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Research article

Temporal dynamics of classroom goal structures in solo- and co-taught mathematics classes

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Abstract: While students' perceptions of classroom goal structure play a key role in student motivation, little is known about how these perceptions change over time, and whether they are influenced by different teaching practices. This study investigated the temporal dynamics of mathematics classroom goal structures over the course of a school year and, importantly, whether these changes were predicted by teaching condition (co-teaching versus solo-teaching). Classroom goal structures were assessed using student surveys administered at the beginning and end of the school year. The co-teaching condition included 70 sixth-grade students in three classes, where mathematics was co-taught by pairs of class teachers and special education teachers. The solo-teaching condition included 76 students in four classes, taught by class teachers. A series of latent change score models demonstrated a concurrent decline in students' perceptions of classroom performance-approach and -avoidance goal structures. Compared to the solo-taught students, co-taught students' initial perceptions of mastery goal structures were lower, but the change over time seemed more positive. Overall, these findings shed light on the temporal dynamics of classroom goal structures and demonstrate the potential positive effect of co-teaching on students' perceptions of the mastery goal structure in mathematics.

Keywords:
mathematics motivation,
classroom goal structures,
co-teaching,
mathematics teaching

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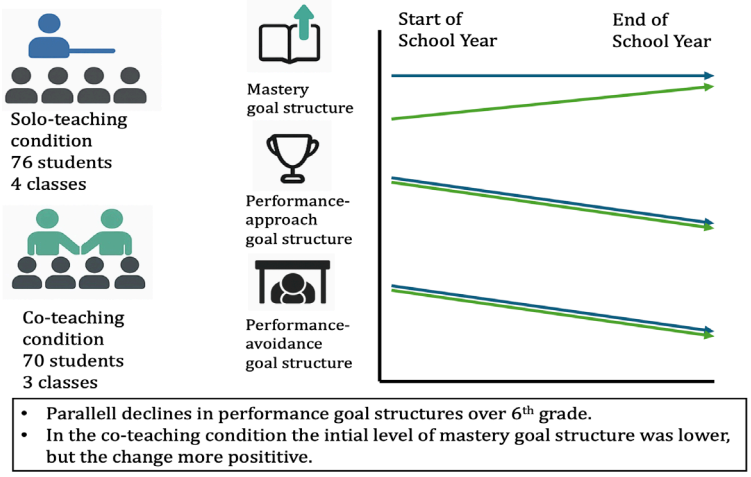

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1 Introduction

"*If men define situations as real, they are real in their consequences*" (Thomas & Thomas, 1928, p. 572).

Students' motivation and behavior are shaped by their subjective perceptions of the classroom motivational climate (Bardach et al., 2020; Midgley et al., 2002). Achievement goal theory provides a framework for understanding classroom climate through the concept of goal structures (Ames, 1992; Midgley et al., 2002), where teachers play a key role by emphasizing learning and effort or focusing on competition and relative ability in their classrooms (e.g., Daumiller et al., 2022; Patrick & Kaplan, 2022; Turner & Meyer, 2004). This may be particularly interesting and relevant in mathematics: a subject characterized by relatively high cognitive demands, an emphasis on correctness and speed, a common framing as a domain of innate ability, and mostly cumulative structure (e.g., Chestnut et al., 2018; Middleton & Spanias, 1999; Urdan, 2010). These features can make student performance highly visible and subject to peer comparison, which may contribute to a classroom goal structure that emphasizes performance over mastery. However, despite a relatively rich body of research on students' perceptions of classroom goal structures, often using these perceptions as predictors (e.g., Madjar et al., 2017; Won et al., 2020), surprisingly little is known about how these perceptions change over time and how these changes are mutually related (Bardach et al., 2020; Urdan, 2010). Additionally, there is a gap in research examining how different teaching practices, such as co-teaching, can shape them.

Co-teaching has been proposed as a method to enhance instructional quality and teacher responsiveness (Friend & Cook, 2013; Villa et al., 2008), which could be particularly pertinent in shaping classroom goal structures. For instance, by facilitating more individualized feedback and differentiating instruction based on students' needs, co-teaching may allow teachers to emphasize personal growth and effort over competition, thereby diminishing the importance of ability-related comparisons. Despite these potential benefits, however, there is lack of empirical evidence on how co-teaching can contribute to students' perceptions of the classroom motivational climate in mathematics. This gap is especially important given that co-teaching is resource intensive and that teachers' practices are theoretically central in shaping goal structures (e.g., Ames, 1992; Anderman & Patrick, 2012). Without clearer evidence of its impact on student outcomes, it is difficult to justify its use as an instructional practice, particularly given the substantial resources it requires. Attending to students' perspectives is therefore essential for clarifying how instructional approaches such as co-teaching shape mathematics motivation and learning.

To address these gaps in research, this study examined the changes in classroom goal structures in Finnish sixth-grade mathematics classes, and, using a natural experimental design, whether these changes differed between two instructional conditions: solo-teaching and co-teaching.

1.1 Classroom goal structures

Classroom goal structures refer to the way certain achievement-related goals are emphasized over others within an educational environment (Urdan, 2010). While peers and classroom context also play a role, they are predominantly shaped by teachers' instructional practices and communication (Anderman & Patrick, 2012; Bardach et al., 2020; Iaconelli & Anderman, 2021). Within the framework of achievement goal theory, classroom goal structures are typically evaluated through student perceptions obtained via self-report surveys (e.g., Bardach et al., 2020), and categorized as classroom mastery goal and performance goal structures, with the latter often further divided into performance-approach and performance-avoidance dimensions (Bardach et al., 2020; Midgley et al., 2002; Urdan, 2010). Both mastery and performance-approach goal structures reflect an environment that emphasizes the value and importance of learning and achievement, but the underlying reasons are different. While the former underscores the importance of skill development, understanding, and effort, performance-approach goal structure highlights the importance of demonstration of competence (Ames, 1992; Midgley et al., 2000). In contrast, performance-avoidance goal structure reflects an environment where the emphasis is on avoiding the demonstration of incompetence (Midgley et al., 2000).

