

Classroom dynamics in physical education: The interplay of student agentic actions, teacher autonomy support and student intrinsic motivation

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ARTICLE INFO

Keywords:

Agentic engagement
Agentic defiance
Autonomy support
Reciprocal dynamics
Cross-lagged panel model

ABSTRACT

This study adopts a transactional perspective on classroom functioning and examines the relations between student-perceived teacher autonomy support, agentic engagement, agentic defiance and intrinsic motivation in physical education lessons taught by pre-service teachers. We conceptualize agentic engagement as constructive and teacher-directed, and agentic defiance as assertive and task-directed. Data from 732 primary school students were collected across three weeks and analyzed using a two-wave latent cross-lagged panel model.

Perceived autonomy support predicted higher agentic engagement and intrinsic motivation, and lower agentic defiance over time, whereas students' agentic actions did not predict later perceptions of autonomy support. We also report findings from an exploratory interaction analysis, which yielded marginally significant patterns.

Together, these findings highlight teachers' role in shaping adaptive classroom functioning and suggest that students' agentic actions may require particularly supportive conditions to elicit changes in teaching practices.

Educational relevance statement

This study shows that when teachers support students' need for autonomy, students are more motivated and more likely to contribute constructively. At the same time, autonomy-supportive teaching reduces students' deviations from assigned tasks, which often reflect attempts to adapt activities to their interests rather than simple misbehavior. Although the study examined how teachers and students influence one another over time, students' actions did not meaningfully change teachers' practices. This underscores the central role teachers play in creating a positive learning environment and highlights the need to pay close attention to how students express their preferences and to respond in ways that foster engagement.

1. Introduction

Students' and teachers' behaviors are mutually dependent and potentially reinforcing. Their classroom functioning emerges from transactional processes in which both parties continuously influence and adapt to one another through ongoing, reciprocal interactions (Nickel, 1976; Sameroff, 2009; Skinner et al., 2008; Reeve, 2012). Although there have been earlier calls to consider this interdependence (Winne &

Marx, 1977), few studies have examined how students' behaviors reciprocally influence teachers' practices (Vieluf et al., 2025), particularly through expressions of student agency (Nurmi, 2012; Nurmi & Kiuru, 2015).

When students act with agency, they do not merely respond to instruction but intentionally seek to direct their own learning and influence ongoing instruction in ways aligned with their interests and values (Mameli et al., 2023; Reeve & Tseng, 2011; Skinner et al., 2009). Such agentic actions range from constructive contributions to deliberate deviations from the assigned task and may be directed toward the teacher's instructional decisions (Reeve, 2013; Reeve & Tseng, 2011) or toward aspects of the task or environment (cf. Duchi et al., 2025; Laporte et al., 2021). Transactionally, the ways in which students express such agency tend to vary with their perceptions of teacher autonomy support (Reeve et al., 2025; Legault et al., 2017; Skinner & Edge, 2002). Physical education provides a particularly suitable context for examining these behaviors, as students bring rich movement experiences and clear activity preferences, while teachers can frame the same activity through different pedagogical perspectives.

In this study, we propose that different forms of agentic actions are distinctly associated with students' perceptions of teacher autonomy support and their intrinsic motivation. Specifically, we introduce and

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<https://doi.org/10.1016/j.lindif.2026.102889>

Received 3 June 2025; Received in revised form 3 February 2026; Accepted 5 February 2026

Available online 19 February 2026

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examine the construct of agentic defiance and distinguish it from the established concept of agentic engagement. Whereas agentic engagement captures students' proactive, constructive, and teacher-directed contributions (Reeve, 2013), agentic defiance describes reflective and assertive departures from the assigned task (Aelterman et al., 2016; Legault et al., 2017; Vansteenkiste et al., 2014). We conducted a longitudinal survey of 732 primary school students in practical physical education lessons. Analyses examined the cross-lagged relations between student-perceived teacher autonomy support, topic-specific intrinsic motivation and the two forms of agentic actions, and explored whether agentic engagement and agentic defiance yield distinct contributions to classroom dynamics.

2. Theoretical background

2.1. A transactional perspective on classroom dynamics

A transactional perspective highlights how teachers and students continuously shape one another's behavior. While research on the relationship between teaching and learning has traditionally assumed a unidirectional causal link from teacher to student, it is now widely recognized that learning is mediated by students' activity, moderated by their individual characteristics, and unfolds through social interaction (Vieluf et al., 2025). Although seldom addressed (Vieluf et al., 2025), understanding these reciprocal dynamics is central to explaining how students' active contributions shape classroom processes (Rickert et al., 2024; Vieluf et al., 2020).

