

Beyond averages: Situational lesson to lesson level interplay between relatedness and competence[☆]

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ABSTRACT

Although relatedness and competence are central psychological needs for students' motivation and well-being, their moment-to-moment variation in classrooms remains underexplored. This study examined fluctuations in adolescents' experiences of relatedness and competence across a school week using intensive longitudinal data from 118 secondary school students (average of 21 responses per student). Multilevel dynamic structural equation models showed that most variance was situational, with 30–40% reflecting stable between-person differences. Subject-specific patterns emerged, as experiences differed across school subjects. Prior relatedness predicted both subsequent relatedness and competence, suggesting that social connection can foster academic confidence. Conversely, prior competence slightly reduced later relatedness satisfaction and increased relatedness frustration, indicating a potential trade-off with social engagement. Additionally, the number of peers per lesson predicted greater relatedness satisfaction and lower frustration. These findings underscore the value of capturing motivational dynamics at the situational level and tailoring support to both academic and social needs. *Educational relevance statement:* Our study shows that students' feelings of social connection (relatedness) and confidence in their abilities (competence) can change from lesson to lesson. We found that when students felt more socially connected in one lesson, they tended to feel more confident in the next. Interestingly, feeling confident sometimes made students feel less socially connected later, especially for those students who usually felt well connected. These findings help us understand the everyday ups and downs of students' motivation and suggest that supporting both academic and social needs in the classroom is important. Schools and teachers can use this knowledge to better support students by creating learning environments that balance academic challenges with the opportunities for social connection.

1. Introduction

According to self-determination theory (SDT), experiences of relatedness and competence are essential psychological needs for fostering students' motivation, learning, well-being, and growth (Deci & Ryan, 2000). Relatedness refers to a student's sense of belonging, connection, and feeling valued by peers and teachers, while competence experiences reflect their confidence and perceived ability in academic tasks. Studies indicate that having friends and feeling socially connected often

improves students' sense of academic competence (Furrer & Skinner, 2003; Wentzel & Muenks, 2016). Although experiences of relatedness and competence are context-dependent and dynamic in nature, they are rarely investigated at the situational level. This paper addresses this gap by examining adolescents' experiences of relatedness and competence throughout a school week. By specifying state-of-the-art Dynamic Structural Equation Models (DSEM), we investigate the process-dynamics of how experiences of relatedness and competence fluctuate from lesson to lesson and investigate their autoregressive ("carry-over")

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and cross-lagged (“spill-over”) relationships. Additionally, we analyze how the number of peers within each lesson relates to students' sense of relatedness and competence.

1.1. Relatedness and competence as basic psychological needs

Experiences of relatedness and competence are basic psychological needs that must be fulfilled for individuals to thrive, learn, and stay motivated (Deci & Ryan, 2000). Their importance is emphasized particularly in SDT, but also in other theoretical frameworks. The term basic refers to the idea that these needs are not learned but innate and universal, serving as “functionally critical elements” that humans require to thrive (Ryan & Moller, 2017, p. 217; see also Chen et al., 2015). Satisfaction of these needs supports, and their frustration or active thwarting undermines well-being and motivation both in the short and long term (Ryan & Moller, 2017). Importantly, need satisfaction and frustration are not opposite ends of a continuum but empirically distinct constructs: satisfaction is associated with positive outcomes such as engagement and well-being, while frustration is linked to maladaptive outcomes including distress and disengagement (Chen et al., 2015; Schmidt et al., 2020; Vansteenkiste & Ryan, 2013).

Relatedness refers to the need for a sense of belonging and connection with others (Baumeister & Leary, 1995; Deci & Ryan, 2000), recognized as a fundamental aspect of human life across several theoretical perspectives (e.g., attachment theory; Bowlby, 1969; hierarchy of needs; Maslow, 1943). Within SDT, relatedness is considered a core need that fosters engagement when satisfied and contributes to disaffection when thwarted (Chen et al., 2015; Furrer & Skinner, 2003).

Despite its centrality, relatedness has received comparatively less empirical attention than other needs (King, 2015; Skinner et al., 2008), and has sometimes been measured only as part of broader constructs, such as autonomy-supportive environments (Mouratidis et al., 2011; Mouratidis & Lens, 2015; Tsai et al., 2008), rather than examined as a distinct construct. However, studies focusing specifically on relatedness highlight its unique role as a motivational resource. For example, Furrer and Skinner (2003) found that relatedness was not only associated with higher engagement at the beginning of the school year but also predicted increases in engagement over time. Moreover, it emerged as a stronger predictor of students' self-reported engagement than perceived control. Research therefore suggests that relatedness may initiate a positive motivational cycle, where feeling connected boosts engagement, which in turn reinforces other adaptive motivational beliefs and academic emotions (e.g., Bürgermeister et al., 2016; Furrer & Skinner, 2003; Skinner et al., 2008). Simultaneously, other findings point to a more complex relationship between relatedness and academic outcomes. For example, van Leeuwen et al. (2023, 2025) found that higher relatedness satisfaction during collaborative tasks was associated with lower group-level performance suggesting that while relatedness can foster engagement and well-being, it may, in certain situations, come at the expense of cognitive focus or task performance.

In the school context, relatedness has typically been examined in relation to children's “significant others”, that is, parents, teachers, and peers (e.g., Furrer & Skinner, 2003). Studies considering multiple sources of relatedness indicate that its effects may vary depending on the relationship type (Furrer & Skinner, 2003; King, 2015). In addition, the quality of interactions has been found to play a critical role, with meaningful conversations and experiences of being understood and appreciated being the strongest predictors of relatedness satisfaction, whereas feelings of insecurity or self-consciousness during social interactions have been negatively associated with relatedness (Reis et al., 2000).

The concept of competence in SDT has its roots in White's (1959) theory of effectance motivation, which defines competence as “an organism's capacity to interact effectively with its environment” (p. 297; see also Ryan & Moller, 2017). According to White (1959), human beings need opportunities to exert control, explore, and influence their

surroundings, because they have a natural innate need toward mastery, learning, and growth. Therefore, in SDT, competence is defined as a psychological need reflecting the satisfaction individuals experience when feeling capable and effective in handling challenges and achieving their goals (Deci & Ryan, 2000; Ryan & Moller, 2017). While competence-related beliefs are central to many motivational theories (for reviews, see Marsh et al., 2017; Muenks et al., 2018), including self-efficacy (Bandura, 1977), agency beliefs (Skinner et al., 1988), academic self-concept (Marsh & Craven, 2006), and expectancy beliefs (Eccles & Wigfield, 2002), SDT distinguishes competence need satisfaction as a felt sense of effectiveness, rather than a belief about future capability (Rodgers et al., 2014; Ryan & Moller, 2017). A large body of research has shown that students' sense of competence is consistently associated with a range of positive academic and psychological outcomes, including not only better academic performance but also enhanced well-being, greater engagement, and more persistent learning behaviors (Deci & Ryan, 2000; Marsh et al., 2017; Muenks et al., 2018).

1.2. Associations between relatedness and competence

Although SDT is a widely used motivational framework, surprisingly few studies have specifically examined the associations between its core psychological needs. Most existing research (e.g., Bureau et al., 2022; Howard et al., 2025; Wang et al., 2019) has focused on how these needs, either jointly or separately, predict student outcomes rather than how they may be interrelated or mutually reinforcing over time. However, findings from studies including both relatedness and competence as predictors (e.g., Chen et al., 2015; Furrer & Skinner, 2003; Maddens et al., 2023; Reis et al., 2000; Wang et al., 2019) suggest that these needs often co-occur at the between-person level, and similar patterns have also been observed at the within-person level (Reis et al., 2000; Yu & Levesque-Bristol, 2020).