Although distinct and in some cases even opposite to each other, classroom goal structures are also overlapping and complex (Bardach et al., 2020; Schwinger & Stiensmeier-Pelster, 2011). Not only do teachers' instructional practices and feedback vary from student to student (Brophy, 1983; Fraser & Tobin, 1991), but teachers may both intentionally and unintentionally convey elements of multiple goal structures simultaneously (Iaconelli & Anderman, 2021; Urdan, 2004). For instance, emphasizing the importance of effort and prioritizing learning, while publicly praising only high achievers or administering frequent timed tests, may prompt students to conclude that although effort is appreciated, learning is also about getting high grades or completing tasks quickly.

To illustrate the complexity further, students may perceive and interpret teachers' goal-related messages differently because they enter classrooms with pre-existing attitudes and motivational tendencies (e.g., Tapola & Niemivirta, 2008). For example, factors such as past experiences, achievement, and particularly individual goal orientations may influence these perceptions (Ames & Archer, 1988; Bardach et al., 2020; Niemivirta et al., 2019; Urdan, 2004; Wolters, 2004). However, rather than these factors being absolute determinants of classroom goal structures, different theoretical perspectives (e.g., Ames 1992; Bandura, 1997; Gurtner et al., 2001; Pekrun, 2023) suggest an interdependent relationship between them. For example, a competitive classroom environment may shape the way all students approach, engage in, and pursue their learning as they adapt to the classroom goal structure (e.g., Murayama & Elliot, 2009). Therefore, rather than representing an either-or dynamic, students' pre-existing motivation and classroom goal structures can be understood as mutually influential, bidirectional processes.

While there is a relatively rich body of research on classroom goal structures, investigations into their change and temporal dynamics are scarce. Exceptions to this include Bong (2005) and Turner et al. (2013), whose research, while not including all three goal structures and their mutual dynamics, regardless provide valuable insights into the change and malleability of mathematics classroom goal structures. Bong's findings indicated that Korean 10th-grade girls' perceptions of performance goal structures increased, while perceptions of mastery goal structures remained stable over the course of a school year. In contrast, Turner et al. (2013) reported a decrease in the mastery goal structure across sixth and seventh grades, although individual variability was observed in the changes, with some students even showing positive trajectories. Other longitudinal studies (Anderman & Midgley, 1997; Urdan & Midgley, 2003) suggest similar patterns of change, although their focus has been on examining changes that occur during school transitions (i.e., from primary to secondary school) rather than within-year changes. Also, given the relevance of teacher support for classroom goal structures, research suggests that students also perceive a decline in both teacher support and instructional quality over time (Lazarides et al., 2021; Reddy et al., 2003). Due to the lack of longitudinal studies, and the possibility of cultural differences and effects of age or gender, drawing definitive conclusions about these changes is difficult (see also, Urdan, 2010). The main aim of this study is to deepen the understanding of these changes and the ways in which they relate to a specific pedagogical approach in the domain of mathematics.

1.2 Aiming for classroom mastery goal structure

A body of evidence suggests that mastery goal structure is associated with a variety of outcomes (for a review see, Patrick & Kaplan, 2022). These include positive predictive effects on achievement (Lau & Nie, 2008), motivation (e.g., interest, self-efficacy, mastery goals) (Bardach et al., 2020; Carmichael et al., 2017; Lavasani et al., 2011; O'Keefe et al., 2013; Skaalvik et al., 2017) and learning-directed behavior (e.g., help-seeking, engagement) (Anderman & Patrick, 2012; Olivier et al., 2024). In contrast, classroom performance goal structures tend to exhibit an opposite, maladaptive pattern, including increased anxiety (Lavasani et al., 2011) and negative effects on motivation (e.g., interest and self-concept) (Murayma & Elliot, 2009) and behavior (e.g., less persistence and lack of effort) (Lau & Nie, 2008; Wolters, 2004). Thus, unsurprisingly, there seems to be a strong consensus among researchers that teachers should prioritize promoting learning, effort, and understanding rather than emphasizing ability-related comparisons among students.

Previous research has acknowledged several factors playing a role behind the different goal structures. The TARGET-framework is often discussed in the context of promoting mastery goal structure and downplaying the importance of performance goal structures (Ames & Archer, 1988; Epstein, 1989). It includes six dimensions: providing optimally challenging tasks, promoting student autonomy, recognizing student effort and improvement, encouraging cooperative learning, using multiple assessment methods, and providing sufficient time for learning (e.g., Fejes, 2023; Lüftenegger et al., 2017). In

addition, student-teacher relationships and emotional support have been found to be closely linked with students' perceptions of a mastery-focused environment (e.g., Patrick & Ryan, 2008; Turner et al., 2013). While these practices have been shown to be particularly relevant in promoting mastery goal structures (e.g., Daumiller et al., 2022; Porter et al., 2022), valid concerns have been raised about the feasibility of teachers realistically implementing them in real-world settings (Lüftenegger et al., 2014; Urdan & Schoenfelder, 2006). Teachers may struggle to provide differentiated tasks, individualized feedback, and scaffolded instruction due to time and resource constraints. However, co-teaching offers a unique collaborative approach to teaching that can enhance the feasibility of these practices and possibly impact how students perceive their classroom goal structures.

1.3 Co-teaching

Co-teaching refers to a collaborative effort of two or more educators, typically a special education teacher and a class teacher, who share all aspects of planning and teaching (Friend, 2008; Friend & Cook, 2013). Notably, co-teaching involves two educators working together in the same classroom, which provides the added benefit of a better teacher-student ratio compared to merging two classes into one (Friend et al., 2010; Sweigart & Landrum, 2015; Villa et al., 2008). This can enable the educators to provide instruction and support learning more effectively, by using adaptive grouping and scheduling methods, providing personalized instruction and feedback, and offering appropriately challenging assignments (e.g., Scruggs et al., 2007; Villa et al., 2008), thus potentially overcoming the challenges associated with implementing mastery practices and thereby also reducing the emphasis on ability-related comparisons.

One of the main strengths of co-teaching, and what distinguishes it from simply reducing class size, is the close collaboration between educators. By pooling different skills, engaging in reflective discourse both in- and out-of-class, and observing both students and colleagues, co-teachers can identify and develop better practices, and adopt more appropriate instructional strategies (see, Rytivaara et al., 2021; Strogilos et al, 2023). Importantly, these collaborative practices can also impact teaching proficiency (e.g., Brophy, 1983; Rytivaara & Kershner, 2012), and thus lead to further refinement of instructional practices to meet the needs of students better (e.g., Guskey, 2002). This may bolster both student motivation and the motivational climate of the classroom.