Studies adopting a transactional approach to classroom functioning report both adaptive and maladaptive dynamics between student and teacher behavior. Adaptive dynamics have been found when student engagement predicts greater need support from teachers, and vice versa (Jang et al., 2016; Koenigs et al., 1977; Matos et al., 2018; Patall et al., 2018; Rickert et al., 2024; Skinner & Belmont, 1993). Observational studies likewise show that students who display more initiative tend to receive more attention from their teachers in return (Clarke et al., 2016; Noble & Nolan, 1976). Conversely, maladaptive dynamics have emerged between teachers' controlling practices and student misbehavior (Nurmi & Kiuru, 2015; Skalická et al., 2015) as well as with student disengagement (Jang et al., 2016; Patall et al., 2018; Van den Berghe et al., 2016; Zhou et al., 2023). Notably, these patterns appear self-reinforcing, creating spirals that sustain adaptive or maladaptive functioning over time (Jang et al., 2016; Skinner & Belmont, 1993; Van den Berghe et al., 2016; Zhou et al., 2023). Taken together, this research illustrates manifold ways in which students' and teachers' behaviors interact. We expect these patterns to be particularly pronounced between teachers' autonomy support and students' agentic actions, with different forms of agentic actions occupying distinct functional roles within these dynamics.

2.2. Students' agentic actions

There is no consensus on the use of the term *student agency*. Definitions in empirical work are often vague (Emirbayer & Mische, 1998; Inouye et al., 2022) and grounded in different research traditions (Eteläpelto et al., 2013; Fu & Clarke, 2019; Varpanen, 2019). This lack of conceptual clarity is particularly evident in educational research (Matusov et al., 2016), where agency frequently appears as a post hoc finding rather than as a construct specified a priori (Inouye et al., 2022). Across the literature, three broad perspectives on agency can be distinguished (e.g., Goller, 2017; Mäkitalo, 2016): (1) agency as a disposition for action or action competence (e.g., Bandura, 2023), (2) agency as action itself (e.g., Eteläpelto et al., 2013), and (3) agency as emergent from (inter)action and context (e.g., Fu & Clarke, 2019). We adopt an action-based perspective that conceptualizes agency as expressed through actions in context (Eteläpelto, Vähäsantanen, Hökkä and Paloniemi, 2013; Shogren et al., 2015). Accordingly, student agency

refers to the quality of those actions that are directed toward shaping their educational experiences (Biesta & Tedder, 2007; Eteläpelto et al., 2013). Such behaviors are observable and deliberately enacted even among primary school students (Varpanen, 2019; Vaughn et al., 2024).

Research on student engagement has traditionally focused on behavioral, cognitive, and emotional involvement in academic tasks (Fredricks et al., 2004; Reeve, 2012), primarily capturing variations in students' learning behaviors within assigned learning activities (Reeve, 2012; Skinner & Pitzer, 2012). Agency extends this compliant notion of engagement by emphasizing students' intentional and autonomous efforts. In contrast to internally oriented forms of self-regulation, which involve adjusting one's motivation or interest (Flunger et al., 2024; Laporte et al., 2021), agentic action is externally oriented (Harteis & Goller, 2014) and aimed at creating conditions that better satisfy their needs (Reeve & Tseng, 2011; Reeve, 2013; Legault et al., 2017). Recent theoretical developments suggest that different motivational environments promote distinct forms of student behavior (Legault et al., 2017; Reeve et al., 2023). We therefore propose that students also express their agency in context-sensitive ways. In the following, we distinguish between two possible forms of agentic action—agentic engagement and agentic defiance—and examine their motivational foundations, behavioral expressions, transactional effects, and empirical interrelations. To clarify how agentic engagement and agentic defiance relate to other forms of student behavior, Table 1 provides an overview of different behavior types and the constructs used in this paper.

2.2.1. Agentic engagement

Agentic engagement denotes teacher-directed, proactive, and constructive action (Reeve, 2013; Reeve & Tseng, 2011). For example, a student might express personal interest by asking to practice a dance they have seen on social media. Agentially engaged learners “act before and during a learning experience” (Reeve & Jang, 2022, p. 97) to adapt it to their interests and goals. In doing so, they actively pursue interactions with teachers to create motivationally supportive environments for themselves (Reeve, 2013).

