g., mastery structure) and W represent a covariate (e.g., performance goals). For this equation, \( a_1 \) and \( a_3 \) are identical to the ones in Table B1. However, \( a_2 \) and \( a_4 \) are calculated according to Table B2, given that W is set to a constant value.

Table B1. Description of surface values for a response surface with two predictors, their quadratic terms, and their interaction.

| Surface value | Formula | Meaning                                      | Equation for significance test |
|---------------|---------|----------------------------------------------|-------------------------------|
| \( a_1 \)     | \( b_1 + b_2 \) | The slope along the line of perfect agreement | \( t = \frac{a_1}{SE_{a_1}} \) |
| \( a_2 \)     | \( b_3 + b_4 + b_5 \) | The curvature along the line of perfect agreement | \( t = \frac{a_2}{SE_{a_2}} \) |
| \( a_3 \)     | \( b_1 - b_2 \) | The slope along the line of disagreement | \( t = \frac{a_3}{SE_{a_3}} \) |
| \( a_4 \)     | \( b_3 - b_4 + b_5 \) | The curvature along the line of disagreement | \( t = \frac{a_4}{SE_{a_4}} \) |

Note. SE = standard error and cov = covariance.

Table B2. Description of surface values for a response surface with two predictors, their quadratic terms, their interaction, and an interaction between one predictor and a control variable.

| Surface value | Formula | Meaning                                      | Equation for significance test |
|---------------|---------|----------------------------------------------|-------------------------------|
| \( a_1 \)     | \( b_1 + b_2 + b_3 W \) | The slope along the line of perfect agreement | \( t = \frac{a_1}{SE_{a_1}} \) |
| \( a_3 \)     | \( b_1 - b_2 + b_3 W \) | The slope along the line of disagreement | \( t = \frac{a_3}{SE_{a_3}} \) |

Note. SE = standard error and cov = covariance.