Studies examining relatedness and competence simultaneously, rather than using them solely as predictors of other outcomes, remain relatively scarce. However, a few longitudinal and experimental studies have provided insights into how these needs may be interrelated. In an experimental study, Sheldon and Filak (2008) manipulated support for autonomy, competence, and relatedness in a game-learning context to examine their individual and combined effects on outcomes such as need satisfaction, mood, intrinsic motivation, and performance. All three needs were positively correlated and showed unique predictive power, but competence and relatedness were stronger predictors than autonomy. Notably, supporting relatedness increased relatedness satisfaction without affecting autonomy or competence, whereas supporting competence boosted both competence and relatedness satisfaction, suggesting a potential directional link between these two needs. A similar pattern was found in a longitudinal quasi-experimental study by Bürgermeister et al. (2016), which examined how supporting autonomy, competence, and relatedness during weekly university seminars influenced students' motivational experiences over time. Prior competence predicted not only later competence but also subsequent relatedness, which in turn predicted later competence, suggesting a dynamic interplay between the needs. Notably, these cross-lagged associations did not appear in the control group, which received support only for autonomy and competence. These findings suggest that supporting all three basic needs may strengthen the interdependence between competence and relatedness across time.

More recently, Wang et al. (2024) investigated within- and between-person associations between academic self-efficacy, intrinsic motivation, and school relatedness among adolescents across four measurements over two years. The results of their random-intercept cross-lagged panel models showed that experience of school relatedness, measured as students' perceived relationships with teachers, was positively associated with self-efficacy and intrinsic motivation at both levels. In addition, significant autoregressive paths were observed for all examined constructs. However, only one cross-lagged relationship was significant,

showing that prior school relatedness predicted an increase in intrinsic academic motivation six months later. The authors suggest that the lack of other cross-lagged effects may be due to their data collection taking place during the COVID-19 pandemic, but also emphasize the need for future studies to explore the associations between these motivational constructs using different time spans and intervals to understand better how they evolve and interact over time.

1.3. Situational dynamics in experiences of relatedness and competence

Even though SDT explicitly posits that psychological needs are dynamic and vary according to situational characteristics and social context (Deci & Ryan, 2000), relatively few studies have examined these needs at the situational level in the school context. Most prior research has focused on trait-level or between-person differences (see Guay, 2022, for a review on SDT studies in the education contexts), leaving the way students' motivational states fluctuate across different classroom environments and lessons unaddressed.

Meanwhile, in the field of work and organizational psychology, various types of momentary and diary studies aimed at capturing within-person dynamics in daily experiences and need satisfaction have become increasingly popular (for a review, see Coxen et al., 2021). These studies underscore the importance of examining psychological needs as distinct, dynamically fluctuating constructs with unique antecedents and outcomes, rather than treating them as a combined construct (Coxen et al., 2021). For example, Olafsen et al. (2025) examined daily fluctuations in employees' need frustration over eight consecutive workdays and found that competence and relatedness frustration were positively correlated at both the within- and between-person levels. While competence frustration was associated with more exhaustion and negative affect and with lower levels of relaxation, relatedness frustration showed weaker quantitative effects but was linked to sleep problems in qualitative responses. These findings highlight not only the unique implications of each need, but also the importance of studying their joint fluctuations.

Within educational psychology, there has also been a growing body of research examining intraindividual fluctuations in students' real-time motivational experiences in the school context (Malmberg & Martin, 2019; Martin et al., 2015; Martin et al., 2020; Murayama et al., 2017; Neubauer et al., 2022; Patall et al., 2018; for reviews of ESM studies on emotional outcomes in educational settings, see Mölsä et al., 2022; Mölsä et al., 2025a). Of particular interest to the present study is the potential interplay between the needs for relatedness and competence, which has been hinted at but rarely examined directly.

Previous research has shown that both relatedness and competence fluctuate meaningfully from moment to moment. Schmidt et al. (2020) reported intraclass correlations (ICCs) between 0.41 and 0.45 for relatedness satisfaction and frustration across three sub-studies with primary school children, indicating that 40–45% of the variance was between-person and 55–60% reflected within-person, day-to-day variation. Studies on competence have yielded more mixed results, partly due to differences in time frames and measurement approaches. Parriusius et al. (2022) examined competence beliefs across five consecutive math lessons among ninth-graders and found that 52% of the variance was within-person, 5% at the classroom level, and 43% at the between-person level. Other studies have found higher trait-level stability in competence-related constructs: Niepel et al. (2022) reported that 73% of the variance in math self-concept over three weeks was at the between-person level, while Martin et al. (2020) found that 66% of the variance in self-efficacy among 12-year-olds was at the between-person level and 31% at the lesson level.

Building on evidence of situational fluctuation, several studies have examined the associations between momentary variations in students' relatedness and competence, and emotional and motivational outcomes. Schmidt et al. (2019) found that both within- and between-person variation in peer relatedness predicted students' positive and negative affect throughout the day. Similarly, Moller et al. (2010) showed that

daily relatedness was positively associated with positive affect, particularly among students with higher overall relatedness. Mölsä et al. (2025b) found that the quality of peer relationships during the day predicted daily variation in positive affect. Schmidt et al. (2020) and Schmidt et al. (2021) further distinguished between relatedness satisfaction and frustration, showing that satisfaction was linked to higher positive affect and fewer emotional or peer problems, whereas frustration was associated with more negative affect, school anxiety, and conduct issues. Regarding competence, Neubauer et al. (2022) found that daily competence exhibited a carryover effect, with competence experiences predicting higher motivation the following school day.

However, the above-mentioned studies focused on either relatedness or competence; for insight into their dynamic interplay and potential interrelations, we must turn to studies incorporating both. Reis et al. (2000) conducted a two-week diary study among psychology students, showing that daily autonomy and competence predicted all well-being indicators, while relatedness was linked only to positive outcomes. However, they did not examine the associations between the needs themselves. Offering further insight, Minnaert et al. (2007) followed vocational students over five days and found that while competence remained stable, relatedness declined midweek, and its correlation with competence increased over time, suggesting an evolving interplay between these needs. Two further studies (Park et al., 2012; Vandekerckhove et al., 2019) showed that need satisfaction fluctuates over short time spans and relates to engagement and affect. However, Vandekerckhove et al. (2019) used aggregated measures without distinguishing between autonomy, competence, and relatedness, while Park et al. (2012) examined each need separately but did not explore how they might influence or co-vary with one another.

While these studies highlight the value of situational approaches in understanding student motivation, the school context, where students move between distinct academic and social settings, makes lesson-level investigations particularly relevant. Tsai et al. (2008) showed that situational interest varied across lessons and was positively associated with autonomy and cognitive support. Although they did not directly measure relatedness or competence, their autonomy support scale included interpersonal aspects (e.g., feeling understood), and cognitive support reflected elements of competence. Similarly, Bieg et al. (2017) found that lesson-specific instructional practices shaped students' academic emotions; collaborative activities, such as peer work, were linked to more positive emotional experiences than teacher-directed instruction. A systematic review of ESM studies by Mölsä et al. (2025a) further showed that being with others, as opposed to being alone, was consistently associated with more positive emotions in educational contexts. Finally, van Leeuwen et al. (2025) demonstrated that working in pairs rather than quartets led to higher relatedness satisfaction, suggesting that even small variations in group structure can influence students' social experiences during learning.

Adding to lesson-level explorations, Malmberg and Martin (2019) examined primary school students' competence beliefs across approximately 15 learning moments per week, finding a significant autoregressive effect within the same school subject. Similarly, Niepel et al. (2022) used dynamic structural equation modeling (DSEM) to study secondary students' math self-concept and perceived achievement across three weeks. Their results showed that the commonly observed reciprocal relationship between self-concept and achievement at the between-person level also held at the within-person level. Crucially, they found individual differences in both autoregressive and cross-lagged effects. For example, students with higher trait-level math self-concept exhibited greater stability in their self-concept over time, suggesting that their self-concept was less influenced by situational fluctuations. Their findings therefore challenge the assumption of homogeneity of within-person processes across individuals typically built into traditional models (Hamaker, 2012; Saqr et al., 2024) and demonstrate the importance of examining motivational processes with a method that not only separates within- and between-person variance but

also makes it possible to examine individual differences in these temporal processes. In the present study, we adopt the same dynamic structural equation modeling (DSEM) approach to examine students' real-time experiences of relatedness and competence in the school context.

2. The present study

Building on previous research highlighting the importance of psychological need satisfaction in students' daily experiences, the present study focuses on the situational interplay between relatedness and competence in the classroom. While prior studies have shown that these needs fluctuate over time, and that their satisfaction is linked to various positive outcomes (Furrer & Skinner, 2003; Reis et al., 2000), few have examined how they dynamically influence each other within the school day. Existing work has often focused on the predictive role of psychological needs in student outcomes (Chen et al., 2015; Wang et al., 2024), using aggregated measures or isolating individual needs in the analysis (Mouratidis & Lens, 2015; Schmidt et al., 2019, 2021; Tsai et al., 2008), thereby largely overlooking their interrelations and potential dynamic co-variation. The present study addresses this gap by investigating the within-person interplay between relatedness and competence at the lesson level across multiple time points. Specifically, we examine both the autoregressive paths, also referred to as carry-over effects, which reflect the stability of each construct from one lesson (time $T - 1$) to the next (time T), and the cross-lagged effects between constructs (i.e., whether relatedness at time $T - 1$ predicts competence at time T , and vice versa). At the between-person level, we also explore individual differences in these temporal processes.

Prior research suggests that collaborative learning can promote positive student experiences (Bieg et al., 2017), in turn possibly supporting the satisfaction of psychological needs in classroom settings. We therefore also examine how the number of peers students work with during each lesson relates to their momentary experiences of relatedness and competence. The present study addresses the following research questions (RQs):

- RQ1: To what extent do students' experiences of relatedness and competence fluctuate from lesson to lesson, and how is the subject of the lesson associated with these fluctuations?
- RQ2: What are the autoregressive and cross-lagged relationships between relatedness and competence across lessons?
- RQ3: How is the number of peers students work with during each lesson associated with their momentary experiences of relatedness satisfaction and frustration and competence satisfaction?

3. Methods

3.1. Sample and procedure

Data were collected in January 2022 in a Finnish lower secondary school¹ as part of a larger research project that had received approval from the Ethics Committee of [anonymised]. The study was conducted in accordance with the ethical principles for research involving human

¹ In Finland, primary and lower secondary education are provided within a comprehensive school system covering grades 1–9. In lower secondary school (grades 7–9), instruction is typically subject-based and taught by specialized subject teachers. A school year consists of approximately 190 school days, and students usually attend 20–30 lessons/week, depending on grade level and optional subjects (Finnish National Agency for Education, 2017). Lessons typically last about 45 min, with daily schedules determined at the school level. The Finnish education system places a strong emphasis on educational equity and does not include, for example, national high-stakes standardized testing or official tracking at the comprehensive school level (Thrupp et al., 2023).

participants. All students at the school ($N = 247$) were invited to participate, and a total of 118 students (Mage = 13.67 years, SD = 0.73, min = 12, max = 16; female 63%). Participation was voluntary, and both students and their parents were informed about the study. Passive parental consent was obtained by allowing parents to opt their child out by informing the researchers. No parental refusals were received for students who personally wished to take part in the study. Students were informed that they were free to withdraw from the study at any point by simply choosing not to continue responding.

Data were collected using the m-Path app (Mestdagh et al., 2023), which students installed on their own smartphones. The data collection spanned six consecutive school days, beginning with an in-person launch and app setup on the first day, followed by five additional days of survey responses. During the first two lessons of the launch day, researchers visited all participating classrooms to guide students through the installation process and ensure the app was working correctly. In addition, the students were given written instructions for downloading the app, and information on participation being voluntary, responses remaining anonymous and inaccessible to teachers, and data being used solely for research purposes. Data collection took place during regular classroom instruction across the school week. Students received short mobile survey prompts (“beeps”) via the m-Path application. Each survey was tailored to the student's schedule and became available within a 30-min window around the end of each lesson (15 min before and after), making the beeps lesson-contingent rather than random. Depending on their daily schedules, students could receive multiple beeps per day. Because instruction in the participating school was organized flexibly across subjects, students did not remain in a single fixed instructional group throughout the day, but studied different subjects with varying peer groups.

During data cleaning, all responses were manually checked. Subject entries were verified against school timetables and lesson timestamps to ensure consistency. Duplicate entries with implausible timestamps were removed. Although the application sent the questionnaires within the designated time windows, students could technically respond later than scheduled. As such, late responses outside the expected timeframe were excluded. After data cleaning, the final analytical sample consisted of 114 students.

On average, each participant received 26.18 beeps across the data collection days, with the number of responses per participant ranging from 7 to 37. Of these, an average of 12.76 responses per participant included complete data on both relatedness and competence. We examined the nature of the attrition by first comparing the distribution of lesson subjects between the full dataset and the subset with valid responses, and found the distributions to be highly similar, indicating attrition was unrelated to lesson subject. We then ran logistic regression analyses in which we predicted attrition in relatedness or competence with beep number, with the results showing that attrition increased significantly over time for all examined variables ($b = 0.075, p < .001$ for relatedness satisfaction, relatedness frustration, and competence satisfaction), indicating that later beeps were more likely to be unanswered and suggesting that missing data were not Missing Completely at Random (MCAR), but rather systematically related to time (e.g., due to response fatigue) and therefore considered to be Missing at Random (MAR) (Bennett, 2001). This assumption is enough to meet with the requirements of the Bayesian estimation used in the DSEM (Asparouhov et al., 2018) framework applied in our analyses.

3.2. Measures

Students rated their relatedness experiences and perceived competence using a sliding scale (0–100) in the m-Path app. As is common in these types of momentary studies (Allen et al., 2022; Gogol et al., 2014; Saqr et al., 2024), each construct was measured with a single item (i.e. relatedness satisfaction: “During the lesson, I felt that my classmates accepted me as part of the group”; relatedness frustration: “During the

lesson, I felt myself lonely”; competence satisfaction: “I did well in the lesson”). The items were adapted from established multi-item measures and reformulated to capture momentary, lesson-specific experiences.²

Students also nominated up to five classmates they had worked with during each lesson. This information was used to calculate the total number of peers each student worked with per lesson. Although the instructions limited nominations to five, some students ($n = 5$) listed up to seven peers on a single measurement occasion each. On average, students reported working with 1.43 peers per lesson ($SD = 1.32$; range 0–7).

Additionally, students selected the subject of each lesson from a drop-down menu with ten predefined options: Mathematics, Finnish, English, Swedish, French, Physics, Chemistry, Biology, Sports, and Other. If “Other” was selected, students could specify the subject in an open text field. These open-text responses indicated that the “Other” category comprised a heterogeneous set of subjects not listed as predefined options, including for example health education, philosophy, history, geography, visual arts, music, international relations, and psychology. The three most frequently reported subjects were Other (ca. 43%), Mathematics (ca. 14%), and Finnish language (10%). Given that “Other” represented the largest category, it was used as the reference category in the analyses, and dummy variables were created for each predefined subject.

3.3. Data analyses

Preliminary analyses, data cleaning, and management were conducted in R, and DSEM in Mplus (Muthén & Muthén, 2018). To address RQ1 regarding the variability in students' experiences of relatedness and competence across lessons, ICCs were first calculated with an empty two-level model for each outcome, to partition the total variance into within-person (i.e., situational, lesson-level variance) and between-person components. DSEM (Asparouhov et al., 2018) was conducted to address the subject-specific part of RQ1, as well as RQ2 and RQ3.

One of the key assumptions of DSEM is stationarity, which means that the main statistical properties of the outcome variables, such as their mean, variance, and autocorrelations, remain constant over time and do not systematically change across measurement points (e.g., Asparouhov et al., 2018; Dettweiler et al., 2024). We therefore first examined the stationarity assumption with the Augmented Dickey-Fuller (ADF) test, in which the null hypothesis assumes a unit root (i.e., that the series is non-stationary, meaning it follows a random walk and drifts over time rather than fluctuate around a stable mean). The ADF tests yielded significant p -values ($p < .01$) for all outcome variables, indicating that the series were stationary and allowing us to reject the null hypothesis of a unit root. Furthermore, following the recommendations of McNeish and Hamaker (2020), we then conducted a series of linear regression models in which measurement occasions were nested within individuals, and time was used to predict each outcome variable at the within-person level. The results of these analyses indicated no significant linear trend over time for relatedness satisfaction ($\beta = 0.02$, $p = .735$), or for competence satisfaction ($\beta = -0.01$, $p = .856$). However, for relatedness frustration ($\beta = -0.10$, $p = .010$), the analyses showed a significant downward trend over time ($b = -0.22$, $t = -3.61$, $p < .001$), indicating a systematic change in the mean level of the variable across measurement points. Therefore, in line with McNeish and Hamaker (2020), we included time as a within-person predictor in the model for relatedness frustration. To check the robustness of our findings further, we also conducted a residual dynamic structural equation model

(RDSEM) (Dettweiler et al., 2024; McNeish & Hamaker, 2020). The results from both the standard DSEM and the RDSEM were consistent. Thus, we report the results from the DSEM in the main text and include the RDSEM results in the Appendix A.

We conducted two separate DSEM models: one for relatedness satisfaction and competence (Model 1), and another for relatedness frustration and competence (Model 2). To facilitate interpretation and improve model convergence, all continuous predictors were standardized prior to analysis. The models were estimated using Bayesian estimation in Mplus with 100,000 iterations, a thinning interval of 10, and two Markov chains. At the within-person level (Level 1), the subject of the lesson and the sum of peers predicted the experiences of relatedness and competence. In addition, the autoregressive and cross-lagged random slopes of relatedness and competence were specified. Random slopes were allowed to correlate at the between level (Level 2). To account for variation in response timing, time interval was specified in minutes with the TINTERVAL option set to 60 min. Model convergence was evaluated using the potential scale reduction criterion (PSR), with <1.05 as criterion for acceptable convergence along with an examination of trace plots for each parameter (Asparouhov & Muthén, 2010).

4. Results

Regarding RQ1, ICCs revealed that for all outcome variables, most of the variance was at the situational (within-person) level, with 39.4% of the variance in relatedness satisfaction, 42.9% in relatedness frustration, and 30.9% in competence attributable to differences between individuals, the remaining variance reflecting lesson-to-lesson fluctuations within students.

Our DSEMs addressing the remaining RQs showed good convergence, with potential scale reduction (PSR) values below 1.05 for both models (Model 1: 1.019; Model 2: 1.045) and trace plots indicating good mixing across chains. Lesson subject significantly predicted momentary experiences of relatedness and competence (see Table 1). Experiences of relatedness varied according to the subject of the lesson, so that relatedness satisfaction was lower and relatedness frustration higher in sports lessons. In addition, relative to relatedness in the “other” (i.e., the baseline) subject, relatedness satisfaction was lower in chemistry lessons, although the effect was small, and the upper bound of the 95% credibility interval was close to zero. Similarly, the subject of the lesson was also associated with students' experiences of competence. Specifically, relative to competence in the “other” (i.e., the baseline), subject competence was lower in Swedish language, chemistry, and mathematics lessons. Furthermore, in Model 2, physics lessons were also associated with lower competence, and this effect was close to statistical credibility also in Model 1.

Regarding RQ2, which focused on the interplay between relatedness satisfaction, relatedness frustration, and competence (see Fig. 1), our results showed that prior experiences of relatedness had a statistically credible carryover effect to the following lesson. This was detected both for relatedness satisfaction in Model 1 ($\beta = 0.152$, CI [0.069, 0.233]) and for relatedness frustration in Model 2 ($\beta = 0.177$, 95% CI [0.105, 0.257]). In contrast, the autoregressive path for competence included zero in both models (Model 1: $\beta = -0.022$, CI [-0.102, 0.055]; Model 2: $\beta = 0.006$, 95% CI [-0.068, 0.078]), indicating no statistically credible carryover effect for experiences of competence between lessons. For the cross-lagged relationships between relatedness satisfaction and competence, results in Model 1 showed that prior experiences of relatedness satisfaction positively predicted later experiences of competence ($\beta =$

² In a larger Finnish student dataset ($N = 1461$), conceptually similar multi-item measures showed excellent internal consistency for relatedness satisfaction ($\alpha = 0.934$), acceptable-to-good internal consistency for relatedness frustration/loneliness ($\alpha = 0.79$), and good internal consistency for competence satisfaction ($\alpha = 0.888$), supporting the coherence of the underlying constructs.

Table 1
Effects of lesson subject and number of peers on relatedness and competence.

	Model 1. Relatedness satisfaction and competence		Model 2. Relatedness frustration and competence	
	Relatedness satisfaction	Competence	Relatedness frustration	Competence
Math	-0.021 [-0.139, 0.095]	-0.232 [-0.358, -0.104]	-0.016 [-0.135, 0.102]	-0.22 [-0.352, -0.093]
Finnish	-0.128 [-0.268, 0.005]	-0.054 [-0.194, 0.090]	-0.074 [-0.212, 0.065]	-0.017 [-0.164, 0.124]
English	-0.108 [-0.258, 0.040]	-0.018 [-0.182, 0.148]	-0.020 [-0.174, 0.131]	-0.050 [-0.219, 0.117]
Swedish	-0.046 [-0.222, 0.131]	-0.313 [-0.499, -0.127]	-0.099 [-0.270, 0.076]	-0.272 [-0.463, -0.078]
French	-0.038 [-0.362, 0.281]	-0.157 [-0.497, 0.195]	0.157 [-0.177, 0.495]	-0.180 [-0.541, 0.186]
Physics	-0.001 [-0.256, 0.257]	-0.259 [-0.528, 0.001]	-0.004 [-0.252, 0.242]	-0.320 [-0.579, -0.053]
Chemistry	-0.176 [-0.344, -0.007]	-0.310 [-0.488, -0.134]	0.095 [-0.076, 0.265]	-0.292 [-0.477, -0.110]
Biology	-0.011 [-0.243, 0.215]	-0.142 [-0.390, 0.101]	-0.027 [-0.257, 0.206]	-0.127 [-0.375, 0.114]
Sports	-0.322 [-0.491, -0.150]	-0.165 [-0.351, 0.016]	0.254 [0.079, 0.424]	-0.120 [-0.305, 0.069]
Peers	0.103 [0.069, 0.137]	0.024 [-0.014, 0.060]	-0.075 [-0.110, -0.039]	0.026 [-0.013, 0.065]

Note. Peers = number of peers; Unstandardized parameter estimates are presented with their 95% Credible Intervals in brackets. Statistically credible effects (i.e. those whose intervals do not include zero) are shown in **bold**.

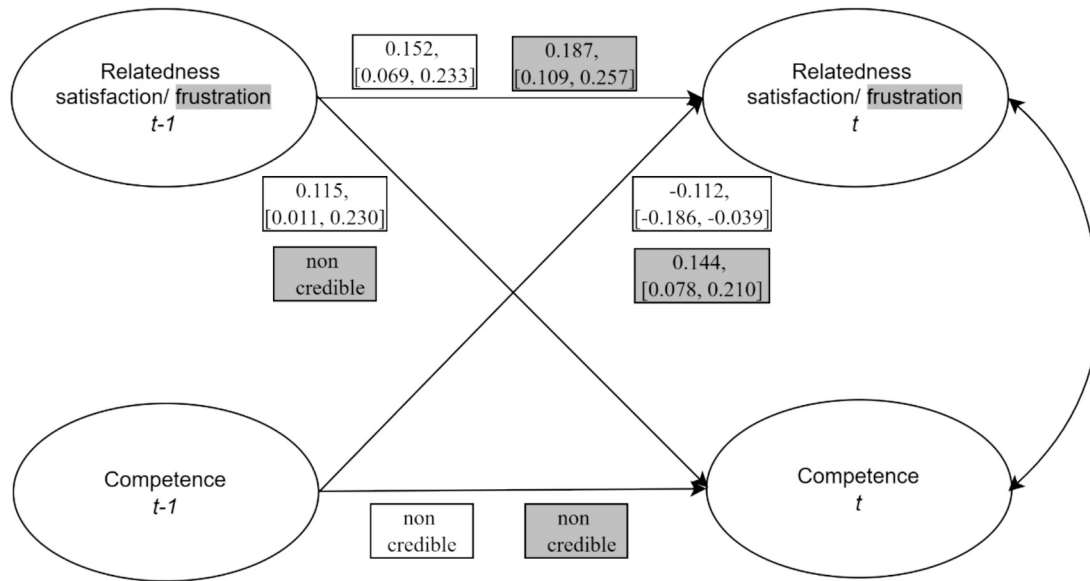


Fig. 1. Graphical representation of both models.

Note. Results from Model 1 with relatedness satisfaction and competence are shown in white boxes and results from Model 2 with relatedness frustration and competence with grey boxes. The figure show the standardized model parameters with their 95% credible intervals in brackets for those paths that were statistically credible.

0.115, CI [0.011, 0.230]).³ Conversely, the reverse relationship was negative, indicating that prior experiences of competence predicted lower levels of relatedness satisfaction in the following lesson ($\beta = -0.112$, CI [-0.186, -0.039]).

In Model 2, relatedness frustration and competence did not show credible cross-lagged effects in the direction from relatedness frustration to competence ($\beta = -0.037$, 95% CI [-0.171, 0.069]). However, consistent with the results from Model 1, prior experiences of competence were associated with a statistically credible increase in relatedness frustration in the following lesson ($\beta = 0.143$, 95% CI [0.065, 0.213]).

Tables 2 and 3 present the between-person level means, variances, and correlations of both models. Based on the credible variances in both models, we see that students differed from each other not only in their

³ This effect was not statistically credible in the unstandardized solution (see Table 2). As explained by Hamaker et al. (2018), this apparent discrepancy arises because the averaged individually standardized parameter generally has a smaller credible interval than the corresponding unstandardized model parameter. The former allows for inferences conditional on the sampled individuals (i.e., within-cluster observations), whereas the latter generalizes to the population level. Therefore, this result should be interpreted with caution, as it may not reflect a reliable effect at the population level.

average (trait-like) experiences of competence and relatedness, but also in the strength of their autoregressive effects reflecting how much their experiences carried over from one lesson to the next. Similarly, statistically credible variances in the cross-lagged effects suggest individual differences in the dynamic interplay between experiences of relatedness and competence across time.

Between-person standardized correlations showed average (trait-like) relatedness satisfaction to correlate positively ($\rho = 0.704$) and relatedness frustration negatively ($\rho = -0.478$) with average (trait-like) competence, indicating that students who felt more connected to others during the week tended to perceive themselves as more competent, while those who felt themselves lonelier reported lower levels of competence. Regarding cross-lagged effects, the negative correlation ($\rho = -0.468$) between the average level of competence and the cross-lagged effect from competence to relatedness satisfaction suggests that prior feelings of relatedness played a more central role in shaping concurrent competence experiences for students who generally felt less competent. Notably, this between-level variation emerged even though the overall cross-lagged effect from relatedness to competence was not statistically credible in the unstandardized solution (see Table 2 and the previous footnote about this at page 17).

For the other cross-lagged effect (i.e., from prior competence to later

Table 2

Level 2. Means, variances (unstandardized estimates), and correlations (standardized estimates) with their 95% Credible Intervals (in brackets) of Model 1.

Variable	Fixed effects (means)	Random effects (variances)	Correlations					
			1.	2.	3.	4.	5.	
1. Comp.	-0.017 [-0.168, 0.136]	0.407 [0.280, 0.603]	-					
2. RelSat.	-0.219 [-0.388, 0.056]	0.523 [0.367, 0.756]	0.704 [0.525, 0.827]	-				
3. AR Comp.	-0.025 [-0.121, 0.071]	0.082 [0.042, 0.143]	0.264 [-0.146, 0.616]	0.485 [0.096, 0.753]	-			
4. AR RelSat.	0.164 [0.055, 0.265]	0.098 [0.053, 0.163]	-0.293 [-0.605, 0.072]	-0.346 [-0.637, 0.009]	-0.550 [-0.840, -0.016]	-		
5. CL: RelSat. → Comp.	0.148 [-0.015, 0.296]	0.261 [0.142, 0.444]	-0.468 [-0.711, 0.099]	-0.153 [-0.503, 0.225]	-0.347 [-0.767, 0.193]	0.230 [-0.196, 0.608]	-	
6. CL: Comp. → RelSat.	-0.100 [-0.194, 0.002]	0.094 [0.051, 0.165]	0.234 [-0.146, 0.541]	0.458 [0.077, 0.739]	0.594 [0.174, 0.870]	-0.505 [-0.788, 0.061]	-0.390 [-0.710, -0.008]	

Note. Comp. = competence; RelSat = relatedness satisfaction; AR Comp. = autoregression of competence; AR RelSat. = autoregression of relatedness satisfaction; CL RelSat. → Comp. = cross-lagged effect from relatedness satisfaction to competence; CL: Comp. → RelSat. = cross-lagged effect from competence to relatedness satisfaction. Statistically credible effects (i.e. those whose intervals do not include zero) are shown in **bold**.

Table 3

Level 2. Means, variances (unstandardized estimates), and correlations (standardized estimates) with their 95% Credible Intervals (in brackets) of Model 2.

Variable	Fixed effects (means)	Random effects (variances)	Correlations					
			1.	2.	3.	4.	5.	
1.Comp.	-0.005 [-0.158, 0.152]	0.368 [0.250, 0.548]	-					
2. RelFr.	0.311 [0.126, 0.504]	0.532 [0.371, 0.733]	-0.478 [-0.669, 0.243]	-				
3. AR Comp.	0.001 [-0.088, 0.091]	0.065 [0.029, 0.117]	0.212 [-0.227, 0.605]	-0.405 [-0.730, 0.012]	-			
4. AR RelFr.	0.181 [0.093, 0.267]	0.049 [0.024, 0.091]	-0.283 [-0.701, 0.164]	0.394 [-0.031, 0.727]	0.152 [-0.468, 0.679]	-		
5.CL: RelFr. → Comp.	-0.067 [-0.234, 0.094]	0.190 [0.101, 0.325]	0.171 [-0.284, 0.538]	-0.017 [-0.322, 0.301]	0.104 [-0.388, 0.519]	0.357 [-0.175, 0.742]	-	
6. CL: Comp. → RelFr.	0.146 [0.048, 0.242]	0.116 [0.059, 0.207]	-0.233 [-0.517, 0.074]	0.762 [0.500, 0.911]	-0.321 [-0.717, 0.191]	-0.066 [-0.490, 0.423]	-0.169 [-0.496, 0.181]	

Note. Comp. = competence; RelFr. = relatedness frustration; AR Comp. = autoregression of competence; AR RelFr. = autoregression of relatedness frustration; CL RelFr. → Comp. = cross-lagged effect from relatedness frustration to competence; CL: Comp. → RelFr. = cross-lagged effect from competence to relatedness frustration. Statistically credible effects (i.e. those whose intervals do not include zero) are shown in **bold**.

relatedness), between-person correlations showed that its strength varied depending on students' average levels of relatedness satisfaction or frustration, as well as the stability of their relatedness and competence experiences. In Model 1, a positive correlation between average relatedness satisfaction and the cross-lagged effect from competence to relatedness satisfaction ($\rho = 0.458$) indicated that this effect was stronger for students who typically felt more connected to their peers. Given that the main cross-lagged effect in this model was negative, this means that, for students with a high average sense of relatedness satisfaction, moments of competence were more likely to disrupt their subsequent feelings of relatedness. A comparable pattern emerged in Model 2 in which a positive correlation between average relatedness frustration and the cross-lagged effect from competence to relatedness frustration ($\rho = 0.762$) indicated that students who generally felt lonelier, feeling competent in one lesson was more likely to be followed by increased feelings of loneliness in the next. Additionally, in Model 1, the cross-lagged effect from competence to relatedness satisfaction correlated negatively with the autoregressive effect of relatedness satisfaction ($\rho = -0.505$) and positively with that of competence ($\rho = 0.594$). This suggests that students with less stable sense of relatedness were more sensitive to the negative social impact of prior competence, whereas students with more stable competence were more likely to experience a disruption in relatedness following moments of competence.

The positive correlation between relatedness satisfaction and the autoregressive effect of competence ($\rho = 0.485$) indicated that students with higher average levels of relatedness exhibited more stable

competence across lessons, even though the overall autoregressive effect of competence was not statistically credible. A similar but opposite pattern was observed in Model 2, where the mean of relatedness frustration correlated negatively with the autoregressive effect of competence ($\rho = -0.405$), suggesting that students who generally felt lonelier showed less stability in their competence experiences. Additionally, in Model 1, a negative correlation between the autoregressions of competence and relatedness satisfaction ($\rho = -0.550$), suggested that students who showed high stability in one domain tended to exhibit less stability in the other. A similar pattern emerged for the cross-lagged effects where a negative correlation ($\rho = -0.390$) indicated that these effects did not typically co-occur within the same individuals. That is, students who benefited more in competence from prior experiences of relatedness were less likely to experience a decline in relatedness following moments of competence and vice versa.

Finally, regarding RQ3, the results showed that the number of peers a student had worked with during the lesson was associated with their experiences of relatedness satisfaction and frustration, but not with competence (see Table 1). Specifically, having worked with more peers predicted higher levels of relatedness satisfaction and lower levels of relatedness frustration during the lesson.

5. Discussion

In this study, we explored the dynamics of lesson-to-lesson variation in students' experiences of relatedness and competence in school.

Although both needs are considered context-sensitive and dynamic within SDT (Deci & Ryan, 2000; Ryan & Moller, 2017), surprisingly little research has investigated them at the situational level. Prior work has focused largely on between-person differences (e.g., Furrer & Skinner, 2003; Wang et al., 2019), and few studies have examined how relatedness and competence interact over time. By addressing these gaps, our findings provide new insights into the within-person dynamics of students' motivational experiences.

5.1. Situational fluctuations and differences between subjects in relatedness and competence

RQ1 considered the amount of situational lesson-to-lesson level fluctuation in students' relatedness satisfaction, frustration, and competence experiences, and how the subject of the lesson was associated with this variance. Consistent with prior research (Schmidt et al., 2020), most of the variation in relatedness and competence occurred at the situational level, with approximately 40% of the variance in relatedness satisfaction and frustration and about 30% of the variance in competence experiences attributable to stable between-person differences.

Prior evidence on the variance in competence experiences has been mixed, with some findings indicating most of the variance in mathematics self-concept (Niepel et al., 2022) or in self-efficacy (Martin et al., 2020) attributable to stable between-person differences, and others showing the majority (57%) of the variance in competence beliefs to reflect situational, lesson-to-lesson fluctuations (Parrisius et al., 2022). Our results align with the latter, as we observed nearly 70% of the variance in competence experiences to be due to situational fluctuation. These differences across studies may partly be due to differences in measurement instruments. Additionally, our design covered a wide spectrum of academic subjects, likely contributing to greater situational variability in students' competence experiences, in contrast to, for instance, studies whose data was collected exclusively after mathematics lessons (Niepel et al., 2022; Parrisius et al., 2022), or those focusing on English and mathematics (Martin et al., 2020).

Subject-specific effects showed systematic, across-subjects variance in students' experiences of competence and relatedness, indicating that certain subjects may pose unique academic and social challenges. Competence experiences were notably lower in several academically demanding subjects, including mathematics, chemistry, and interestingly, Swedish language. The nature of Swedish as one of Finland's two official languages, and a compulsory subject throughout basic education (From, 2023), may to some extent explain this latter finding, particularly with previous research showing students' attitudes toward Swedish language to be sometimes less than favorable (Broermann, 2007). This pattern may vary across regions, as in Swedish-speaking municipalities, the language is likely more integrated into students' daily lives. Regarding relatedness, fewer subject differences were present, but interestingly, relatedness satisfaction levels were lower and frustration higher during sports compared with other subjects, in line with the finding that adolescents experiencing higher levels of emotional or relational loneliness tend to have less favorable attitudes toward physical education (Padial-Ruz et al., 2020). Particularly for students who feel socially isolated, PE lessons may pose unique social challenges that could reflect the more competitive, performative, or socially exposing nature of physical education, which may amplify social comparison processes.

5.2. Temporal dynamics and individual differences in relatedness and competence

Our findings confirmed prior findings (Chen et al., 2015; Maddens et al., 2023) showing positive associations between relatedness and competence at the between-person level, with students who felt more socially connected or less lonely perceiving themselves as more

competent. However, our analytical approach enabled us to go beyond these static relationships. In RQ2, we examined the autoregressive and cross-lagged relationships between relatedness satisfaction and competence (Model 1) and relatedness frustration and competence (Model 2), as well as between-person differences in these processes.

We found statistically credible autoregressive effects regarding both relatedness satisfaction and relatedness frustration, meaning students' experiences in one lesson predicted their experiences in the next. To our knowledge, few if any studies have specifically examined autoregressive effects for relatedness at the lesson level in school contexts, making this a novel contribution to the field. However, significant autoregressive effects in school relatedness have been observed across two school years (Wang et al., 2024). Together with our findings, this suggests relatedness experiences can show meaningful temporal stability.

In contrast, we found no statistically credible autoregressive effect for competence, which was somewhat surprising in light of prior research, which has reported evidence of carryover effects in students' competence beliefs from one day or lesson to the next (Neubauer et al., 2022; Niepel et al., 2022). This may be due to the structure of our study: unlike previous studies focusing on one subject (typically mathematics), our design captured students' experiences across a number of subjects. This diversity likely introduced greater situational variability in academic demands, thus diluting the stability of competence perceptions across time. This reasoning is supported by findings from Malmberg and Martin (2019), who tested the autoregressive effects of competence both within day (from one learning moment to the next) and within subject domains. They found that the autoregressive effect within the same school subject was more prominent than the effect from one learning moment to the next, indicating that competence beliefs were sustained more strongly within a given subject than across varying lessons during a day. Thus, in our results, the absence of an autoregressive effect for competence satisfaction should not be interpreted as evidence against temporal stability per se, but rather as reflecting the heightened situational variability introduced by shifting subject-specific demands across lessons.