Agentic engagement has shown additional value in predicting key educational outcomes beyond other engagement dimensions, specifically as the strongest predictor of teacher support (Reeve et al., 2025). Individual studies have further demonstrated that agentic engagement explains a unique share of students' academic achievement (Reeve, Cheon, & Jang, 2020; Reeve & Tseng, 2011), enhances motivational resources like interest, need satisfaction, and self-efficacy (Patall et al., 2019; Patall, Kennedy, et al., 2022; Reeve, Cheon, & Jang, 2020; Reeve, Ryan, et al., 2022). More recently, it has been proposed that agentic engagement may also include instances in which learners contest or question teachers' instructions—for example by challenging the choice of a softball for playing soccer. Although these behaviors appear resistant, they did not form a distinct latent factor but contributed to the overall explanation of agentic engagement (Mameli & Passini, 2019). Taken together, these findings highlight agentic engagement as a teacher-directed expression of student agency that can inform collaborative adjustments to instruction.

2.2.2. Agentic defiance

Developmental research describes a rich repertoire of ways in which children modify or substitute assigned activities, which can be understood as assertive forms of agency. It further shows that children express autonomy through resistance from very early on, with such behaviors becoming increasingly assertive and socially skilled with age (Kuczynski et al., 2018). Agentic defiance refers to students acting directly on the task itself without involving the teacher. These behaviors reflect students' deliberate and autonomous departure from, or modification of, assigned activities after reflecting on their personal interest or the value of the task. For example, a student might transform a dribbling drill into a game by trying to snatch the ball from their peers. This form of defiance is typically motivated by a perceived mismatch between the

Table 1
Overview of student behavior types and constructs used in the present study.

Behavioral category	Construct	Action orientation	Behavioral expression	Classroom examples
Agentic actions	Agentic engagement	Teacher-directed, proactive	Signaling personal needs, interests, or preferences to the teacher	Asking for alternatives; suggesting task variations; questioning instructions
	Agentic defiance	Task-directed, reflective	Modifying or substituting tasks without directly involving the teacher	Adapting task difficulty; creating alternative tasks
Self-regulation	Need crafting; study crafting; motivational regulation	Self-directed, regulatory	Applying internal strategies to regulate task-related motivation or effort	Self-encouragement; reframing task value; effort regulation
Engagement	Behavioral, cognitive, and emotional engagement	Task-focused, active	Active involvement in learning activities within given instructional structures	Following instructions; completing tasks; active participation
Passivity/ disengagement	Behavioral, cognitive, and emotional disengagement	Withdrawn, inactive	Minimal or absent involvement in learning activities	Doing the minimum; non-participation; quiet disengagement
Deviant off-task behavior	Oppositional defiance	Externally oriented, disruptive	Deviation from instructional or social norms that undermines learning and classroom order	Open refusal; interrupting activities; provoking peers

assigned task and students' own interests or values. Rather than disengaging passively, students reflect on their reasons for non-compliance and actively assert their autonomy by adapting or substituting the activity with something else that is more need-supportive or meaningful for themselves (Aelterman et al., 2016; Haerens et al., 2016; Vansteenkiste et al., 2014). However, it is important to distinguish agentic defiance from negative or destructive off-task behaviors (Mameli et al., 2023; Reeve & Tseng, 2011).

In the literature, conceptually similar behaviors have been referred to as autonomously motivated off-task behavior, reflective defiance, or asserted autonomy (Haerens et al., 2016; Legault et al., 2017; Vansteenkiste et al., 2014) and have been linked to agency and agentic engagement (Aelterman et al., 2016; Legault et al., 2017). Furthermore, there are closely related but distinct concepts. Need crafting (Laporte et al., 2021) and study crafting (Duchi et al., 2025) involve proactive self-regulatory behaviors through which students adapt their engagement with existing tasks or learning opportunities to increase need satisfaction or align with personal preferences. Unlike agentic defiance, these behaviors are positively associated with need satisfaction and typically occur in autonomy-supportive contexts (Duchi et al., 2025; Laporte et al., 2021). Oppositional defiance, in contrast, describes teacher-directed, often conflictual resistance triggered by external pressure or control (Flamant et al., 2023; Skinner et al., 2003). Agentic engagement and agentic defiance are conceptualized as two distinct forms of student agency that reflect students' attempts to maintain autonomy under varying conditions. Accordingly, we expect them to be negatively correlated. The following sections examine how these agentic actions relate to teacher autonomy support and student intrinsic motivation, including their relations across time and insights from PE.

2.3. Autonomy support and the interplay with student agency

Teacher autonomy support and student agency ideally complement each other in fostering a collaborative environment. Autonomy-supportive teaching involves taking a student-centered approach and adopting an understanding interpersonal tone. It includes practices such as offering choices, organizing activities based on student interests, providing meaningful explanations, and creating opportunities for student questions and opinions (Reeve & Cheon, 2021). While autonomy support creates the conditions for students to act agentially, agentic engagement simultaneously provides teachers with information that can elicit more autonomy-supportive responses (Matos et al., 2018; Reeve & Tseng, 2011) and may serve as an indicator of students' autonomy need satisfaction (Reeve, Ryan, et al., 2022). Research consistently emphasizes positive effects of autonomy-supportive teaching on student motivation and engagement, and negative associations with disengagement (Guo et al., 2023; Howard et al., 2024; Mammadov & Schroeder, 2023; Reeve & Cheon, 2021; Vasconcellos et al., 2020; Yang et al., 2022). Moreover, teachers who adopt autonomy-supportive practices report greater motivation and emotional well-being in return

(Cheon et al., 2020).

Student-perceived autonomy support leads to increases in agentic engagement (Bordbar, 2021; Michou et al., 2023; Patall et al., 2019; Patall, Kennedy, et al., 2022; Reeve, 2013; Reeve, Cheon, & Jang, 2020). In turn, agentic engagement predicts later perceptions of autonomy support and elicits more autonomy-supportive responses from teachers (Patall et al., 2019; Reeve, Jang, et al., 2022). Michou et al. (2023) found that teacher perceptions of agentic engagement align with student perceptions of autonomy support. Longitudinal cross-lagged studies further support the positive reciprocal association between agentic engagement and autonomy support. Matos et al. (2018) found that while autonomy-supportive teaching predicted an increase in all four aspects of students' engagement, only agentic engagement predicted longitudinal increases in perceived autonomy support. Similarly, Jang et al. (2023) reported positive reciprocal effects between agentic engagement and autonomy-supportive teaching in PE, independent of students' trait levels. However, Patall et al. (2019, p. 89) noted a potential "backfire effect", as higher agentic engagement was associated with increased perceptions of both autonomy support and teacher control, indicating that agentic contributions can reveal limits in teachers' capacity to accommodate student input (see also Patall, 2024).

Students' agentic actions do not necessarily rely on autonomy-supportive environments (Kuczynski et al., 2018; Matusov et al., 2016). For agentic engagement, autonomy-supportive teaching remains the typical developmental condition: high levels of agentic engagement most often emerge in autonomy-supportive environments and only rarely when autonomy support is low (Grazia et al., 2021). At the same time, it is difficult for learners to sustain agentic engagement in persistently unsupportive or oppressive contexts (Reeve, Cheon, & Yu, 2020). By contrast, agentic defiance is expected to follow a different logic. In contexts perceived as low in autonomy support, students tend to turn to task-related initiatives rather than relying on the teacher (Legault et al., 2017). Although some authors have argued that such agentic defiance may prompt co-constructive negotiation (Aelterman et al., 2016; Haerens et al., 2016), empirical work shows that teachers frequently interpret students' resistance as opposition and respond with more controlling practices (Rainio, 2008; Rajala et al., 2016). Therefore, we expect reciprocal relations that differ in direction: autonomy support and agentic engagement should be positively linked over time, whereas autonomy support and agentic defiance should show negative reciprocal associations.

2.4. Physical education as motivational context

Physical education provides a particularly suitable context for studying classroom dynamics and student agency. PE lessons in the DACH region (Germany, Austria and Switzerland) are typically structured around *thematic units* (*Thema*) that link movement-oriented content with pedagogical objectives and encourage teachers to adopt different perspectives on the same movement area (Döhrling & Gissel,

2024). This structure provides favorable conditions for autonomy-supportive instruction. Moreover, students enter PE with rich prior experiences and clear preferences shaped by their leisure activities and everyday involvement with sport culture (Gerlach et al., 2006). These experiences translate into measurable effects: students report activity-specific patterns of autonomous motivation that vary substantially between sports (Chanal et al., 2025; Chanal & Paumier, 2025), and they tend to show higher engagement in activities they enjoy, such as soccer, swimming, or dancing (Behzadnia et al., 2018; Gerlach et al., 2006; Leo et al., 2022).

Autonomous motivation—comprising intrinsic motives (interest and enjoyment) and identified motives (personal value) (Ryan & Deci, 2020)—functions as both an antecedent and an outcome of students' experiences. It shapes how students perceive teachers' practices (Patall, 2013; Patall et al., 2018), energizes engagement in general (Bureau et al., 2022; Mammadov & Schroeder, 2023; Vasconcellos et al., 2020), including agentic engagement (Michou et al., 2023; Reeve, 2013), and is strengthened through meaningful learning activities (Ryan & Deci, 2020; Mammadov & Schroeder, 2023). In this study, we focus on intrinsic motivation as one core component of autonomous motivation, and expect it to be positively associated with agentic engagement and perceived autonomy support, and negatively associated with agentic defiance in physical education lessons.

2.5. Aim of the study

Adopting a transactional framework, the present study examines two forms of students' agentic action—agentic engagement and agentic defiance—and their reciprocal relations with perceived teacher autonomy support over time. These forms represent different ways in which students act on their learning environment. We include intrinsic motivation to account for students' topic-specific interests, which may influence both their agentic actions and their perceptions of autonomy support. All constructs refer to students' experiences and actions in the specific physical education lessons surveyed and were expected to vary as a function of the activity at hand (e.g., Sulis & Mercer, 2025).

First, we examine correlational patterns among agentic engagement, agentic defiance, perceived autonomy support, and intrinsic motivation. Agentic engagement is expected to correlate positively with autonomy support and intrinsic motivation, and agentic defiance is expected to correlate negatively with both, reflecting their distinct motivational underpinnings.

Second, we test cross-lagged effects over a three-week period. Autonomy support at Time 1 (T1) is expected to promote agentic engagement and intrinsic motivation while reducing agentic defiance at Time 2 (T2). In turn, agentic engagement at T1 is expected to predict increases in autonomy support and intrinsic motivation at T2, whereas agentic defiance at T1 is expected to predict decreases in these variables at T2. Finally, intrinsic motivation at T1 is expected to increase agentic engagement and autonomy support, and reduce agentic defiance at T2.

3. Method

3.1. Participants and procedures

The study followed a two-wave longitudinal design and was conducted during a six-week full-time teaching internship, a mandatory component in the final semester of the primary education program at St. Gallen University of Teacher Education, Switzerland (CH). Participating primary-school students were taught by pre-service teachers in 80–100% of their lessons, including three mandatory physical education lessons per week (Bildungsdepartement Kanton St. Gallen, 2017). Data were collected at two measurement points (T1 and T2) spaced three weeks apart. To reduce topic-related variation, pre-service teachers were instructed to select one movement area of their choice and structure both survey lessons around it.

Primary-school classrooms offered a particularly meaningful context for this study because young learners are increasingly recognized as active participants who exert influence on instructional processes (Varpanen, 2019; Vaughn et al., 2024). This internship setting provided an authentic context for examining development within newly formed teacher–student relationships. Pre-service teachers' practices were expected to be particularly responsive to students' behaviors. At the same time, they were supervised by the classroom teacher and overseen by a university lecturer.

Participants were 732 students from 39 primary education classrooms (average class size = 18.79, range = 11 to 24) across 28 schools in the St. Gallen region, CH. The participants reported their age between 6 and 13 years ($M_{age} = 9.4$ years, $SD = 1.7$; 10 NA) and attended grades 1 to 6,¹ partly in mixed-grade classrooms. There were 378 males, 338 females, 12 non-binary, and four students with unreported genders. The 39 pre-service teachers (92% female) reported their age between 21 and 31 ($M_{age} = 23.4$ years, $SD = 2.8$, 0 NA).

The survey was conducted alongside a multi-group intervention study (Baumgartner et al., 2025) that investigated pre-service teachers' professional competencies in classroom management in PE, but does not rely on any student data. For the present study, students of pre-service teachers in the control group and the minimal-intervention group were selected as a convenience sample. Of their 39 pre-service teachers, 20 were in the control group, and 19 participated in the minimal intervention which consisted of a 3 h course to improve classroom management-related knowledge.

Data were collected from February to March of 2023, in the beginning (weeks 1–2) and toward the end (weeks 4–6) of the internship, with an average time interval of 21.1 days (range: 14–28 days). The survey was administered, immediately after the PE lesson. Pre-service teachers received written instructions, including a read-out-loud-text, adapted from Vaughn et al. (2020), which explained the procedure and informed students about data confidentiality. They read each question aloud twice to facilitate comprehension among younger students. