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Motivation belief profiles in science: Links to classroom goal structures and achievement

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ABSTRACT

Using a person-centered approach, this study examined science motivation belief (achievement goals and self-efficacy) profiles among middle school students ($N = 1443$). Three profiles were identified across grades: *confidently mastery*, *high all*, and *low confidence/low mastery*. For grades 6 ($n = 520$) and 7 ($n = 307$), a fourth profile, *indifferent*, and for grade 8 ($n = 613$), two new profiles, *low all* and *performance-driven*, were identified at the end of the school year. Results from latent transition analyses showed relatively stable profile membership; 42–89% of students remained in the same profile between time points. Classroom goal structures predicted profile membership and were aligned to students' personal goal endorsements. Evidence was also found for the association between profile and science achievement. *Confidently mastery* students demonstrated the highest science achievement, whereas performance was lower for all other profiles, with *low confidence/low mastery* students generally demonstrating the lowest science achievement.

1. Introduction

Students' motivation towards academic goals (i.e., achievement goals) and beliefs in their ability to successfully complete tasks in school (i.e., self-efficacy) are fundamental to their science achievement (Cerasoli, Nicklin, & Ford, 2014; Usher & Pajares, 2006; Valentine, Dubois, & Cooper, 2004). Increasingly, scholars are calling for a deeper examination of students' achievement goal orientation and self-efficacy in science classrooms, by exploring how these forms of motivation co-exist within individuals. Person-centered approaches are well-suited for this line of inquiry, as they allow for the identification of subgroups of individuals characterized by distinct configurations of motivation factors and self-efficacy beliefs (Marsh, Lüdtke, Trautwein, & Morin, 2009). Findings from existing person-centered studies indicate that students endorse distinct combinations of achievement goals (see Wormington & Linnenbrink-Garcia, 2017 for review), and few studies have examined related profiles of students' self-efficacy beliefs (e.g., Chen, 2012; Conley, 2012; Roeser, Strobel, & Quihuis, 2002). Different student profiles that reflect unique combinations of achievement goals and/or self-efficacy have direct implications for learning behaviors and academic outcomes (e.g., Chen, 2012; Conley, 2012; Lo, Chen, & Lin, 2017; Mar Ferradás, Freire, & Núñez, 2017; Schwinger & Wild, 2012). However, the small body of literature on motivation profiles in science, technology, engineering, and mathematics (STEM) fields among middle school students are primarily focused on math (e.g., Lo et al., 2017; Luo, Paris, Hogan, & Luo, 2011; Schwinger & Wild, 2012). Exceptions include studies in middle school science (e.g., Chen, 2012; Chen & Usher, 2013; Roeser et al., 2002); however, these studies examined profiles in regards to implicit theories, epistemic beliefs, distress, and/or sources of self-efficacy. Thus, the present study adds to the existing body of literature by using latent profile analysis (LPA) to examine the co-occurrence of achievement goals and self-efficacy beliefs among diverse middle school students in science (referred hereafter as 'motivation belief' profiles).

Additionally, examining the longitudinal stability of motivation belief profiles is needed to inform efforts aimed to support persistence in STEM, particularly among students who traditionally opt out of advanced studies in these fields (Morgan, Farkas, Hillemeier, & Maczuga, 2016; Quinn & Cooc, 2015). Middle school is an important period to examine, as significant drops in students' science motivation, interest, and achievement have been documented during this time (Anderman, Maehr, & Midgley, 1999; Britner & Pajares, 2006; Shim, Ryan, & Anderson, 2008; Wang & Holcombe, 2010). Findings from recent studies examining the stability of students' motivation profiles are mixed (e.g., Gillet, Morin, & Reeve, 2017; Gonçalves, Niemivirta, & Lemos, 2017; Jansen In De Wal, Hornstra, Prins, Peetsma, & Van Der Veen, 2016; Lee, Wormington, Linnenbrink-Garcia, & Roseth, 2017; Lo et al., 2017; Shim & Finch, 2014) and no study to date has examined the

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stability of motivation belief profiles among middle school students in science. By applying latent transition analysis (LTA), we address this gap to provide a more detailed account of the potential shifts in students' profile membership over the school year.

Finally, no study to date has taken a person-centered approach to examine important context-related predictors of students' motivation profiles. However, scholars have increasingly noted the need to account for classroom goal structures in person-centered studies of student motivation (Lo et al., 2017; Schwinger, Steinmayr, & Spinath, 2016; Shim & Finch, 2014). This study addresses this call by examining science classroom goal structures (including students' perceptions of mastery, performance-approach, and performance-avoid oriented teaching practices), as well as grade-specific science achievement in relation to students' profiles. Taken together, this study aims to fill several gaps in the literature by examining a) science motivation belief profiles among a diverse sample of middle school students, b) patterns of stability and change in students' profile membership over the school year, and c) the relationships among students' motivation belief profiles, classroom goal structures, and science achievement.

1.1. Achievement goals and self-efficacy in middle school science

A large body of work points to achievement goals as one of the most influential motivation constructs related to a host of desired student outcomes (see Linnenbrink-Garcia et al., 2012; Midgley, Kaplan, & Middleton, 2001; Senko, Hulleman, & Harackiewicz, 2011 for reviews). The trichotomous achievement goal theory proposes that students hold three qualitatively distinct goals that drive their approach to learning: 1) *mastery* goals focused on developing competence, 2) *performance-approach* goals focused on demonstrating competence, and 3) *performance-avoidance* goals focused on avoiding failure or appearing incompetent (Ames, 1992; Dweck & Leggett, 1988; Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Midgley et al., 2001; Pintrich, 2000; Weiner, 2000). Although we used the common trichotomous goal theory in this study, a 2 × 2 achievement goal framework that differentiates mastery-approach from mastery-avoidance goals (goals focused on avoiding performing worse than one has done before) has also been proposed (DeShon & Gillespie, 2005; Elliot & McGregor, 2001; Madjar, Kaplan, & Weinstock, 2011; Van Yperen, Elliot, & Anseel, 2009). Finally, a construct central to science learning, self-efficacy (the beliefs students hold about their academic abilities) is also examined (Bandura, 2001, 2006). In science, self-efficacy has been linked to perseverance on challenging academic tasks, science achievement, and continuation in science-related majors and careers (Britner & Pajares, 2006; Chen & Usher, 2013; Gwilliam & Betz, 2001; Lau & Roeser, 2010; Lee, Hayes, Seitz, DiStefano, & O'Connor, 2016). As discussed next, there is strong evidence to show that achievement goals and self-efficacy are closely related constructs highly predictive of students' propensity to learn and achieve in science.

1.2. Achievement goal and self-efficacy profiles: A person-centered approach

1.2.1. A person-centered approach

A person-centered approach focuses on identifying naturally occurring combinations of variables at the individual level (Bergman & Trost, 2006; Pastor, Barron, Miller, & Davis, 2007). Latent profile analysis is an analytic method used to identify different profiles of individuals with similar indicator variable responses (Masyn, 2013; Nylund, Asparouhov, & Muthén, 2007; Pastor et al., 2007; Wingate & Tomes, 2017). Advantages of person-centered approaches include the ability to statistically estimate a model for group membership and fit, allowing for the examination of complex interactions and dynamics among motivation and belief variables (Hagenaars & McCutcheon, 2002; Nylund et al., 2007). Person-centered analytic techniques also allow researchers to examine the relationships of student profiles to key predictors and academic outcomes. Further, latent transition analysis (LTA) provides the added benefit of modeling change in individual's profile configurations over time (Collins & Lanza, 2013).

A large number of studies related to achievement goal profiles have emerged in recent years. A meta-analytic review of these studies showed that profiles characterized by high mastery goals, as well as high approach goals, are linked to positive outcomes such as adaptive learning processes (e.g., self-regulation strategies, engaging in school tasks) and outcomes (e.g., grades), whereas the reverse is true for profiles characterized by average to low goal endorsement (Wormington & Linnenbrink-Garcia, 2017). Another notable finding was that the relationship between profiles and outcomes vary as a function of school level and the number of achievement goals assessed (trichotomous vs. 2 × 2 goal theory). Thus, to inform the present work, studies using the same trichotomous achievement goal model and/or self-efficacy, as well as similar school level population (middle school or secondary students) are reviewed in more detail next.

1.2.2. Achievement goal profiles

Previous studies of achievement goal profiles in middle school have identified between three to seven profiles, and consistently find that high endorsement of mastery and/or performance-approach goals are associated with positive academic outcomes (Conley, 2012; Lo et al., 2017; Luo, Paris, et al., 2011; Shim & Finch, 2014). For example, Shim and Finch (2014) conducted a study of academic achievement goals (also including social achievement goals) among middle school students in the United States, and identified six profiles that ranged from high, moderate, and low endorsements of academic and social goals. Mastery-oriented academic and social profiles were linked with higher levels of positive learning behaviors. Studies of achievement goal profiles among middle school students in other countries also identified profiles characterized by high mastery and/or performance-approach (and low performance-avoid) goals and moderate endorsement of all goals. For example, Luo, Paris, et al. (2011) examined achievement goal profiles in math among secondary students in Singapore using cluster analysis, and more recently, Lo et al. (2017) examined the stability of achievement goal profiles in math, among Taiwanese students in grades 7 and 8. In both of these studies, the profile characterized by high mastery and performance-approach goals were linked to positive academic outcomes (e.g., self-efficacy, self-concept, engagement, time management, self-regulation), whereas moderate endorsement of achievement goals (e.g., diffuse, indifferent) and high endorsement of avoidance goals were found to be maladaptive (Lo et al., 2017; Luo, Paris, et al., 2011).