In addition, when co-teachers co-teach and engage in content discussions with their students, they can model collaboration and learning (Scruggs et al., 2007; Villa et al., 2008). By doing so, they can demonstrate that the process of problem solving and understanding is more valuable than simply getting the right answers. This may not only deepen understanding, but also foster a sense of teamwork and exploration, and most importantly, help emphasize learning, effort, and understanding, while downplaying the importance of comparing one’s performance with that of others (see, Turner et al., 2002).

While co-teaching shows promise, and students predominantly view it as a positive method of organizing teaching (Rönn-Liljenfeldt et al., 2023; Wilson & Michaels, 2006), there is still surprisingly limited empirical evidence on how its implementation is linked with various student outcomes, much of which focuses on students with special education needs (for reviews, see Cook et al., 2017; King-Sears et al., 2021; Strogilos et al., 2023). That is, despite these positive perceptions and potential benefits of co-teaching being well recognized, actual empirical support for its effectiveness in improving specific student outcomes is still sparse. Existing empirical evidence provides some support for increased teacher feedback and instruction (Sweigart & Landrum, 2015; Wilson & Michaels, 2006), as well as increased student-to-student and student-to-teacher interactions (Spörer et al., 2021). Interestingly, given that mastery goal structures are linked to student engagement (e.g., Anderman & Patrick, 2012; Wolters, 2004), the findings from both co-teaching (Lochner et al., 2019) and class-size reduction studies (Blatchford et al., 2011; Brühwiler & Blatchford, 2011) suggesting increased student engagement are particularly noteworthy. Considering these, it is intriguing to examine whether co-teaching can also contribute to students' perceptions of classroom goal structures.

2 Present study

Given the importance of students' perceptions of classroom goal structure for their motivation and behavior (Bardach et al., 2020; Kaplan et al., 2002a; Midgley & Urdan, 2001; Pekrun, 2023) – particularly in math given its distinctive nature – it is essential to understand the changes of these perceptions and, most importantly, how they are predicted by different teaching conditions: co-teaching and solo-teaching. While some research has focused on classroom-level examinations of goal structures, our interest lies specifically in how individual student's *subjective* perceptions and their experiences of classroom goal structures evolve over time (see, Urdan, 2010).

Accordingly, the present study aimed to examine how students' perceptions of classroom goal structures change over time and whether these changes are predicted by the teaching condition (co-teaching versus solo-teaching). To address this aim, the present study investigated following research questions:

> RQ1) How do students' perceptions of classroom goal structures change over a school year, and how are these changes connected with each other?

Drawing from prior research on classroom goal structures (Anderman & Midgley, 1997; Bong, 2005; Lazarides et al., 2021; Reddy et al., 2003; Turner et al., 2013; Urdan & Midgley, 2003) and given the task-intensive nature of mathematics, where students are more likely to make ability-related comparisons than in other subjects, (e.g., Urdan, 2010), we tentatively hypothesized that students' perceived importance of mastery goal structure would decrease over time, and the perceived importance of both performance (i.e., performance-approach and performance-avoidance) goal structures would increase

over time. While we assumed that the levels and the changes between classroom mastery goal structure and performance goal structures would be negatively associated, we expected a concurrent change between classroom performance goal structures (e.g., Bong, 2005). We also anticipated significant individual variability in both the initial levels and changes in each classroom goal structure (e.g., Olivier et al., 2024; Reddy et al., 2003; Turner et al., 2013).

> RQ2) How does teaching condition (co-teaching and solo-teaching) predict the onsets and changes of students' perceptions of classroom goal structures?

We assumed that the students in the co-teaching group would show more favorable changes in their perceptions of learning and effort (i.e., mastery goal structure), as well as a decrease in the salience of ability-related comparisons (i.e., performance goal structures) (see also, O'Keefe et al., 2013).

Considering previous research that has highlighted gender differences in students' mathematics motivation and also perceptions of classroom goal structures and teacher support (e.g., Michou et al., 2013; Olivier et al., 2024; Reddy et al., 2003; Wolters, 2004), we included gender as a covariate in our analyses.

3 Method

3.1 Design

In this study, we followed two teaching conditions in sixth grade mathematics for one school year. The co-teaching group comprised pairs of classroom teachers working with special education teachers. In contrast, the solo-teaching group had individual classroom teachers who taught mathematics, with some part-time special education support. This support is a standard practice in Finland, provided for about fifth of students (OSF, 2021), and aims to assist all those who have difficulties in any subject area, such as their mother tongue, a foreign language, or mathematics, without requiring any formal diagnoses.

The researchers conceptualized and designed the study, but the actual implementation was done in partnership with the participating schools and teachers. Recognizing that insufficient preparation can hinder co-teaching (e.g., Scruggs et al., 2007), an initial introductory session was held for the co-teachers before the co-teaching began. The aim of this session was to ensure alignment and consistency in co-teaching practices. This session covered essential characteristics of co-teaching, drawing on previous research and focusing on key aspects such as shared planning, instruction, and assessment (e.g., Friend, 2008; Friend et al., 2010; Friend & Cook, 2013; Scruggs et al., 2007; Villa et al., 2008). Following the recommendations of Fluijt et al. (2016; see also Murawski & Lochner, 2011, McTigue et al., 2022), the introduction highlighted active reflective practice as an integral part of co-teaching. Note that these sessions did not include information related to classroom goal structures.

Despite this preparatory phase, all teachers were free to plan and implement their lessons without researcher interference – a deliberate choice to capture the authentic dynamics of classroom teaching (see, Tunnell, 1977). Consistent with the principles outlined by Remler and Van Ryzin (2011), these features categorize our study as a natural experiment with quasi-experimental characteristics.

3.2 Participants and procedure

Participants were 146 sixth-graders and ten teachers from four elementary schools in a Finnish city. The co-teaching group included three classes with 70 students (47 girls and 23 boys), and class sizes ranging from 23 to 27. The solo-teaching group included four classes with 76 students (40 girls and 36 boys), and class sizes ranging from 21 to 23.

The teachers were first recruited to the co-teaching group and then to the solo-teaching group. To have some similarity in the pedagogical background, all participants had to have an MA in Education and a minimum of five years of teaching experience. To promote equitable partnerships based on shared educational goals and pedagogies (Friend, 2008; Scruggs et al., 2007), the teachers were given the freedom to choose their co-teaching partner.

Students completed surveys, first at the beginning of the school year in August 2019 (t1), and then again near the end of the semester in April 2020 (t2), shortly after schools had transitioned to online instruction due to the onset of the Covid-19 pandemic.

The teachers, students, and their guardians were fully informed about the study, and all signed a written consent that followed the ethical guidelines of the Finnish National Board on Research Integrity (2019), the University guidelines, and European Union GDPR requirements. In compliance with the Finnish National Board on Research Integrity guidelines (2019), no ethical review was required.

3.3 Measures of classroom goal structures

The scales for classroom goal structures were drawn from the *Manual for the Patterns of Adaptive Learning Scales* (Midgley et al., 2000). Although the manual distinguishes between a scale for perceptions of classroom goal structures (e.g., items starting with the stem “In our class…”) and perceptions of teacher’s goals (e.g., items starting with the stem “My teacher…”), they have often been used interchangeably to describe classroom goal structures (see, Fejes, 2023; Bardach et al., 2020). While correlated (see also, Turner et al., 2013), they show distinct patterns of association with personal achievement goals (Bardach et al., 2020). Although the original scale may reflect students’ personal goals more than the teacher-focused scale (e.g., Bardach et al., 2020; Koskey et al., 2010), we chose it for two reasons. First, the students do not have to make inferences on teachers' “wants and thinks” (Patrick & Ryan, 2008), which can be susceptible to teacher-student relationships (see, Turner et al., 2002). Second, we were not sure whether the teacher-focused scale in the co-teaching group would cause confusion, because students would

have to make inferences about two teachers.

Prior to data collection, the scale was first piloted, and the wording of the items was discussed with a small sample of students to identify any ambiguities. The items were then revised accordingly. Classroom mastery and performance-avoidance goal structures were assessed by four items and performance-approach goal structure by three items (for item wordings, see, Appendix). All measures demonstrated acceptable internal consistency (shown in Table 1). Students responded to the statements on a Likert-scale of 1 (*strongly disagree*) to 5 (*strongly agree*).

3.4 Fidelity

Several indirect measures (see, Carroll et al., 2007; Gresham et al., 2000) were used to assess and ensure the implementation fidelity of co- and solo-teaching. For the co-teachers, these included the aforementioned initial introductions, interviews on three occasions, and a weekly check-list diary. The diary comprised information on the co-teaching models used, whether all aspects of teaching were shared, how much time was spent on planning and reflection, and an evaluation of lesson success on a scale of 1 (*not at all satisfied*) to 5 (*very satisfied*).

The solo teachers had similar check-list diaries designed to investigate if they continued to work predominantly alone. The diaries included weekly hours of part-time special education support, whether it was in-class or pull-out (i.e., in a separate classroom), and who was involved in planning and evaluation of mathematics instruction.

These fidelity measures suggested that the co-teachers collaboratively planned, implemented, and assessed instruction as intended. Although co-teaching was implemented in about 70% of the mathematics lessons, substitute teachers were frequently used to maintain a higher teacher-student ratio throughout the year. Co-teachers spent about three-quarters of an hour each week planning and reflecting, and reported being very satisfied with their partnership and the progress they made during the year. While co-teachers were flexible in their use of different co-teaching models, alternating teaching and team teaching were most often applied. In alternating teaching, each teacher led portions of the lesson, whereas in team teaching instruction was shared throughout the lesson. These arrangements may have provided opportunities for greater differentiation and more immediate feedback, for instance, by allowing one teacher to offer clarification or individual support while the other continued with the lesson.

The solo teachers, in turn, reported that they were mainly responsible for planning and teaching their mathematics lessons. Special education was typically provided for approximately one hour per week, most often in pull-out sessions.

3.5 Analyses procedure

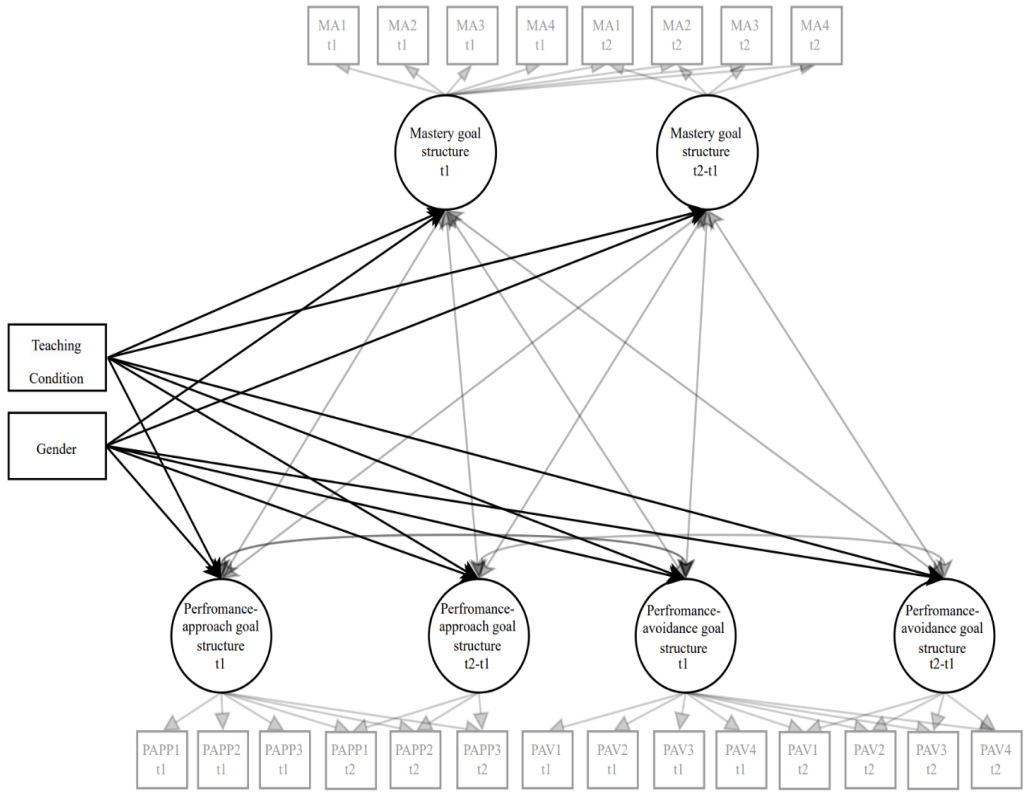
We used latent change score modeling (LCS) within the structural equation modeling framework to investigate our research questions. LCS is a useful method of investigating

change and identifying the dynamics between parallel processes over time (Ferrer & McArdle, 2010; Steyer et al., 2000).

To ensure that each measurement on each occasion reflected the same construct over time, a stepwise analysis procedure was used to test longitudinal measurement invariance (Widaman & Reise, 1997). We estimated a series of models with correlated residuals and with progressively more restrictive parameter constraints (configural, weak, strong, and strict; e.g., Widaman & Reise, 1997) and then compared the fit of each model to the preceding one. In determining the level of invariance, we followed the suggestions of Cheung and Rensvold (2002), who proposed that the invariance assumption holds if the change in CFI between the compared models is less than or equal to 0.01.

As a first step in our main analyses, we estimated a multivariate latent state model to investigate the mutual relationships between the classroom goal structures at different time points. Then, the latent state model was extended to a latent change score model (the latter factor now represents a latent change score between t2 and t1). This was done separately for each classroom goal structure to investigate the changes and the individual variability in them. Next, a multivariate parallel process change model was estimated to examine how the levels and the changes of classroom goal structures were related to each other. Following this, a conditional latent change score model with predictors (i.e., teaching condition and gender) was estimated, as shown in Figure 1.

Figure 1. Hypothetical latent change score model with predictors



Jamovi 2.3.18 software (the jamovi project, 2022) was used for descriptive statistics, manifest correlations, and confirmatory factor analyses. All other analyses were conducted using Mplus statistical software 8.6 (Muthén & Muthén, 2019). Intraclass correlations (ICCs) for the indicators ranged from .016 to .065, with the majority clearly below .05. This pattern was corroborated by design effects, which indicated only minor clustering across classes (i.e., mostly below the threshold of 2). Together, these results suggest that only a small fraction of the variance occurred between classrooms (6.5 % percent at most), with the vast majority attributable to differences between students. ML estimator was used, and missing data (only 2.7% at t2) were handled using full information maximum likelihood (FIML) estimation throughout the analyses (Little's MCAR test: χ^2 (32) = 27.328; p = .702).

4 Results

The comparison of the models (see, Appendix Table 1S) indicated strong (i.e., time-invariant factor loadings and item intercepts) measurement invariance over time, ensuring that the constructs were invariant over time. Note that the specification of strong measurement invariance was used in all of subsequent latent state and change models, as suggested by Steyer (2000).

Descriptive statistics, reliabilities (McDonald's omegas) and correlations are presented in Table 1. Overall, the means indicated that, on average, students reported a high level of mastery goal structure, with a moderate level of performance-approach goal structure, and a relatively low level of performance-avoidance structure throughout the school year.

The multivariate latent state model with strong invariance (i.e., time-invariant factor loadings and intercepts) fit the data well, $\chi^2(196) = 231.286$, p = .043, CFI = .977, RMSEA = .035 (90% CI: .007–.052), SRMR = .059. As shown in Table 2, the negative latent correlations between mastery and performance-avoidance classroom goal structures were moderate at each timepoint, while the association between mastery and performance-approach goal structures had a weak correlation only found at t1. The latent correlations between performance goal structures were strong at each respective measurement point. Strong rank-order stability was observed in all classroom goal structures (latent correlations ranging from .65 to .70).

The univariate change score model for mastery goal structure fitted the data well, $\chi2(21) = 23.30$, p = .328, CFI = .990, RMSEA = .027 (90% CI: .000–.077), SRMR = .050, and showed (see Fig. 2) students' perceived importance of showing effort and learning to be stable over time ($\Delta M = -0.01$, p = .924, S2 = 0.24, p < .001). The univariate models for both performance-approach goal structure, $\chi2(9) = 5.91$, p = .749, CFI = 1.000, RMSEA = .000 (90% CI: .000–.066), SRMR = .026, and performance-avoidance goal structure, $\chi2(20) = 29.205$, p = .084, CFI = .988, RMSEA = .056 (90% CI: .000–.097), SRMR = .048, also fit the data well. Surprisingly, the results showed both students' perceived

importance of demonstrating competence (ΔM = −0.28, p = .001, S2 = 0.63, p < .001), and avoiding the demonstration of incompetence (ΔM = −0.16, p = .045, S2 = 0.45, p < .001) to decline over time. The variances of all classroom goal structures were significant, pointing to significant individual differences in both the initial levels and changes over time.

Table 1. Descriptive statistics and correlations at t1 and t2

	Solo–teaching			Co–teaching			All students											
	M	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*Skewness*	*Kurtosis*	*ω*	1.	2.	3.	4.	5.	6.	7.
1.MA t1	4.40	0.51	76	4.19	0.56	70	4.30	0.54	−0.45	−0.62	.63	1.00						
2.MA t2	4.31	0.68	72	4.32	0.63	70	4.31	0.65	−1.36	3.57	.76	.46***	1.00					
3.PAPP t1	3.11	1.04	76	3.18	0.93	70	3.14	0.99	−0.28	−0.44	.83	−.12	−.05	1.00				
4.PAPP t2	2.77	1.07	72	2.96	1.06	70	2.86	1.06	0.03	−0.58	.84	−.22**	−.06	.55**	1.00			
5. PAV t1	1.93	1.05	76	1.98	0.82	70	1.95	0.94	0.99	0.43	.89	−.30***	−.27**	.55***	.36***	1.00		
6. PAV t2	1.71	0.90	72	1.85	0.93	70	1.78	0.92	1.23	0.84	.90	−.25**	−.41***	.39***	.49***	.63***	1.00	
7. Gender												.03	−.08	.17*	.12	−.02	−.01	1.00
8.Teaching condition												−.20*	.01	.03	.09	.03	.08	−.15†

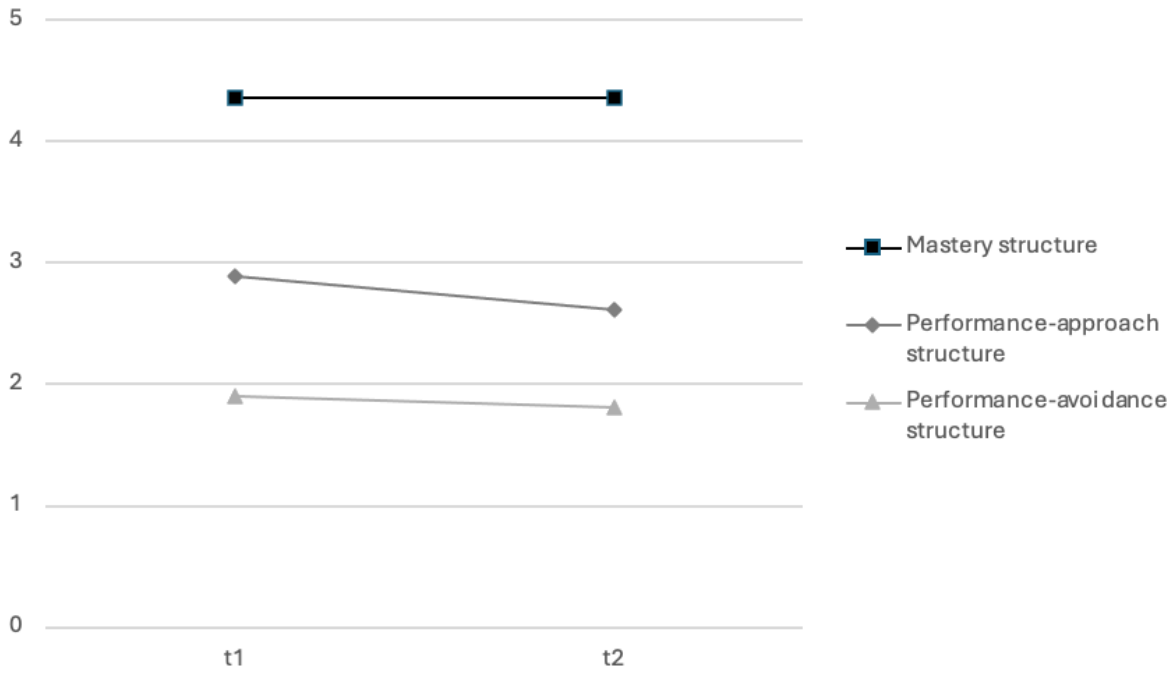
Note. MA = Mastery goal structure, PAPP = Performance-approach goal structure, PAV = Performance-avoidance goal structure;
Gender coding: 0 = girls, 1 = boys; Teaching condition coding: 0 = solo-teaching, 1 = co-teaching
† p < .10. * p < .05. ** p < .01. *** p < .001

Table 2. Descriptive statistics and latent correlations from the latent state model

Measure	*M*	S^2	1. MA t1	2. MA t2	3. PAPP t1	3. PAPP t2	5. PAV t1	6. PAV t2
1. MA t1	4.36	0.23***	1.00					
2. MA t2	4.36	0.40***	.65***	1.00				
3. PAPP t1	2.89	0.84***	-.15	-.05	1.00			
4. PAPP t2	2.61	0.99***	-.26*	-.03	.66***	1.00		
5. PAV t1	1.90	0.80***	-.43***	-.37***	.61***	.39***	1.00	
6. PAV t2	1.81	0.77***	-.35***	-.52***	.42***	.53***	.70***	1.00

Note. MA = Mastery goal structure, PAPP = Performance-approach goal structure, PAV = Performance-avoidance goal structure
† p < .10, * p < .05, ** p < .01, *** p < .001

Figure 2. Model estimated means of the trajectories of classroom goal structures



A multivariate latent change model was then estimated, and found to fit the data well, $\chi 2(198) = 233.569$, p = .042, CFI = .977, RMSEA = .035 (90% CI: .007–.052), SRMR = .061. The latent correlations (Table 3) showed the changes of mastery goal structure to be negatively associated with the changes in performance-avoidance goal structure (r = -.36, p = .008), meaning that students' perceived importance of showing effort and learning increased when their perceived importance of avoiding the demonstration of incompetence decreased, and vice versa. The changes of both performance classroom goal

structures showed a moderate correlation (r = .51, p < .001), indicating that students' perceived importance of demonstrating competence and avoiding the demonstration of incompetence declined concurrently.

Table 3. Descriptive statistics and latent correlations from the parallel processes model

Measure	MA t1	MA t2-t1	PAPP t1	PAPP t2-t1	PAV t1	PAV t2-t1
MA t1	1.00					
MA t2-t1	−.15	1.00				
PAPP t1	−.15	.08	1.00			
PAPP t2-t1	−.16	.20	−.33**	1.00		
PAV t1	−.43***	−.05	.61***	−.22*	1.00	
PAV t2-t1	.13	−.36**	−.26**	.51***	−.42***	1.00
Note. MA = Mastery goal structure, PAPP = Performance-approach goal structure, PAV = Performance-avoidance goal structure † p < .10, * p < .05, ** p < .01, *** p < .001						

Next, we included teaching condition (i.e., co-teaching and solo-teaching) and gender as predictors to our model, with a good model fit, $\chi^2(230) = 283.715$, $p = .009$, CFI = .965, RMSEA = .040 (90% CI: .021–.055), SRMR = .062. While the teaching condition was a negative predictor of the initial level of mastery goal structure ($\beta = -.48$, $p = .016$), it was found to predict change in mastery goal structure positively ($\beta = .41$, $p = .077$). This indicated that in the co-taught group, the initial level of mastery goal structure was lower, but the change over time was more positive. Gender predicted positively the initial level of performance-approach goal structure ($\beta = .43$, $p = .014$), suggesting that the demonstration of competence was perceived to be more important by boys.

Table 4. Predictive effects from the multivariate latent change model with predictors

	MA t1			PAPP t1			PAV t1			MA t2–t1			PAPP t2–t1			PAV t2–t1		
	β	*z*	*p*	*β*	*z*	*p*	*β*	*z*	*p*	*β*	*z*	*p*	*β*	*z*	*p*	*β*	*z*	*p*
Teaching condition	.48	2.40	.016	.13	0.72	.471	−.01	-.05	.960	.41	1.77	.077	.17	0.86	.391	.23	1.18	.238
Gender	-.03	-0.15	.884	.43	2.46	.014	-.04	0.24	.814	-.13	-.56	.577	-.20	-.95	.342	.04	0.20	.844
Note. MA = Mastery goal structure, PAPP = Performance-approach goal structure, PAV = Performance-avoidance goal structure; Gender coding: 0 = girls, 1 = boys; Teaching condition coding: 0 = solo-teaching, 1 = co-teaching																		

5 Discussion

The significance of research linking classroom goal structures with authentic school contexts has been underscored by Urdan and Kaplan (2020; see also, Anderman, 2020). Simultaneously, there is little empirical evidence on how co-teaching is related to student learning and motivation (e.g., Cook et al., 2017). In this study, we linked these two themes in a setting that mirrors real-life contexts, resulting in novel theoretical and practical insights. Specifically, we investigated how sixth-graders' perceptions of classroom goal structures changed over one school year in mathematics, how these changes were mutually related, and, most importantly, whether the changes varied between teaching conditions.

5.1 Changes in classroom goal structures

Regarding the initial levels and changes, and contrary to our predictions and previous studies (e.g., Bong, 2005; Lazarides et al., 2021; Turner et al., 2013), students' perceptions of mastery goal structure remained rather stable, while the perceptions of both performance goal structures showed an overall decline. That is, the perceived importance of ability-based comparisons became less important over time. This may be attributed to the fact that students have been in the same class with the same peers for several years. As a result, the novelty and significance of comparing abilities may diminish, leading to a reduced emphasis on such comparisons. What makes this intriguing is that previous research has shown an average decline in mathematics motivation (e.g., interest and self-concept) over time (e.g., Jacobs et al., 2002), but it appears that observed changes of classroom goal structures do not necessarily mirror these. In this context, the reduced emphasis on ability and competition in classrooms can be seen as reassuring, as these factors are often potential risks to students' motivation (e.g., self-efficacy, self-concept, and anxiety) (Arens et al., 2017; Bandura, 1997; Dijkstra et al., 2008; Pekrun, 2023; Skaalvik et al., 2017) and well-being (Tuominen et al., 2020).

The observed individual variability (see also, Turner et al., 2013) in all the levels and changes in classroom goal structures highlights that educators, in particular, might benefit from being aware of students' varying perceptions of these structures (see also, Olivier et al., 2024). This suggests that both awareness of and sensitivity to the instructional practices used are needed to reduce the salience of ability-related comparisons (i.e., performance goal structures) in the classroom further. Note that this sensitivity should also apply to mastery-related practices, as an overabundance of autonomy, for instance, can elicit negative emotions in some students (Tapola & Niemivirta, 2008).

5.2 Associations between changes in classroom goal structures

When we looked at how the changes in classroom goal structures were associated with each other, a pattern similar to the latent state model emerged, partially confirming our

hypothesis. Interestingly, only the changes in mastery and performance-avoidance goal structures were negatively associated: when the importance of showing effort and learning increased, the importance of not showing incompetence decreased, and vice versa. As expected, the changes in performance goal structures were strongly linked with each other: as the importance of showing competence declined, the importance of not showing incompetence decreased, and vice versa. These high associations between the classroom performance goal structures, both concurrently and longitudinally, may indeed suggest some overlap between these two dimensions (e.g., Michou et al., 2013; Urdan, 2004, 2010).

Given that students interpret classroom goal structures through their "motivational lenses" (e.g., Tapola & Niemivirta, 2008), one could argue that the same students who perceive the importance of demonstrating ability in the classroom may also perceive the importance of concealing their shortcomings (see also, Anderman & Patrick, 2012; Kaplan et al., 2002b; Olivier et al., 2024). On the other hand, the observed link between the changes in mastery and performance-avoidance goal structures (and gender), however, underscores divergences between the two performance goal structures (Kaplan et al., 2002b; Schwinger & Stiensmeier-Pelster, 2011). Again, this would seem particularly relevant for educators: encouraging effort, trying, and understanding in the classroom seems effective in downplaying students' perceived importance of avoiding to demonstrate incompetence.

5.3 Predictive role of teaching group

Regarding co-teaching, our results showed that the students' perceptions of mastery goal structure were lower in the co-taught group at the beginning of the school year, but the change over time was more positive. From a pedagogical perspective, this finding is encouraging with respect to the feasibility of co-teaching (e.g., Cook et al., 2017). Also, from a theoretical perspective, it suggests that students' perceptions of mastery goal structures can be fostered in authentic classroom settings (e.g., Robinson, 2023). This finding is all the more notable because the change in mastery goal structure appears to be more influential in motivating students than changes in performance goal structures (Ames & Archer, 1988; Bong, 2005; Urdan & Midgley, 2003). Overall, this finding highlights the potential of co-teaching as a promising instructional approach for cultivating students' perceptions of the importance of effort and learning for its own sake, thereby perhaps also fostering more adaptive motivational patterns.

Yet, the question remains as to what exactly drove this positive shift in mastery goal structure, as our design did not include direct observations or cross-validation measures (e.g., specific TARGET-dimensions: cf. Daumiller et al., 2022; Fejes, 2023; Lüftenegger et al., 2017; Tapola & Niemivirta, 2008). These limitations partly stem from the practical challenges associated with the labor-intensive nature of the study design. Based on previous research linking mastery goal structure to TARGET-practices and particularly to perceived teacher support (e.g., Daumiller et al., 2022; Iaconelli & Anderman, 2021; Patrick & Ryan, 2008; Turner et al., 2013), as well as association with engagement (e.g.,

Anderman & Patrick, 2012), it is possible that co-teaching, as we have outlined, may have played a key role in this positive change.

An alternative (or complementary) explanation is that the co-teachers' instructional practices remained relatively unchanged. Instead, there may have been a shift in co-teachers' motivation (see, Colson et al., 2021), professional development (Guskey, 2002), or enthusiasm towards teaching mathematics, which then had an impact on how the co-taught students perceived their classroom mastery goal structure. Lazarides et al. (2018; see also, Carmichael et al., 2017) found that when students perceived their teachers as enthusiastic, and when teachers themselves felt efficacious in class management, the students reported their classroom environment to be more focused on mastery. On the one hand, this explanation is supported by the lack of group differences in changes in performance goal structures. On the other hand, we still know little about how different teacher practices are specifically related to performance goal structures (Anderman & Patrick, 2012), nor do we know whether students' perceptions of these structures are as easily malleable in the first place.

6 Limitations and future directions

It is important to note, that the changes in classroom goal structures could also reflect aspects of pandemic-era schooling, given the timing of the post-measure. Nevertheless, Finnish teachers were relatively well-prepared for online teaching and the post-measure was collected very shortly after the transition to online schooling; the observed changes may not reflect the broader impacts of Covid-19. In this context, the cultural context in which this study was carried out should also be taken into consideration (see also, Skaalvik et al., 2017). Finnish teachers do not have stringent external demands such as standardized testing that can undermine mastery goal structures and promote performance goal structures (Urdan & Schoenfelder, 2006). With respect to the classroom context, although class-level differences likely exist, the relatively small intraclass correlations indicate that most variance occurred at the individual rather than the classroom level. This finding suggests that students' perceptions of classroom goal structures are largely individual and may reflect subjective interpretations, similar to constructs such as interest.

Given the differences in students' initial perceptions of mastery goal structures between the teaching conditions also warrant further consideration and limit the conclusion that co-teaching had the said effect. It is possible that the lower baseline in the co-taught group was due to factors such as differences in students' previous learning environment, or differences in student demographics or teacher motivation. This and a possible ceiling effect may have allowed for greater positive change over time. Although the improvement occurred in the co-taught context, the change may not have been unique to co-teaching. In other words, the improvement may have been driven by general aspects of a well-organized, supportive classroom environment or initial differences between the

conditions. Clearly, further research is needed to validate this or to see whether similar positive changes would occur with other teaching approaches.

Assuming this positive shift resulted from co-teaching, it is also important to note that the change did not stem from casual co-teaching, but from a continuous and deliberate approach, as suggested by the fidelity measures. While this highlights the importance of meticulous planning and preparation for successful co-teaching, it also underscores the costs involved, such as time and resources (e.g., Cook et al., 2017). Clearly, more research is needed on both fronts: exploring how co-teaching influences instructional practices and understanding the dynamics and malleability of performance classroom goal structures in this context.

Moreover, the quasi-experimental features of this study restrict causal inferences, as does its reliance on student perceptions, the relatively small sample size, and potential confounds arising from limited control variables for pre-existing group differences or unmeasured factors such as teachers' practices, professionalism or enthusiasm. Future research should try to triangulate findings by incorporating classroom observations and teacher reports alongside student perceptions. Such an approach would better address pre-existing group differences, account for the aforementioned factors, and enable a more detailed examination of instructional fidelity and quality, for example, to determine whether feedback or differentiation is indeed boosted. A larger sample would also enhance validity and enable the use of multilevel modeling. Nevertheless, it remains important to pursue ecologically valid experimental designs that integrate multiple data sources and, ideally, include direct intervention components to further advance research on co-teaching.

7 Conclusion

In summary, our study shows the importance of considering both classroom performance goal structures (Bardach et al., 2020; Schwinger & Stiensmeier-Pelster, 2011), as they may have varying associations with classroom mastery goal structure and gender. Although our findings contribute to an understanding of the classroom goal structures both concurrently and longitudinally, further research is needed not only to perfect instruments for measuring students' perceptions of classroom goal structures, but also to clarify theoretical underpinnings to resolve conceptual ambiguities, a step recently taken by Robinson (2023; see also, Olivier et al., 2024). Co-teaching seemed to be associated with a positive shift in how students perceived their classroom mastery goal structure in mathematics. While this finding is encouraging, the association should be understood as reflecting the relative influence of several contributing factors, rather than implying a causal effect of co-teaching. Nevertheless, fostering these perceptions not only relates to the perceived importance of performance-avoidance goal structure, increased student motivation (e.g., Fast et al., 2010; O'Keefe et al., 2013), and learning-directed behavior (e.g., Kaplan et al., 2002a; Porter et al., 2022), but, most importantly, also aligns well with the educational

ethos of instilling in students a sense of the value of learning, understanding, and effort.

Research ethics

Author contributions

Lehikoinen: Conceptualization; Funding acquisition; Investigation; Methodology; Formal Analysis; Writing – original draft.

Tuominen: Supervision; Writing – review and editing.

Viljaranta: Supervision; Writing – review and editing.

Väisänen: Supervision; Conceptualization; Writing – review and editing.

Niemivirta: Methodology; Supervision; Formal Analysis; Writing – review and editing

All authors have read and agreed to the published version of the manuscript.

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Institutional review board statement

The ethical principles of research provided by the Finnish National Board on Research Integrity (TENK) have been followed throughout the study.

Informed consent statement

Informed consent was obtained from all research participants. Permission from guardians was obtained to involve children in the study.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request within the EU

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Conflicts of interest

The authors declare no conflicts of interest.

Appendix A

Items Used in the Study to Assess Classroom Goal Structures

Classroom Mastery Goal Structure
1. In our math class, trying hard is very important.
2. In our math class, it's important to understand the work, not just memorize it.
3. In our math class, learning new ideas and concepts is very important.
4. In our math class, it's OK to make mistakes as long as you are learning.

Classroom Performance-Approach Goal Structure
1. In our math class, getting good grades is the main goal.
2. In our math class, getting the right answers is very important.
3. In our math class, it's important to get high scores on tests.

Classroom Performance-Avoidance Goal Structure
1. In our math class, it's important that you don't make mistakes in front of everyone.
2. In our math class, it's important not to do worse than other students.
3. In our math class, it's very important not to look dumb.
4. In our math class, one of the main goals is to avoid looking like you can't do the work.

TABLE 1S. Measurement Invariance

Model	χ^2	*df*	*CFI*	*RMSEA*	*SRMR*	*Δdf*	*△χ2*	*△CFI*	*△RMSEA*	*△SRMR*
Configural	218.926*	183	0.976	.037	.056					
Weak	223.294	191	0.979	.034	.059	8	4.368	.003	−.003	.003
Strong	231.286*	196	0.977	.035	.059	5	7.992	−.002	.001	.000
Strict	264.214**	207	0.962	.044	.090	11	32.928*	−.015	.009	.031

Note *$p < .05$ ** $< .01$

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