The cross-lagged relationships between relatedness and competence revealed complex temporal dynamics, offering new insights into how these psychological needs interact within students over time. In Model 1, prior experiences of relatedness satisfaction positively predicted later competence, in line with SDT (Deci & Ryan, 2000) and the idea that social connection fosters motivation and engagement (Furrer & Skinner, 2003). This cross-lagged association was credible within our sample, indicating that increases in relatedness satisfaction were followed by increases in competence. However, this pattern was not statistically credible in the unstandardized results, suggesting the need for caution when generalizing beyond the current sample (Hamaker et al., 2018). As such, this result should be interpreted as a within-sample dynamic pattern rather than a robust population-level association. Despite this limitation, our finding aligns with prior research showing that psychological needs can influence each other over time (e.g., reciprocal links between competence and relatedness over time; Bürgermeister et al., 2016; competence support enhancing relatedness satisfaction; Sheldon & Filak, 2008). Extending previous work, the discovered between-person correlations further revealed that the strength of the cross-lagged effect from relatedness to competence varied depending on students' average competence levels, the effect of earlier relatedness satisfaction on later competence being weaker for students who generally perceived themselves as more competent. This suggests that social connectedness may be particularly important for supporting the academic confidence of students who feel less capable, whereas students with a strong sense of competence may be less reliant on peer relatedness.

The reverse cross-lagged path from prior competence to later relatedness yielded less expected results. Contrary to previous findings (Bürgermeister et al., 2016; Sheldon & Filak, 2008), prior competence experiences predicted lower relatedness satisfaction and higher

relatedness frustration in the following lesson, suggesting a potential trade-off between academic and social experiences. It appears moments of competence may at times come at the expense of social connectedness potentially due to various mechanisms. Academic success may shift focus toward individual achievement, trigger social comparison and distance (Butera & Darnon, 2017), or demand cognitive effort that limits social engagement. Prior findings also link high relatedness to lower group performance (van Leeuwen et al., 2025), highlighting how social and academic goals can sometimes be in tension. Interestingly, the negative influence of prior competence on relatedness was particularly pronounced among students who typically reported high relatedness satisfaction or greater loneliness, suggesting that students with stronger average experiences of social connection, or disconnection, may be more sensitive to how academic experiences shape their social feelings. By comparison, prior competence experiences were less likely to influence later relatedness satisfaction for students with more stable sense of relatedness over time. Together, these findings highlight that a high average sense of belonging is not synonymous with a consistently experienced one. This insight underscores the value of our analytical approach in disentangling between-person differences in moment-to-moment dynamics, which might remain invisible in more traditional between-person analyses (Hamaker, 2012; Hamaker et al., 2018). For socially oriented students, academic success may temporarily disrupt their social experience, while those with a stable sense of belonging appear more resilient. In contrast, competence showed the opposite trend: among students with more stable competence, prior competence experiences more strongly predicted lower relatedness satisfaction. This may reflect a stronger focus on achievement or heightened social comparison among students for whom competence is a central, enduring aspect of their academic identity. At the same time, these interpretations warrant further investigation, as our data did not allow us to explicitly account for lesson transitions, subject sequencing, or other lesson-level contextual factors that may also shape students' momentary experiences and contribute to the observed competence-relatedness dynamics.

Furthermore, additional between-person correlations revealed meaningful insights into the stability of students' experiences. Specifically, in both models, higher mean levels of relatedness satisfaction were associated with stronger autoregressive effects in competence, whereas students who generally experienced more frustration in their peer relationships showed less stability in their competence perceptions. This suggests that feeling socially connected may support not only momentary experiences of competence, but also foster a more coherent sense of academic self. Conversely, a lack of social belonging may destabilize students' academic confidence over time.

Finally, the negative correlation between the autoregressive effects of relatedness and competence in Model 1 indicated that stability in one psychological need was not accompanied by stability in the other. This finding further underscores the value of our analytical approach, which allowed us to uncover such distinct intraindividual patterns.

5.3. The role of peers for situational experiences of relatedness and competence

RQ3 examined how the number of peers students worked with during lessons related to their experiences of relatedness and competence. The results showed that working with more peers was associated with higher relatedness satisfaction and lower relatedness frustration, but showed no statistically credible association with competence experiences. These findings align with previous research on the social benefits of collaborative learning formats (e.g., Bieg et al., 2017), suggesting that peer interaction directly supports students' sense of social belonging and connection in the classroom.

The absence of a direct effect on competence was somewhat surprising, given that working with peers could be thought to be associated also with competence experiences. However, this finding might reflect the complex nature of peer collaboration effects on academic

confidence. While working with peers clearly enhances social experiences (e.g., Bieg et al., 2017), its impact on competence may depend on factors such as the quality of collaboration (e.g., van Leeuwen et al., 2025), the relative ability levels of group members (e.g., Marsh et al., 2017), or the specific nature of the academic task.

5.4. Limitations and future directions

Several limitations should be acknowledged when interpreting these findings. Our study relied on single-item measures of relatedness and competence. While common in experience sampling research (Saqr et al., 2024) and considered appropriate for well-defined constructs (Allen et al., 2022; Gogol et al., 2014), single items may not fully capture the nuance of psychological needs. Future studies could test whether similar patterns hold with multi-item scales, though this must be balanced against participant burden in intensive designs.

Although we handled missing data in our analyses using Bayesian estimation under a Missing at Random (MAR) assumption, attrition increased over time, with later lesson prompts being less likely to be answered. This pattern likely reflects response fatigue and may have resulted in some selectivity toward more motivated or engaged students in the later measurement occasions. Consequently, while the applied modeling approach appropriately accounts for this form of missingness, our findings should be interpreted with the understanding that within-person dynamics may be somewhat underrepresented for students who disengaged from responding over time.

Our data were collected across various subjects rather than a single one. While this approach made our analytical model more complex than in studies focusing on a single subject area, it can be considered a strength, as it allowed us to identify subject-specific differences that might otherwise go unnoticed. However, future studies could extend this work by collecting data over a longer period, thereby increasing sample size and enabling more detailed analysis of subject-specific patterns and potential covariates. In the present study, the relatively short observation period and the dispersion of observations across multiple subjects limited our ability to model lesson transitions, subject continuity, and other lesson-level covariates that may shape students' momentary experiences. Future research with longer follow-up period could more explicitly account for lesson sequences, transitions between subjects, and contextual demands, thereby enabling a more fine-grained examination of situational processes in classroom settings.

A key limitation of this study was the lack of information on what occurred during each lesson, such as instructional content or teaching style. In addition, our data did not allow us to disentangle teacher effects from subject effects. Because instruction in Finnish lower secondary schools is typically subject-based and taught by subject-specialist teachers, subject-level differences may also partly reflect teacher-specific practices. Without information on lesson content and teaching practices, we could not account for lesson-specific factors that may confound students' momentary experiences in competence and relatedness. For example, lower competence in mathematics or chemistry may reflect task difficulty, instructional pacing, or feedback practices rather than subject-specific motivational processes per se (Ryan & Moller, 2017). In addition, the quality of interpersonal interactions with peers and teachers during lessons could be particularly relevant for understanding fluctuations in relatedness and would be valuable to measure directly alongside relatedness experiences (Reis et al., 2000; van Leeuwen et al., 2025). Future studies could address these limitations by incorporating lesson-level indicators, such as students' perceptions of task difficulty, classroom climate, and teaching style, and modeling these as time-varying covariates in multilevel or dynamic structural equation models. In particular, incorporating students' perceptions of teaching style, specifically how controlling or autonomy-supportive they felt the lesson to be, would be valuable, as controlling teaching strategies have been shown to frustrate students' psychological needs and predict disengagement (Bartholomew et al., 2018), whereas

autonomy supportive practices enhance motivation and need satisfaction (Pataall et al., 2018). Such approaches would help disentangle within-person motivational dynamics from lesson-specific instructional effects and deepen understanding of dynamic need fluctuations.

In our study, peer nominations were restricted to a maximum of five peers to reduce participant burden. A small number of students ($n = 5$) exceeded this limit by nominating six or seven peers on a single measurement occasion each, which is unlikely to have influenced the findings. Nevertheless, restricting nominations to a maximum of five may have limited the accurate capture of some students' peer networks. Future studies could consider allowing unrestricted peer nominations to more fully capture variation in students' peer networks.

In addition, while this study focused on peer-related aspects of relatedness, teacher-student relationships are also central source of relatedness in classroom (e.g., Furrer & Skinner, 2003). Future research could explore how teacher relationships influence the temporal dynamics between relatedness and competence, potentially revealing distinct patterns like those seen in peer interactions.

One obvious limitation of the present study is that although SDT conceptualizes three basic psychological needs (i.e. autonomy, competence, and relatedness), we focused only on two of them. This decision was driven primarily by methodological rather than theoretical considerations. Due to the intensive experience sampling design and the secondary nature of the data, the mobile surveys had to remain very brief, which limited the number of items that could be included. Within these constraints, competence and relatedness were prioritized because they aligned most closely with the study's focus and were considered more feasible to operationalize with single-item situational measures. In contrast, autonomy satisfaction was deemed more difficult to capture validly with a single item across heterogeneous classroom situations, where opportunities for choice and self-direction may vary substantially between lessons. Consequently, the findings provide only a partial picture of students' motivational experiences within the SDT framework. Autonomy satisfaction may interact with or shape the observed dynamics between competence and relatedness, and its exclusion limits conclusions about the full motivational system. Future studies would benefit from incorporating autonomy satisfaction alongside other needs in intensive longitudinal designs, particularly in light of recent advances in brief and single-item measures of psychological need satisfaction (e.g., Martela & Ryan, 2024). When considering the generalizability of the findings, it should be noted that the study was conducted in a single Finnish lower secondary school. Although intensive longitudinal designs primarily aim to capture within-person processes and their temporal dynamics, which may be considered less context-dependent than between-person differences, context nevertheless remains important when evaluating generalizability. The Finnish comprehensive school system is relatively homogeneous and characterized by a strong emphasis on equity and the absence of formal tracking, which may shape students' everyday classroom experiences. Consequently, the observed process-level patterns might differ in educational contexts with more explicit tracking or stratification. Future research can build on these findings by testing whether similar within-person dynamics emerge across different educational contexts, school systems, and institutional arrangements.

5.5. Practical implications

Our findings offer practical implications for education. The substantial situational variability in students' relatedness and competence suggests that these experiences are not fixed traits but can be shaped by the learning environment, giving educators meaningful opportunities to

influence motivation in each lesson. Subject-specific patterns highlight areas for targeted support, such as fostering academic confidence in math and chemistry or addressing social challenges in physical education.

The temporal dynamics between relatedness and competence suggest that educators should consider both social and academic dimensions when designing learning experiences. While peer collaboration can enhance relatedness, our findings suggest that simply maximizing one dimension may not yield optimal outcomes. Instead, integrating social and academic goals, helping students see how peer relationships can support rather than compete with academic achievement, may be more preferable. Moreover, it is important to create classroom environments where succeeding academically is socially accepted and supported by the peer culture.

Finally, individual differences discovered in the temporal dynamics suggest that students benefit from tailored support. For example, for students who generally feel less competent, fostering positive peer relationships may be particularly important for supporting their academic confidence. Recognizing these individual differences can enable teachers to more effectively address students' varying motivational needs.

6. Conclusions

Our study adds to the growing body of research that moves beyond between-person averages to capture how students' motivation fluctuates within individuals over time. A major advantage of situational designs like this is their ability to reduce recall bias and measurement error (Minnaert et al., 2007; Murayama et al., 2017), while also uncovering nuanced insights into motivational processes as they unfold within individuals and across time.

Our results revealed that relatedness and competence showed substantial situational variability, with systematic differences across school subjects. The temporal associations between these needs also varied across individuals, underscoring that the interplay between social and academic experiences is more complex than traditional between person analyses typically suggest. These findings contribute to theory and offer practical implications for supporting students' social and academic development.

CRedit authorship contribution statement

Satu Koivuhovi: Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Lars-Erik Malmberg:** Writing – review & editing, Methodology, Formal analysis. **Anna Maria Rawlings:** Writing – review & editing. **Reito Visajaani Salonen:** Data curation. **Risto Hotulainen:** Writing – review & editing, Funding acquisition.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used Chat GPT and Grammarly for assistance with fluent academic writing (i.e. grammar and style check, shortening and editing). After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

The authors declare no conflicts of interest.

Appendix A. rDSEM results for model with relatedness frustration and competence

To assess the robustness of our findings, we specified a residual dynamic structural equation model (rDSEM) in addition to the standard DSEM for the model including relatedness frustration and competence, following recommendations by Dettweiler et al. (2024) and McNeish and Hamaker (2020). In rDSEM autoregressive paths are modeled based on the residuals rather than the observed variables themselves (Dettweiler et al., 2024).

The model was estimated using the same settings reported in our main analyses: Bayesian estimation in Mplus with 100,000 iterations, a thinning interval of 10, and two Markov chains. Like the models reported in the article, the rDSEM showed good convergence, with potential scale reduction (PSR) values below 1.050 and trace plots indicating good mixing across chains.

The results of the rDSEM are presented in Tables A1 and A2 and align with the findings reported in the main text of the article.

Table A1
Effects of lesson subject and number of peers on relatedness and competence.

	Relatedness frustration	Competence
Math	-0.052 [-0.172, 0.068]	-0.267 [-0.394, -0.139]
Finnish	-0.088 [-0.218, 0.044]	-0.046 [-0.191, 0.094]
English	-0.029 [-0.187, 0.128]	-0.064 [-0.219, 0.095]
Swedish	-0.095 [-0.270, 0.075]	-0.326 [-0.517, -0.131]
French	0.070 [-0.266, 0.401]	-0.286 [-0.660, 0.102]
Physics	-0.038 [-0.288, 0.215]	-0.420 [-0.679, -0.164]
Chemistry	0.094 [-0.077, 0.265]	-0.328 [-0.510, -0.144]
Biology	-0.001 [-0.224, 0.226]	-0.183[-0.419, 0.061]
Sports	0.235 [0.079, 0.407]	-0.112 [-0.297, 0.074]
Peers	-0.076 [-0.108, -0.043]	0.018 [-0.020, 0.055]

Table A2
Level 2. Means, variances (unstandardized estimates), and correlations (standardized estimates) with their 95% credible intervals (in brackets) of residual DSEM model with relatedness frustration and competence.

Variable	Fixed effects (means)	Random effects (variances)	Correlations				
			1.	2.	3.	4.	5.
1. Comp.	0.028 [-0.120, 0.170]	0.372 [0.262, 0.535]	-				
2. RelFr.	0.283 [0.116, 0.455]	0.479 [0.331, 0.699]	-0.441 [-0.631, -0.221]	-			
3. AR Comp.	0.002 [-0.094, 0.095]	0.066 [0.031, 0.120]	0.123 [-0.301, 0.526]	-0.424 [-0.739, -0.001]	-		
4. AR RelFr.	0.182 [0.093, 0.269]	0.050 [0.023, 0.099]	-0.360 [-0.725, 0.079]	0.342 [-0.076, 0.690]	0.144 [-0.473, 0.659]	-	
5. CL: RelFr. → Comp.	-0.121 [-0.275, 0.050]	0.198 [0.106, 0.346]	0.078 [-0.346, 0.442]	-0.020 [-0.329, 0.307]	0.035 [-0.501, 0.503]	0.159 [-0.329, 0.615]	-
6. CL: Comp. → RelFr.	0.138 [0.041, 0.233]	0.110 [0.057, 0.192]	-0.147 [-0.431, 0.168]	0.794 [0.536, 0.928]	-0.273 [-0.677, 0.219]	0.001 [-0.441, 0.457]	-0.118 [-0.449, 0.231]

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