Conley (2012) examined patterns of motivation profiles among 7th grade students in mathematics, that included achievement goals as well as expectancy-value perspectives and self-efficacy beliefs. A seven-profile solution was identified, including a low profile (low on all motivational indices), three average clusters (average ratings with an emphasis on mastery, cost, or across motivational indices), and 3 high clusters (high ratings on competence beliefs, cost, or high across motivational indices) (Conley, 2012). The profiles characterized by average endorsement on the achievement goal, task value, and self-efficacy belief factors were associated with higher academic achievement and positive affect (Conley, 2012). Of note, a high mastery oriented profile commonly found in other person-centered studies was not identified (e.g., Jang & Liu, 2012; Tuominen-Soini, Salmela-Aro, & Niemivirta, 2011). Possible explanations for this discrepancy include the domain of study (mathematics) and developmental stage of participants (middle school) that together is associated with lower levels of mastery goals (Conley, 2012). Therefore, when making comparisons across motivation profile studies, in addition to the achievement goal model and grade level, the role of content domain may also be an important feature to consider. In fact, several scholars have argued that attention to subject area in person-centered studies is particularly relevant during the secondary years when subjects become more differentiated (Madjar & Chohat, 2017; Shim & Finch, 2014).

1.2.3. Self-efficacy profiles

With the exception of Conley (2012), person-centered studies accounting for self-efficacy in motivation profiles are lacking. However related studies point to self-efficacy as an important component of students' motivation profiles in science (e.g., Chen, 2012; Chen & Usher, 2013; Kim, Wang, Ahn, & Bong, 2015; Roeser et al., 2002). For example, Chen and Usher (2013) examined profiles of middle and high school students' characterized by four sources of self-efficacy (how students form self-efficacy beliefs in science). Four profiles were identified, and each were uniquely related to students' implicit beliefs regarding whether ability in science was fixed or malleable (Chen & Usher, 2013). In another study of middle school students in science and social studies, Roeser et al. (2002) found that the profile characterized by high self-efficacy and valuing of the subject matter (as well as high mental health) was associated with classroom engagement and adaptive socio-emotional functioning. Although these studies inform our current work, there are notable differences including the input variables (e.g., sources of self-efficacy, mental health measures) as well as the relatively homogeneous sample of students that represent middle to upper class backgrounds (e.g., Roeser et al., 2002). Therefore, this paper will contribute to the limited number of person-centered studies examining the role of science self-efficacy in achievement goal profiles among diverse middle school students from urban school contexts in the United States.

1.3. Stability of motivation and self-efficacy profiles

During the developmentally complex stage of middle school, marked by rapid intra-individual changes and significant shifts in the academic environment, fluctuation in students' achievement goals and self-efficacy is expected. Specifically, studies show that students' academic self-efficacy become differentiated by domain (e.g., science, math, social studies) and decline in the secondary years, as social comparisons based on normative standards become more salient (Archambault, Eccles, & Vida, 2010; Bong, 2001; Caprara et al., 2008; Rice, 2001; Song, Bong, Lee, & Kim, 2015). Motivation orientations also change considerably from year to year in relation to increasingly differentiated learning trajectories in subjects (e.g., Lepola, Poskiparta, Laakkonen, & Niemi, 2005; Morgan & Fuchs, 2007). For example, in the United States, grade 6 marks many students' transition from elementary to secondary schooling, where they are faced with greater discipline, fewer instances of positive teacher-student interactions, and increased use of standardized measures to monitor ability and achievement (Eccles & Roeser, 2009; Midgley et al., 2001). This in turn, has been associated with declines in students' motivation, interest, and ultimately achievement in STEM (Otis, Grouzet, & Pelletier, 2005; Pajares & Graham, 1999; Wang & Holcombe, 2010). Mastery goals in particular tend to decline, whereas performance goals show more variation in patterns of change (e.g., Pajares, Britner, & Valiante, 2000; Shim et al., 2008). Similar trends have been documented during the transition from middle to high school (Eccles et al., 1993; Eccles & Midgley, 1989; Midgley, Middleton, Gheen, & Kumar, 2002).

Longitudinal studies examining achievement goal profiles demonstrate mixed findings regarding the probability of students shifting profiles, as well as the qualitative nature of the profile change (e.g., Eccles et al., 1993; Lo et al., 2017; Schwinger & Wild, 2012; Wigfield et al., 2015). For example, studies among elementary students in math showed that students had a low probability of staying in the same profile (approximately 30%), and the changes in profile mainly involved decreasing in level across goal endorsements (from high to average motivation) (Schwinger et al., 2016; Schwinger & Wild, 2012). However, other studies showed that secondary students had a higher probability of maintaining profile membership (approximately 60%), and the shifts were to similar profiles (high mastery to high approach) (Tuominen-Soini et al., 2011; Tuominen-Soini, Salmela-Aro, & Niemivirta, 2012). Recently, Lo et al. (2017) found that among seventh and eighth grade students in Taiwan, the majority (approximately 76%) remained in the same achievement goal profile over the course of a school year, and shifts included students moving to a profile with a different pattern of goal endorsements. In contrast, Lee et al. (2017) found a larger range of shifts (46% to 81%) among undergraduate students, and the degree of changing profiles over the course of the semester varied by level of goal endorsement. Finally, Gonçalves et al. (2017) showed a lower probability of profile stability (approximately 40%) among 9th and 10th grade students, and shifts included adaptive and maladaptive profile changes. Given these divergent results, combined with research pointing to important changes in students' motivation and self-efficacy during the middle school years, this study will examine the stability of students' motivation belief profiles between the start and end of the school year, within each middle school grade.

1.4. Predictors and consequences of students' motivation belief profiles

1.4.1. Classroom goal structures

Perceived classroom goal structures represent the goal-related messages that are emphasized in an academic setting (Kaplan, Middleton, Urdan, & Midgley, 2002). These classroom goal structures, largely influenced by teachers' instructional approaches and related cues, are observed and interpreted by students, and in turn influence students' adoption of personal goal orientations and their self-efficacy beliefs (Bandura, 2001; Lau & Nie, 2008; Meece, Anderman, & Anderman, 2006; Pintrich, 2003; Schwinger & Stiensmeier-Pelster, 2011; Shim, Cho, & Wang, 2013). For example, when teachers convey to students that improvement and effort are important, they are promoting a mastery classroom goal structure. On the other hand, when teachers emphasize external benchmarks of performance (e.g., grades, ability differences), a performance classroom goal structure is promoted. Classroom goal structures also provide information to influence students' scientific self-efficacy (e.g., Bandura, 2001; Britner & Pajares, 2006; Laursen, Hunter, Seymour, Thiry, & Melton, 2010; Luo, Hogan, & Paris, 2011). Currently, there is a lack of research examining how aspects of students' immediate learning environment influence their profile makeup. We address this gap by examining how students' perceptions of their science classroom goal structures relate to their motivation belief profile membership.

1.4.2. Science achievement

Both mastery goals and self-efficacy are strong predictors of proximal and distal science outcomes such as the use of study strategies, cognitive engagement, persistence on difficult tasks, increased content knowledge, and higher grades, whereas performance-avoidance orientation is consistently associated with negative academic outcomes (Britner & Pajares, 2006; Lee et al., 2016; Linnenbrink, 2005; Pajares et al., 2000). The relationship between performance-approach goals and science achievement is less clear (Cury, Elliot, Sarrazin, Da Fonseca, & Rufo, 2002; Harackiewicz, Barron, Pintrich, et al., 2002; Hulleman, Schrager, Bodmann, & Harackiewicz, 2010; Midgley & Urdan, 2001; Pajares et al., 2000; Senko et al., 2011). However, from an 'optimal motivation' perspective; that is, understanding how pursuit of multiple goals may be differentially advantageous (Harackiewicz, Barron, Tauer, & Elliot, 2002; Pintrich, 2000; Schwinger et al., 2016), researchers have shown that profiles characterized by both high mastery and performance approach-oriented goals are commonly associated with positive academic outcomes, whereas the reverse is found for profiles characterized by high levels of performance-avoid goals (e.g., Gillet et al., 2017; Gonçalves et al., 2017; Lo et al., 2017; Schwinger et al., 2016). Studies also indicate that achievement goals and self-efficacy interact to jointly influence students' academic achievement in specific domains including science and math (e.g., Bong, 2001; Conley, 2012; Komarraju & Nadler, 2013; Lee et al., 2016).

This study will examine different configurations of achievement goals and self-efficacy within unique motivation belief profiles, and the relationship of these profiles to students' science achievement.

1.5. The present study

In the present study, we aimed to identify motivation belief profiles of middle school students within each grade level (6, 7, and 8). These profiles were examined in the context of science learning, which is important as findings increasingly point to the domain specific nature of achievement goals and self-efficacy (e.g., Bong, 2001; Chen & Usher, 2013; Usher & Pajares, 2009). Secondly, we identified motivation belief profiles at the beginning and end of the school year within each grade, and longitudinally examined the stability of students' motivation belief profile membership over the academic year. Finally, we examined important contextual predictors (science classroom goal structures) and outcomes (science achievement) of the profiles.

The following three questions guided our study:

(1) What science motivation belief profiles emerge at the beginning and end of the school year for grades 6, 7, and 8?
(2) What is the stability and change in profile membership across the school year?
(3) How do the profiles relate to science classroom goal structures and science achievement?

In line with prior studies (e.g., Conley, 2012; Wormington & Linnenbrink-Garcia, 2017) we expected to find adaptive motivation belief profiles characterized by 1) high mastery orientation and self-efficacy, and 2) a similar profile also characterized by high levels of performance-approach orientation. However, we recognize that a prior study examining achievement goals and self-efficacy among high school students in math did not find a high mastery profile, which may have been due to domain (math)-specific factors (Conley, 2012). Thus, it is possible that a high mastery profile may also not be identified in our sample of middle school students in science. We also expected to identify maladaptive profiles characterized by 1) moderate levels on all goal orientations and self-efficacy (commonly referred to as 'indifferent'), and 2) low mastery goals and low self-efficacy. Additionally, based on variable-centered studies that demonstrate significant changes in students' science motivation and self-efficacy during the middle school years (e.g., Eccles et al., 1993; Midgley et al., 2002; Wigfield et al., 2015), we expected to find unique profile make-ups within each grade. However, given that our study is the first to examine how goal orientations and self-efficacy combine to form unique profiles in science, and within each middle school grade, the examination of the grade-specific motivation belief profiles was exploratory. Based on prior studies examining profile stability (Lee et al., 2017; Lo et al., 2017; Tuominen-Soini et al., 2012), we expected that students' motivation belief profiles would be relatively stable throughout the school year. Finally, we expected the adaptive motivation belief profiles to correspond to higher science achievement, whereas the reverse was expected for the less adaptive profiles (e.g., Conley, 2012; Lee et al., 2017; Lo et al., 2017).

2. Materials and method

2.1. Participants

This study was conducted in 26 middle schools across seven diverse school districts in the western region of the United States. Students were recruited based on their teachers' participation in a large science education project. Approval from the university's institutional review board was obtained, and permission was granted by parents via a signed consent form for their child's participation prior to data collection. A total of 1443 students from 54 teachers in grades 6 (n = 520), 7 (n = 307), and 8 (n = 613) participated in the study. The student sample included male (46.6%) and female (53.4%) students who identified as American Indian (0.30%), Asian or Pacific Islander (25.6%), Black (5.0%), Hispanic or Latino (44.50%), White (22.50%), and Two or more Races (1.50%), and those who did not report race (0.30%). Students attended urban schools where 52.1% of the students qualified for Free and Reduced Lunch (FRL), 13.5% were identified as English Language Learners, and 83.9% were identified as a minority.

2.2. Procedures and measures

Self-report questionnaires and grade-level science concept inventories were administered via paper-and-pencil by the teacher. Students completed the same measures at the beginning of the 2013 fall semester (Time 1/T1) and end of the 2014 spring semester (Time 2/T2) during regularly scheduled science classroom time. All questionnaire items were rated on a 5-point Likert scale, ranging from 1 (*Not true at all*) to 5 (*Very true*). Items were adapted to ask students about their goal orientation and self-efficacy in the context of their middle school science classrooms. Additionally, to address time constraints and risk of survey fatigue, the 3-item version of the science achievement goal and self-efficacy subscales were administered. Evidence for the reliability (test-retest, factor structure, internal consistency) and validity of these subscales is provided in a prior study (Lee et al., 2016). Students were informed that their participation was voluntary and that their responses would remain confidential.

2.2.1. Achievement goals in science

Three goal orientation scales were adapted (Lee et al., 2016) from the Patterns of Adaptive Learning Survey (PALS) (Midgley et al., 2000), to examine mastery (T1: $\alpha = 0.67$, T2: $\alpha = 0.75$), performance-approach (T1: $\alpha = 0.83$, T2: $\alpha = 0.86$), and performance-avoid (T1: $\alpha = 0.75$, T2: $\alpha = 0.78$) goals. The items asked students to report their mastery (e.g., "One of my goals in science class is to learn as much as I can"), performance-approach (e.g., "One of my goals is to show others that science class work is easy for me"), and performance avoid (e.g., "It's important to me that my science teacher doesn't think that I know less than others in class") goal endorsements in science.

2.2.2. Self-efficacy in science

Self-efficacy was assessed using the adapted (Lee et al., 2016) PALS (Midgley et al., 2000) subscale (T1: $\alpha = 0.79$, T2: $\alpha = 0.81$). The items asked students about their self-efficacy in science ("Even if the science classwork is hard, I can do it").

2.2.3. Science classroom goal structures

Classroom goal structures were assessed using the PALS (Midgley et al., 2000) scales including mastery classroom goals (5 items, T1: $\alpha = 0.75$, T2: $\alpha = 0.80$), performance-approach classroom goals (3 items, T1: $\alpha = 0.72$, T2: $\alpha = 0.76$), and performance-avoid classroom goals (4 items, T1: $\alpha = 0.73$, T2: $\alpha = 0.75$). The items were adapted to ask students about their science classroom goal endorsements reflected by their science teachers' mastery (e.g., "My science teacher thinks mistakes are okay as long as we are learning"), performance-approach (e.g., "My science teacher points out the students who get good grades"), and performance-avoid (e.g., "My science teacher tells us that it is important that we are not confused in class") oriented instructional approaches.

2.2.4. Science achievement

Science achievement was measured using a multiple-choice science concept inventory (CI) that corresponded to students' grade level content (see supplemental materials for example items). The earth science CI (grade 6) consists of 30 items from a validated assessment tool (Libarkin, Kurdziel, & Anderson, 2007) (T1: $\alpha = 0.86$, T2: $\alpha = 0.83$). The life science CI (grade 7) consists of 18 items that were adapted from the Conceptual Inventory of Natural Selection (Anderson, Fisher, & Norman, 2002) (T1: α = 0.84, T2: α = 0.74). The physical science CI (grade 8) consists of 25 items developed and validated by the Physics Underpinnings Action Research Team from Arizona State University (Evans et al., 2003) (T1: α = 0.71, T2: α = 0.78). Science CI scores represent the total percentage correct.

2.3. Data analysis strategy

All analyses were conducted with Mplus 8 (Muthén and Muthén, 1998-2017) using the maximum likelihood with robust (MLR) estimator. First, confirmatory factor analyses (CFA) were conducted for scores collected at the beginning and end of the school year to confirm adequate factor structure and fit at both time points. Next, measurement invariance (MI) was tested using longitudinal CFA to examine equivalence of scores over time. Three models were tested: equivalence of factor parameters (configural invariance), factor loadings (metric invariance), and item intercepts (scalar invariance) (Vandenberg & Lance, 2000). Fit was assessed using the goodness-of-fit (GOF) criteria recommended by Hu and Bentler (1998, 1999) and Kline (2015) including the Comparative Fit Index (CFI ≥ 0.90), the Root Mean Square Error of Approximation (RMSEA < 0.06), the Tucker-Lewis index (TLI ≥ 0.90), and the Standardized Root Mean Square Residual (SRMR < 0.06). Invariance was evaluated using the guidelines suggested by Chen (2007) (e.g. intercept ΔCFI $\geq$0.01, supplemented by a ΔRMSEA $\geq$0.015, indicates a lack of scalar invariance).

For each of the three achievement goals (mastery, performance-approach, performance-avoid) and self-efficacy, a composite score was computed from an average of observed subscale scores, based on evidence for the subscale reliability, adequate factor loadings, and overall model fit found in a prior study (Lee et al., 2016). Scores on each of the three goal subscales and self-efficacy were matched between time points to ensure at least one score was present from each participant at each time point, and no variable included > 1% missing data. Latent profile analyses were conducted for each grade and time point to identify science motivation belief profiles (Nylund-Gibson & Masyn, 2016). Compared to cluster analysis methods (e.g., two-steps K-means, Ward's method), LPA is a model-based technique for identifying distinct latent classes derived from a mixture of indicator probability distributions, which provide fit statistics to guide model selection (Vermunt & Magidson, 2002). Additionally, LPA allows for between-group comparisons, modeling change and stability over time, and the examination of class predictive covariates and class influenced outcomes (Asparouhov & Muthén, 2014; Bakk & Vermunt, 2016; Masyn, 2013).

Two through six class models were estimated and inspected for statistical fit based on minimum values of Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample-size adjusted BIC (aBIC). When comparing models, smaller values of AIC, BIC, and aBIC estimates indicate more parsimony. Additionally, a non-significant Vuong Lo-Mendell-Rubin (VLMR) *p*-value suggests that the *k*-1 (reduced) model is preferable over the *k* (estimated) model (Collins & Lanza, 2013; Geiser, 2013). We also examined the entropy value (indicating how well a model classifies individuals into different profiles) and classification probabilities, with values closer to 1 indicating higher precision and reliability of classification (Masyn, 2013). Finally the latent profile class proportions (size of profiles) and substantive and theoretical justification of the profiles were considered (Geiser, 2013; Muthén, 2003). The LPAs were estimated as mixture complex models to account for grouping effects (students nested in classrooms), using the TYPE = COMPLEX option in Mplus 8, which takes into consideration the non-independence in observations when computing standard errors.

We then examined the extent to which perceived classroom goal structures predicted latent profile membership. Each classroom goal structure (mastery, performance-approach, performance-avoid) was evaluated by the R3STEP function, which provides a multinomial logistic regression of each categorical latent class on each predictor (Bakk & Vermunt, 2016; Vermunt, 2010). Additionally, differences between classes related to perceived classroom goal structures were examined at each time point using the BCH function, which uses classification error in a weighted multiple group (between profile) analysis of distal outcomes (Bolck, Croon, & Hagenaars, 2004; Vermunt, 2010). Differences between classes related to science achievement were examined at T2, controlling for T1 scores. This was accomplished using Asparouhov and Muthén's (2014) manual BCH method. Both distal outcome BCH methods provide individual class means and comparisons between classes for all observed covariates using the Wald chi-squared test (Agresti, 1990).

Finally, LTAs were conducted between the profiles at T1 and T2 for each grade, to assess the probability of students shifting group membership. Using the LPAs as a measurement model, LTA integrates an autoregressive component that describes the probability of transitioning between T1 and T2 profiles (Nylund, 2007). The latent transition probabilities (LTP) represent a coefficient of stability or instability of profiles and range from 0 to 1, with scores closer to 1 indicating a higher probability that students in a given motivation belief profile at T1 will remain in the same profile at T2. Compared to other person-centered longitudinal methods (e.g. I-States-as-Objects, growth mixture models) LTA addresses both within-person profile stability (individual transitions between profiles) and within-sample profile stability (whether the motivation belief profiles change over the school year) (Kam, Morin, Meyer, & Topolnytsky, 2016).

3. Results

3.1. Confirmatory factor analysis (CFA) and longitudinal measurement invariance

The results from the CFA showed that a four-factor (mastery, performance-approach, performance-avoid, and self-efficacy) measurement model fit the data well at both time points for each of the grades (Table 1). Descriptives of all observed variables are presented in Appendix A for each grade at T1 and T2.

Using longitudinal CFA, MI of the four factor model across both time points was tested for each grade. Fit indices for the series of nested models are presented in Table 2. Results showed good fit of the data to the configural, metric, and scalar invariance models. Additionally, based on Chen's (2007) recommendations, we found that changes in model fit through the iterative MI constraints were acceptable. Thus, MI was established at each grade level for the equivalence of the factor structure, factor loadings, and item intercepts across time points for the achievement goal and self-efficacy measurement models.

3.2. Science motivation belief profiles

Fit indices for the 2 to 6 latent class solutions, estimated at T1 and T2, are presented in Table 3. First, we examined the motivation belief

Table 1
Fit statistics for CFA of four-factor achievement goal and self-efficacy models across grades at T1 and T2.

Grade		χ^2	*df*	*p* Value	RMSEA	CFI	TLI	SRMR	Range of stdyx. factor loadings
6	T1	73.98	48	< 0.01	0.03	0.98	0.97	0.03	0.48–0.79
	T2	84.18	48	< 0.01	0.04	0.98	0.97	0.04	0.61–0.81
7	T1	67.23	48	< 0.05	0.04	0.98	0.98	0.04	0.60–0.81
	T2	50.38	48	0.38	0.01	0.99	0.99	0.03	0.68–0.91
8	T1	101.12	48	< 0.001	0.04	0.98	0.97	0.04	0.64–0.84
	T2	90.50	48	< 0.001	0.04	0.98	0.97	0.03	0.68–0.89

Note. Stdyx = Standardized.

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Table 2
Fit statistics for longitudinal CFA of measurement models of science achievement goals and self-efficacy across grades.

Grade	MI test	χ^2	*df*	*p* Value	RMSEA	ΔRMSEA	CFI	ΔCFI	SRMR
6	Configural	336.239	224	< 0.001	0.032	–	0.967	–	0.038
	Metric	366.697	236	< 0.001	0.034	−0.002	0.962	0.005	0.063
	Scalar	456.345	248	< 0.001	0.041	−0.007	0.939	0.023	0.087
7	Configural	276.84	224	< 0.001	0.03	–	0.98	–	0.04
	Metric	303.70	236	< 0.001	0.03	0.00	0.98	0.01	0.07
	Scalar	340.08	248	< 0.001	0.04	0.00	0.97	0.01	0.08
8	Configural	406.35	224	< 0.001	0.04	–	0.97	–	0.04
	Metric	415.71	236	< 0.001	0.03	0.00	0.97	0.00	0.04
	Scalar	438.16	248	< 0.001	0.03	0.00	0.97	0.00	0.04

Note. Stdyx = Standardized.

profiles in science within each middle school grade. For most groups, the information criterion values (e.g., AIC, BIC) continued improving with the addition of latent profiles to the data; thus, providing limited information to determine the optimal class solution. Therefore, we relied on solutions where the decrease in BIC values lowered (Nylund et al., 2007) and other indicators suggested better fit (significant VLMR values, high entropy values), and where there were substantively distinguishable profiles based on theory and previous research (Marsh et al., 2009). Results showed that for grades 6 to 7, three class solutions at T1 and four class solutions at T2 best fit the data (Figs. 1 and 2). For grade 8, a five class solution was most optimal at both time points (Fig. 3).

For grade 6, our analyses revealed three distinct profiles at T1 that were labeled *confidently mastery*, *high all, and low confidence/low mastery* (see Table 4 for descriptives). The students in the *confidently mastery* profile represented the largest group at T1 and the second largest group at T2, characterized by high levels of mastery orientation and self-efficacy, and low levels of performance-approach and -avoid orientation. These students are characterized as being confident in their science ability, and are motivated primarily by an approach towards understanding the content and improving their scientific skills (mastery) rather than demonstrating ability or avoiding looking incompetent in

Table 3
Latent profile analysis fit indices across grades at T1 and T2.

$N_{Classes}$	Log L.	AIC	BIC	aBIC	VLMR	*p* Value	Entropy
Grade 6 T1							
2	−2298.79	4623.79	4678.05	4636.78	209.52	0.00	0.70
3	**−2239.60**	**4515.20**	**4590.63**	**4533.49**	**118.37**	**0.01**	**0.75**
4	−2216.17	4478.34	4574.72	4501.72	46.86	0.48	0.77
5	−2197.30	4450.60	4567.92	4479.05	37.75	0.02	0.78
6	−2176.96	4419.94	4558.22	4453.48	40.66	0.000	0.72
Grade 6 T2							
2	−2432.33	4890.67	4945.14	4903.88	233.31	0.00	0.70
3	−2375.28	4786.55	4861.98	4804.85	114.11	0.04	0.71
4	**−2339.75**	**4725.51**	**4821.88**	**4748.88**	**71.05**	**0.05**	**0.76**
5	−2310.68	4677.36	4794.69	4705.82	58.14	0.44	0.73
6	−2289.22	4644.45	4782.73	4677.989	42.91	0.00	0.75
Grade 7 T1							
2	−1448.55	2923.10	2971.55	2930.32	132.95	0.00	0.69
3	**−1411.01**	**2858.01**	**2925.11**	**2868.02**	**75.07**	**0.10**	**0.71**
4	−1389.66	2825.31	2911.03	2838.08	42.71	0.27	0.70
5	−1367.34	2790.67	2895.03	2806.22	44.64	0.04	0.81
6	−1349.33	2764.66	2887.65	2782.98	36.01	0.05	0.77
Grade 7 T2							
2	−1555.33	3136.65	3185.10	3143.87	175.29	0.00	0.83
3	−1490.21	3016.40	3083.49	3026.40	130.25	0.001	0.79
4	**−1463.85**	**2973.69**	**3059.41**	**2986.46**	**52.71**	**0.06**	**0.77**
5	−1446.01	2948.03	3052.38	2963.57	35.67	0.32	0.82
6	−1433.09	2932.18	3055.17	2950.51	28.84	0.22	0.83
Grade 8 T1							
2	−3360.03	6746.05	6804.84	6763.56	298.05	0.00	0.70
3	−3293.29	6622.58	6703.98	6646.83	133.47	0.02	0.71
4	−3264.04	6574.07	6678.08	6605.05	58.51	0.22	0.72
5	**−3238.76**	**6533.52**	**6660.14**	**6571.23**	**50.55**	**0.17**	**0.73**
6	−3244.58	6515.16	6664.39	6559.61	28.35	0.45	0.74
Grade 8 T2							
2	−3395.91	6817.82	6876.60	6835.33	303.67	0.00	0.71
3	−3320.76	6677.53	6758.92	6701.77	150.29	0.03	0.68
4	−3277.07	6600.13	6704.14	6631.11	87.40	0.00	0.71
5	**−3256.75**	**6569.50**	**6696.12**	**6607.22**	**40.63**	**0.02**	**0.74**
6	−3225.52	6537.05	6686.28	6581.50	42.46	0.39	0.68

Note. LogL = Log Likelihood; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion;
aBIC = Sample Size Adjusted Bayesian Information Criterion; VLMR-LRT = Vuong Lo-Mendell-Rubin Likelihood Ratio Test. Minimal BIC indicates best relative fit. Significant VLMR denotes an improvement in fit given the additional class. Bold values represent the final model selected.

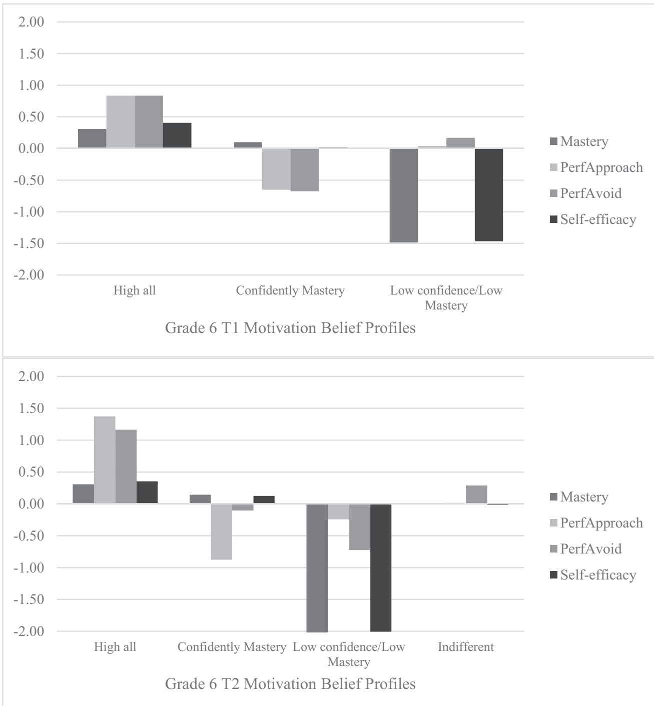

Fig. 1. Profile solutions for grade 6 motivation belief profiles at T1 and T2.

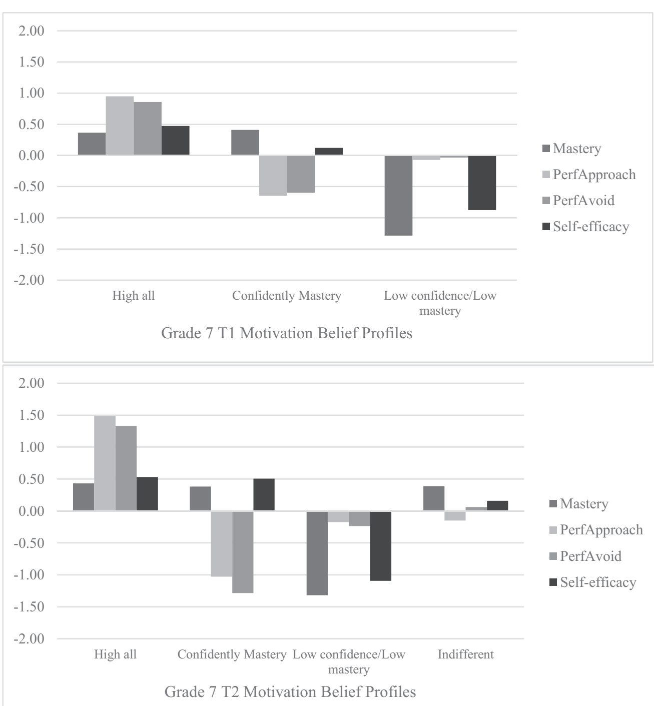

Fig. 2. Profile solutions for grade 7 motivation belief profiles at T1 and T2.

their science classrooms (performance-approach or -avoid). The students in the *high all* profile represented the second largest group at T1 and the third largest group at T2, characterized by high levels on all four indicators (mastery, performance-approach, performance-avoid, and self-efficacy). These students are characterized as being confident in their science ability, and being motivated by all three goals. The students in the *low confidence/low mastery group* represented the smallest group at both time points, characterized by low self-efficacy and low mastery goals, and average performance-approach and -avoid

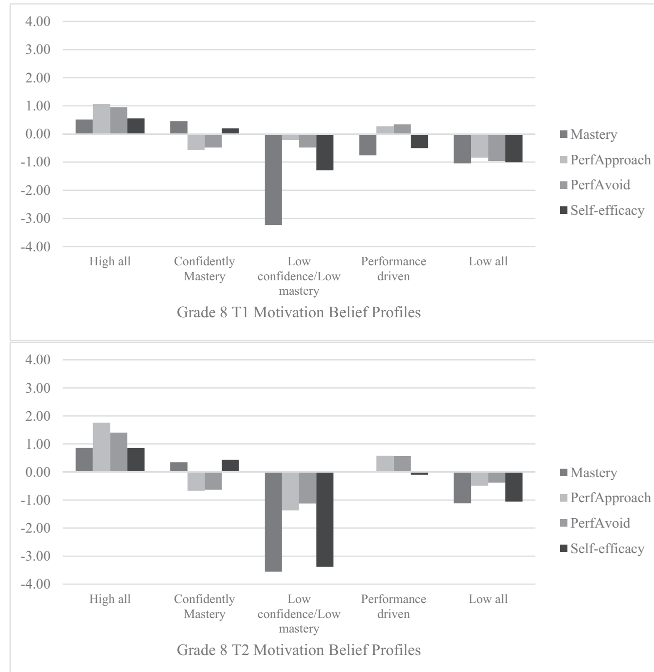

Fig. 3. Profile solutions for grade 8 motivation belief profiles at T1 and T2.

goals. For T2 among grade 6 students, a fourth profile was identified, labeled *indifferent*. These students were characterized by moderate levels on all four indicators, characterized as a relatively 'flat' profile as they did not display a dominant tendency towards any specific achievement goal or self-efficacy belief.

Results showed that for grade 7, the same three profile solution at T1 and the same four profile solution at T2 identified in grade 6 best fit the data (see Table 5 for descriptives). Thus, similar profile patterns were examined among students in grades 6 and 7, in which students differentiated from three to four distinct profiles over the course of the school year. Of note, for both grades, the number of students in the *confidently mastery* profile decreased noticeably from T1 to T2, and the *indifferent profile* had the largest profile membership at T2. It is also worth noting that although the raw scores of the indicators in the *indifferent* profile solution are relatively high, they were all < 0.50 standard deviations above the means (thus, showing no clear differentiations in the level of achievement goal endorsements and self-efficacy). In contrast, the *confidently mastery* profile was characterized by mastery and self-efficacy indicators that were above the mean, and indicators of performance-approach and -avoidance goals that fell below the mean. The indifferent profile was also distinct from the *high all* profile, which was characterized by all indicators approximately 0.50 to 1.0 SDs above the mean.

Finally, results showed that for grade 8, students' motivation belief profiles were the most differentiated compared to students in grades 6 and 7, with a five class solution representing best fit to the data at both T1 and T2 (see Table 3), including the smallest BIC value as well as theoretically justifiable profiles. The five profiles included three similar profiles identified in the previous two grades, including *confidently mastery* (largest group at T1 and T2), *high all* (second largest group at T1, but second smallest group at T2), and *low confidence/low mastery* (smallest group at T1 and T2). Although the *low confidence/low mastery* profile included very few students, these participants provided unique indicator variable responses that have substantive explanatory value. The five profile solution was also supported by the lowest BIC value, non-significant 6 profile VLMR *p*-value, and substantively meaningful profile arrangement. Two profiles unique to grade 8 were labeled *low all* and *performance-driven*. Students in the *low all* profile were

Table 4
Descriptive statistics on all variables by science achievement goals and self-efficacy profile membership for grade 6 at T1/T2.

Variable	Confidently mastery *M*	High all *M*	Low confidence/low mastery *M*	Indifferent *M*
n	251/146	188/93	49/21	−/228
Ave. posterior probabilities	89.94/88.04	89.53/87.40	85.50/89.41	−/84.21
Mastery approach	4.39/4.22	4.51/4.33	3.48/2.71	−/4.12
Performance approach	2.12/1.55	3.70/3.90	2.86/2.21	−/2.48
Performance avoid	2.62/1.87	4.21/4.24	3.51/2.23	−/3.31
Self-efficacy	4.07/4.03	4.36/4.23	2.94/2.18	−/3.90
Class mastery	3.91/3.77[ab]	4.13/3.98[a]	3.28/2.38	−/3.70[b]
Class performance approach	2.29[a]/1.93	2.54[a]/3.02	2.43[a]/2.46[a]	−/2.43[a]
Class performance avoid	2.46[a]/2.17[a]	3.35/3.35	2.86[a]/2.20[ab]	−/2.81[b]
Science achievement	33.44[a]/40.22[a]	28.75/33.53[b]	28.75[a]/34.17[ab]	−/34.55[b]

Note. Ave. posterior probabilities = Average posterior probabilities for determining most likely class membership. Superscripts denote non-significant differences at $p < .05$ using the Wald test.

Table 5
Descriptive statistics on all variables by science achievement goals and self-efficacy profile membership for grade 7 at T1/T2.

Variable	Confidently mastery *M*	High all *M*	Low confidence/low mastery *M*	Indifferent *M*
n	137/50	99/61	71/69	−/127
Ave. posterior probabilities	88.48/87.18	86.39/88.82	84.96/90.1	−/84.92
Mastery approach	4.60/4.53	4.58/4.57	3.59/3.33	−/4.54
Performance approach	1.93/1.39	3.57/4.37	2.52/2.40	−/2.43
Performance avoid	2.61/1.65	4.12/4.53	3.20/2.80	−/3.13
Self-efficacy	4.13/4.51	4.40/4.53	3.37/3.20	−/4.23
Class mastery	4.13[a]/4.07[a]	4.21[a]/4.25[a]	3.42/3.29	−/4.23[a]
Class performance approach	1.97/2.28[a]	2.69[a]/3.67	2.41[a]/2.50[a]	−/1.86
Class performance avoid	2.37/2.82[a]	3.04[a]/3.71	2.82[a]/2.77[a]	−/1.94
Science achievement	49.57[a]/66.92	46.26[a]/49.61[a]	34.90/46.17[a]	−/56.19[a]

Note. Ave. posterior probabilities = Average posterior probabilities for determining most likely class membership. Superscripts denote non-significant differences at $p < .05$ using the Wald test.

characterized by low levels on all three achievement goals, and low self-efficacy, and represented the second smallest group at T1, but the third largest group at T2. Students in the *performance-driven* profile were characterized by high levels of performance-approach and -avoid goals, and low levels of mastery goals and self-efficacy in science, and represented the third and second largest group at T1 and T2, respectively.

3.3. Latent transition analysis (LTA): Stability and change in profile membership

Latent transition analyses were conducted with the number of classes identified in the LPAs for each grade to examine within-person stability patterns from T1 to T2. The classes in the LTA aligned with the LPA results. Entropy values for the models were 0.77, 0.86, and 0.85 for grades 6, 7, and 8, respectively. The LTPs from T1 to T2 for each grade are presented in Table 7.

Results from the LTA showed that between T1 and T2, 6th grade students who were in the *high all* group had the highest probability (LTP = 0.55) of staying in this group at the end of the school year, followed by the *low confidence/low mastery* (LTP = 0.49), and *confidently mastery* (LTP = 0.42) groups. There were also notable shifts: students in the *confidently mastery* group shifted to either the *low confidence/low mastery* (LTP = 0.28) and *high all* (LTP = 0.25) groups; students in the *high all* profile had relatively similar probabilities (LTP ranging from 0.12 to 0.18) of moving to one of the other three profiles; and finally, students in the *low confidence/low mastery* group shifted into either the *confidently mastery* (LTP = 0.20) or the *high all* (LTP = 0.25) groups. Results for grade 7 showed that between T1 and T2, students

Table 6
Descriptive statistics on all variables by science achievement goals and self-efficacy profile membership for grade 8 at T1/T2.

Variable	Confidently mastery *M*	High all *M*	Low confidence/low mastery *M*	Low all *M*	Performance-driven *M*
n	306/274	174/52	16/3	60/117	124/234
Ave. posterior probabilities	84.49/84.27	86.06/89.08	88.08/99.7	77.93/79.90	74.48/82.13
Mastery approach	4.54/4.40	4.58/4.76	2.01/1.65	3.52/3.37	3.70/4.17
Performance approach	2.08/1.84	3.86/4.47	2.46/1.08	1.77/2.04	2.99/3.19
Performance avoid	2.61/2.33	4.11/4.47	2.61/1.81	2.11/2.60	3.47/3.59
Self-efficacy	4.18/4.31	4.474.66	3.00/1.16	3.23/3.08	3.63/3.88
Class mastery	4.01/4.04	4.27/4.44	3.00[a]/1.49	3.44[a]/3.29	3.58/3.69
Class performance approach	1.99[a]/1.87	2.57[b]/3.76	1.91[a]/0.99	2.19[ac]/2.22[a]	2.65[bc]/2.43[a]
Class performance avoid	2.34[a]/2.33[a]	3.21/3.59	2.47[a]/1.12	2.27a/2.47a	4.05/3.00
Science achievement	42.41[a]/48.10[a]	41.94[ab]/46.32[ab]	21.81/22.00	36.40[bc]/40.94[b]	31.76[c]/40.93[b]

Note. Ave. posterior probabilities = Average posterior probabilities for determining most likely class membership. Superscripts denote non-significant differences at $p < .05$ using the Wald test.

Table 7
Cross-classification of type membership *n* and latent transition probabilities (in brackets) of profile membership from T1 to T2 for grades 6, 7, and 8.

		Grade 6 T2				
Grade 6 T1		Confidently mastery	High all	Low confidence/low mastery	Indifferent	
	N	145	151	165	27	
Confidently mastery	210	94 (0.42)	48 (0.25)	58 (0.28)	10 (0.05)	
High all	100	15 (0.16)	57 (0.55)	17 (0.18)	11 (0.12)	
Low confidence/low mastery	178	36 (0.20)	46 (0.25)	90 (0.49)	6 (0.06)	
		Grade 7 T2				
Grade 7 T1		Confidently mastery	High all	Low confidence/low mastery	Indifferent	
	N	34	67	72	134	
Confidently mastery	117	31 (0.27)	2 (0.02)	14 (0.13)	70 (0.57)	
High all	101	1 (0.02)	36 (0.38)	5 (0.04)	59 (0.59)	
Low confidence/low mastery	89	2 (0.03)	29 (0.34)	53 (0.59)	5 (0.05)	
		Grade 8 T2				
Grade 8 T1		Confidently mastery	High all	Low confidence/low mastery	Low all	Performance-driven
	N	50	201	164	81	184
Confidently mastery	38	28 (0.65)	0 (0.00)	7 (0.22)	2 (0.07)	1 (0.07)
High all	178	1 (0.01)	170 (0.85)	1 (0.09)	5 (0.04)	1 (0.01)
Low confidence/low mastery	177	15 (0.01)	0 (0.00)	147 (0.79)	4 (0.03)	11 (0.09)
Low all	116	1 (0.01)	31 (0.24)	3 (0.04)	70 (0.56)	11 (0.15)
Performance-driven	171	5 (0.04)	0 (0.00)	6 (0.07)	0 (0.00)	160 (0.89)

who were in the *low confidence/low mastery* group had the highest probability (LTP = 0.59) of staying in the same group at the end of the school year, followed by the *confidently mastery* (LTP = 0.57), and *high all* (LTP = 0.56) groups. In contrast to sixth grade students, seventh grade students shifted primarily to one profile, rather than two or more profiles: students in the *confidently mastery* profile had the highest probability of shifting to the *indifferent* profile (LTP = 0.28), students in the *high all* profile had the highest probability of shifting to the *confidently mastery* profile (LTP = 0.34), and students in the *low confidence/low mastery* profile had the highest probability to shift to the *high all* profile (LTP = 0.39). Finally, students in grade 8 showed the highest probability of remaining in the same profile from T1 to T2; LTP = 0.65, 0.85, 0.79, 0.56, and 0.89 for the *confidently mastery*, *high all*, *low confidence/low mastery*, *low all*, and *performance-driven* profiles, respectively.

3.4. Classroom goal structures and science achievement in relation to students' motivation belief profiles

Next, classroom goal structures, as well as grade-level science achievement, were examined in relation to students' motivation belief profiles for each grade. Results showed that all three classroom goal structures (mastery, performance-approach, performance-avoid) significantly predicted profile membership ($p < .05$), with the exception of the performance-approach classroom goal structure at T1 in 6th grade. For substantively meaningful interpretation of the motivation belief profiles, the classroom goal structures and science achievement means for all profiles at T1 and T2 are presented (Tables 4 to 6).

Results of grade-specific science achievement by profile are also presented in Tables 4 to 6. Students in the *confidently mastery* profile had the highest science achievement scores for all three grades. For grades 6 and 7, science achievement among the *high all*, *low confidence/low mastery*, and *indifferent* profiles were comparable. For grade 8, students in the *high all* profile also demonstrated high science achievement (slightly lower but not statistically different from the *confidently mastery* students), whereas students in the *low confidence/low mastery* profile demonstrated the lowest scores of all profiles. The *low all* and *performance-driven* profiles that were unique to grade 8 were associated with similar science test scores that fell in between the highest and lowest scores.

4. Discussion

The three objectives of this study were to identify science motivation belief profiles among diverse middle school students at the beginning and end of the school year, examine the stability and change of profile membership over the school year, and explore the relations of the profiles to classroom goal structures and science achievement. To date, studies examining achievement goal profiles in conjunction with self-efficacy are sparse. Additionally, this is the first LTA study to examine motivation belief profiles within the domain of science, among middle school students in urban U.S. classrooms.

4.1. Science motivation belief profiles in middle school

Akin to prior studies, our findings support the notion that students are pursuing multiple goals simultaneously to different degrees (e.g., Harackiewicz, Barron, Pintrich, et al., 2002; Schwinger et al., 2016). In our study, three science motivation belief profiles were consistently identified across time points and grades, including *high all*, *confidently mastery*, and *low confidence/low mastery*. The *confidently mastery*, and *low confidence/low mastery* profiles aligned with our expectations and results obtained in prior work, indicating that mastery orientation and self-efficacy generally work together in adaptive or maladaptive ways (e.g., Conley, 2012). The *high all* profile identified in all three grades diverged from our expectation as past studies showed that performance-approach goals can often work in tangent with mastery goals and self-efficacy in adaptive ways, whereas performance-avoid goals are consistently associated with negative academic outcomes (e.g., Luo, Paris, et al., 2011; Pastor et al., 2007; Tuominen-Soini et al., 2012). However, we found that high levels of mastery, performance-approach, and self-efficacy also coincided with high levels of performance-avoid within the same profile. Although this profile type is less common, a similar profile was identified among secondary students in Singapore (Luo, Paris, et al., 2011).

We also found that students pursued both performance goals in a similar way across the profiles (i.e., high or low levels on both performance-approach and -avoid goals within the same profile). Despite the large body of evidence from variable-centered approaches that indicate distinct influences of performance-approach vs. -avoid goals on students' learning, our findings raise the question of whether it is always useful to make this distinction. In fact, a growing body of person-centered studies point to the possibility that at the student level, the two types of performance goals seem highly intertwined, and students may endorse these goals in similar ways (e.g., Lee et al., 2017; Luo, Paris, et al., 2011; Schwinger et al., 2016; Shim & Finch, 2014). Thus, it has been suggested that from a practical perspective, the usefulness of teachers distinguishing between the two performance goals in students' motivation profiles may not be necessary (Schwinger et al., 2016). Our study provides additional evidence for this position, specifically in the context of middle school science.

In both grades 6 and 7, a fourth profile, *indifferent*, characterized by no particularly salient endorsement of achievement goals or self-efficacy, was identified as the largest group (47% and 42%, respectively) at the end of the school year. This aligns with our expectations, and findings from prior studies conducted in different countries (e.g., Singapore, German, Finland), grades (elementary, secondary, and undergraduate), and domains (math, general) that also identified a profile characterized by moderate levels of achievement goals and/or other motivational indices (e.g., Conley, 2012; Gonçalves et al., 2017; Lo et al., 2017; Luo, Paris, et al., 2011; Schwinger et al., 2016; Shim & Finch, 2014). Thus, there is converging evidence that an indifferent or 'flat' motivation profile may generalize across cultures, age groups, and subject areas. In past studies, this type of profile has been labeled 'indifferent' (e.g., Lo et al., 2017; Tuominen-Soini et al., 2012;), 'disengaged' (e.g., Pahljina-Reinić & Kolić-Vehovec, 2017), 'overall moderate' (e.g., Gonçalves et al., 2017), or 'diffuse (Luo, Paris, et al., 2011). The consistent identification of an indifferent profile has practical implications, pointing to the need for educators to recognize this motivation belief profile in students, and provide supports needed to build students' motivation and self-efficacy beliefs in science as they progress through middle school (Hidi & Harackiewicz, 2000).

Of note however, the grade-specific examination of motivation belief profiles in our study allowed us to see that the *indifferent* profile emerges at the end of grades 6 and 7, and interestingly, was not identified in grade 8. Additionally, in grades 6 and 7, the number of students in the *confidently mastery* profile at T1 dropped significantly at T2, and the *indifferent* profile that emerged at T2 had the highest membership for both grades at the end of the school year. The implications of these shifts are discussed in the section below. In grade 8 we identified two new, unexpected profiles including *performance-driven* (second highest group at T1 and T2) and *low all* (second smallest group at T1, third largest group at T2). Further, concerning trends in profile membership across the school year was also identified among 8th graders. These include a noticeable decrease in the number of students in the *high all* profile from T1 to T2, coupled with the membership in the *performance-driven* and *low all* profiles approximately doubling from the beginning to the end of the school year. The emergence of these two profiles at the end of the middle school years may be explained by the increasing performance-based nature of secondary schooling contexts (Eccles & Roeser, 2009; Midgley et al., 2001). For example, standardized testing in science occurs in 8th grade for the students in this study, which likely increases attention to academic performance as well as the pressures to demonstrate ability and/or avoid being perceived as lacking ability.

Our results contribute to the literature by identifying motivation belief profiles at the beginning and end of the school year within each middle school grade. Findings show that the nature of science motivation belief profiles are similar for students in grades 6 and 7 (three to four profiles identified at T1 and T2), whereas the profiles become more differentiated in grade 8 (five profiles identified at T1 and T2). Thus, we did not find that the profiles identified within each of the three middle school grades replicated across measurement occasions (for grades 6 and 7), or across groups. Instead, our results indicate that depending on the grade and time in the school year, the number and nature of the profiles may differ.

4.2. Motivation belief profile stability and change within each middle school grade

Another goal of this study was to examine the stability in science motivation belief profile membership at a finer grain size (within each grade level). Our findings generally supported our expectation that students' membership in a motivation belief profile would remain stable over the school year. However, a closer look at the trends within each grade indicate that there are more shifts occurring in grade 6 compared to grade 7 (42 to 55% vs. 56 to 59% probability of students remaining in the same profile, respectively), and that profile membership becomes most stable in grade 8 (approximately 56 to 89% probability of students remaining in the same profile). One interpretation of these trends is that by 8th grade, students have more solidified and differentiated endorsements of science motivation beliefs. That is, unlike 6th and 7th grade, where we identified an *indifferent* profile at the end of the year, by 8th grade, students' science motivation belief profiles are no longer 'flat' but instead, more strongly endorse low motivation beliefs (*low all*), or high performance goals (*performance-driven*). These findings align with prior results that showed high profile stability among students the later middle school years (e.g., Lo et al., 2017; Tuominen-Soini et al., 2011; Tuominen-Soini et al., 2012) or older (e.g., Pulkka & Niemivirta, 2013), whereas profile membership has shown to be more variable across time among younger students (e.g., Schwinger et al., 2016).

The grade-specific trends in profile membership over time also warrant further investigation, particularly for grades 6 and 7 where high transition probabilities were observed. Additionally, some of the changes in our study differed from the results of prior studies, in which most of the shifts were towards similar, neighbouring groups with fairly similar profiles (e.g., Gonçalves et al., 2017; Pulkka & Niemivirta, 2013; Tuominen-Soini et al., 2011, 2012). The majority of the shifts were adaptive, including students shifting from the *low mastery/low confidence* profile into the *confidently mastery* or the *high all* profiles. These patterns indicate that as students progress through grades 6 and 7, they are shifting towards more strongly adapting goals that endorse mastery and/or performance approaches to science learning, as well as developing more confidence in their science ability. As discussed next, mastery classroom goals structures may play a positive influence on these shifts. Other classroom context factors may contribute to these shifts, including teacher-student and peer relationships, as well as the science learning opportunities presented to students (e.g. Wang & Holcombe, 2010; Wigfield et al., 2015). These influences should be examined in future person-centered studies to understand how to promote the positive shifts in science motivation belief profile membership identified here. On the other hand, although less common, there were cases in which students demonstrated maladaptive shifts, moving from either the *confidently mastery* or *high all* profiles to the *indifferent* or the *low confidence/low mastery* profiles. The shift to the *indifferent* profile represents a drop in science goal orientations and self-efficacy, and this profile was the largest in size at the end of the school year for both grades 6 and 7. These trends align with the literature showing students' motivation and confidence in science tend to decline during the middle school years, explained by changes in the classroom environment such as increased teacher control and use of social comparison-based standards (e.g., Otis et al., 2005; Pajares et al., 2000; Shim et al., 2008). Our findings adds to the existing literature by providing evidence from a person-centered approach that this decline is characterized by decreases in mastery goals and self-efficacy in science. However, it is important to note that students' goal endorsements and self-efficacy in the *indifferent* profile are still above the mean, so the shifts represent a drop, but not a lack of goal orientation or confidence in science. On the other hand, the shift to the *low confidence/low mastery* profile (albeit small in size) is more concerning, as this represents a negative (below the mean) shift in mastery orientation and self-efficacy in science. Future research is needed to identify supports for students who exhibit these undesirable shifts, particular during the first two years of middle school.

4.3. The relationships among science motivation belief profiles, classroom goal structures, and science achievement

Our study also demonstrates the utility of the science motivation belief profiles relative to classroom goal structures and achievement in science. In the variable-centered literature, it is well-established that classroom goal structures influence students' internal achievement goal orientations (Ames, 1992; Elliot & Church, 1997; Lau & Nie, 2008; Luo, Hogan, & Paris, 2011, Meece et al., 2006; Shim et al., 2013). Here, we address the need to examine this relationship using a person-centered approach, by exploring how students' science motivation belief profiles relate to their classroom goal structures. Overall, we found that students' perceptions of their science classroom goal structures largely mirrored the degree to which they endorsed personal achievement goals. For example, students in the *confidently mastery* profile reported high classroom mastery goal structures (*M* ranging from 4.01 to 4.13), and the lowest classroom performance-approach (*M* ranging from 1.87 to 2.29) and avoidance (*M* ranging from 2.17 to 2.82) goal structures. In contrast, students in the *low confidence/low mastery profiles* reported low to moderate classroom mastery goal structures (*M* ranging from 1.49 to 3.42). This indicates that students' achievement goal environment may exert significant influences on their dispositional differences, which have important implications for structuring science classrooms to promote mastery goals and self-efficacy, and reduce performance goals, for optimal learning.

This is particularly the case given that students' profile type differentially related to end of the year science achievement. As expected, the *confidently mastery* science motivation belief profile was linked to higher science achievement across all grades, and the opposite was true for the *low confidence/low mastery* profile for all grades. These findings align with prior person-centered studies that showed that profiles characterized by high mastery goal endorsement and/or high self-efficacy are associated with positive learning behaviors and outcomes (e.g., Conley, 2012; Lo et al., 2017; Shim & Finch, 2014; Wormington & Linnenbrink-Garcia, 2017). For grades 6 and 7, our findings also support prior research regarding maladaptive outcomes associated with students characterized by no particular goal endorsement (e.g., ‘flat’ goal profiles) (Luo, Paris, et al., 2011; Tuominen-Soini et al., 2012).

However, inconsistent results regarding the relationship between science motivation belief profiles and science achievement emerged when making comparisons across grades. Whereas science achievement among grade 6 and 7 students in the *high all*, *low confident/low mastery*, and *indifferent* profiles were comparable, for grade 8, students in the *low confident/low mastery* profile demonstrated significantly lower science scores. Additionally, unlike grade 6 and 7 students, the *high all* profile students in 8th grade demonstrated higher science achievement that was similar to the *confidently mastery* students. These mixed findings regarding the *high all* profile is difficult to interpret, as this type of profile is not commonly identified in past studies. Exceptions include a study conducted in Singapore that identified a *success oriented* (high mastery, performance approach, and performance avoid) profile among older secondary students in math that was associated with higher engagement, time management, and self-regulation (Luo, Paris, et al., 2011), and a study among elementary students in Germany that showed a *multiple goals* profile was linked to greater intrinsic motivation (Schwinger et al., 2016). We provide some additional evidence that highly endorsing multiple goals can also be beneficial for science achievement, but this was the case only among grade 8 students. Given the small number of studies regarding a profile characterized by high endorsement of all achievement goals, as well as the differences across these studies (e.g., age group, country, domain) future research is needed to better understand how high endorsement of all goals relates to academic outcomes.

Finally, two profiles that were identified among grade 8 students included the *low all* and *performance-driven* profiles, which were both associated with similar science achievement scores that fell between the higher scores of the *confidently mastery* and *high all* students and the low scores of the *low confidence/low mastery* profile. A closer examination of the magnitude of students' endorsement of the goal orientations and self-efficacy shows that the *low all* profile rated all indices approximately 0.50 to 1 standard deviation below the mean, whereas students in the *low confidence/low mastery* profile rated mastery orientation and self-efficacy approximately 3 standard deviations below the mean. Examined together, our results indicate that moderately low endorsement of all motivation belief indices (*low all*), or moderately positive endorsement of performance goals (*performance-driven*) is less detrimental to science performance compared to extremely low levels of mastery and self-efficacy. Further, we found that the *low confidence/low mastery* profile is particularly detrimental for 8th graders. On the other hand the *low all* and *performance-driven* students represented a much larger proportion of the 8th grade sample, and also demonstrated low science scores. An implication is that a tiered intervention approach may be appropriate to target low motivation and self-efficacy at the end of middle school, with more individualized and high intensity approaches for the *low confidence/low mastery* group, and more generalized approaches for the *low all* and *performance-driven* students. Lack of motivation to master complex science topics, drops in confidence in science ability, and increases in external pressures to performance have been proposed as factors that impede students' science learning (Eccles et al., 1993). We add to this literature by identifying specific profile makeups of students with different combinations of these risk-factors (low mastery, low self-efficacy, and/or too much focus on performance), which can inform future practice and research aimed to target students who are at higher risk for losing interest and motivation in science. This is particularly important during the pivotal middle school years, when students begin to make decisions about their academic and professional goals.

4.4. Limitations and future directions

Although our study contributes to a deeper understanding of motivation belief profiles in middle school science, there are some limitations that should be noted. First, the educational outcome examined in this study was restricted to students' science achievement, focused on their understanding of grade-level science content. Although this type of outcome is common in LPA studies, future research is needed to examine additional outcome variables such as self-regulation strategies, engagement, and mastery of academic outcomes beyond content knowledge (e.g., nature of science, skills specific to scientific inquiry). Secondly, although the longitudinal maintenance of students' profiles over the school year were examined within each grade, inferences about students' profile stability across all three middle school grades are limited. Future longitudinal research that model individual growth trajectories over middle school is needed to further investigate the patterns of increasing differentiation and stability in profiles identified in this study. Additional research is also needed to determine whether additional measurement points are needed within the school year, as some studies have documented profile shifts within a single semester (e.g., Lee et al., 2017). It is also important to note that the analytic approach taken in this study may influence the results related to the stability and change in profile membership over time (e.g., using LTA vs. configural frequency analysis). Additionally variations in the interval in which the stability of profile membership was examined across studies may also influence the results. All of these fators should be taken into account in future studies, as well as when making comparisons across studies. Nevertheless, compared to other longitudinal analytic approaches (e.g. configural frequency analysis), LTA provides a probabilistic model-based approach that allows for model comparisons, fit analyses, and transition probabilities to be assessed (Collins, 2006). Thirdly, we used a trichotomous achievement goal framework. An important extension of the current study is to examine profiles that include mastery-avoidance orientation. Past studies have shown that the approach vs. avoidance distinction of mastery goals can influence the types of motivation profiles identified, and can also have meaningful relationships to academic outcomes (e.g., Lo et al., 2017; Lo et al., 2017; Madjar et al., 2011). Researchers may also consider including work-avoidance and social goals in future person-centered studies, which are related to achievement goals and influence important student outcomes (e.g., Gonçalves et al., 2017; Shim et al., 2013; Shim & Finch, 2014). Finally, while the examination of achievement goal and self-efficacy profiles in science, among students who represent a diverse population in the United States is a strength of this study, the findings may not generalize to students from other cultures or countries. In particular, studies are needed to test the replicability of the profile solutions identified here that demonstrated marginal fit and/or included a profile that was small in size (e.g., *low confidence/low mastery* profile). Additional research in the domain of science, within and beyond secondary grades, and among different student populations is also needed to test whether the results presented here can be generalized.

5. Conclusions

The present study provides new insights into the science motivation belief profiles of middle school students. The examination of students' profiles within each grade level, and across the school year, contributes to a deeper understanding of how key motivation and socio-cognitive factors operate within individuals at a finer grain size. Findings indicate important grade-specific differences in motivation belief profiles and patterns of stability that warrant further longitudinal investigation. Another important contribution is the finding that students' perceptions of the classroom goal structure influences their personal motivation belief profiles. These profiles in turn, were differentially associated with science achievement.

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Appendix A. Descriptive statistics for all variables across grades 6, 7, and 8 at T1 and T2

Variable	Grade	T1				T2				$M_{T2}–M_{T1}$
		M	SD	Skew	Kurtosis	M	SD	Skew	Kurtosis	
Mastery	6	4.33	0.58	−1.06	1.15	4.11	0.70	−0.83	0.54	−0.22
	7	4.36	0.59	−1.01	1.01	4.26	0.71	−0.87	0.30	−0.10
	8	4.23	0.69	−1.11	1.12	4.16	0.71	−0.75	0.62	−0.07
PerformAp	6	2.82	1.06	0.13	−0.81	2.47	1.05	0.44	−0.59	−0.35
	7	2.59	1.03	0.48	−0.34	2.61	1.19	0.48	−0.67	0.02
	8	2.66	1.09	0.38	−0.53	2.57	1.09	0.45	−0.50	−0.09
PerformAv	6	3.33	1.05	−0.24	−0.80	3.01	1.07	−0.06	−0.84	−0.32
	7	3.23	1.04	−0.10	−0.75	3.06	1.10	−0.01	−0.66	−0.17
	8	3.08	1.04	0.01	−0.64	2.97	1.05	0.12	−0.70	−0.11
Self-efficacy	6	4.05	0.77	−0.82	0.69	3.91	0.87	−0.75	0.22	−0.14
	7	4.03	0.77	−0.49	−0.33	4.09	0.83	−0.68	−0.05	0.07
	8	4.02	0.80	−0.60	−0.09	3.96	0.83	−0.57	0.02	−0.06
Class mastery	6	3.92	0.65	−0.75	0.74	3.71	0.80	−0.65	0.42	0.21
	7	3.99	0.66	−0.54	0.78	3.95	0.73	−0.66	0.65	−0.04
	8	3.90	0.73	−0.55	0.44	3.71	1.00	−1.05	0.66	−0.19
Class performAp	6	2.40	0.94	0.50	−0.20	2.39	1.00	0.57	−0.32	−0.01
	7	2.31	0.94	0.47	−0.31	2.52	1.15	0.44	−0.72	0.21
	8	2.31	0.96	0.70	0.20	2.24	1.10	0.58	0.10	−0.07
Class performAv	6	2.85	0.91	0.37	−0.42	2.69	0.86	0.38	−0.08	−0.16
	7	2.69	0.82	0.38	0.05	2.83	0.91	0.37	−0.18	0.14
	8	2.69	0.87	0.57	0.08	2.61	0.97	−0.06	0.65	−0.08
Science achievement	6	31.12	12.99	0.57	0.23	36.13	15.05	0.43	−0.09	5.01
	7	44.93	16.97	−0.06	−0.49	54.24	20.03	−0.15	−0.57	9.31
	8	39.40	17.41	0.72	0.21	44.33	19.53	0.50	−0.37	4.93

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.lindif.2018.08.003.

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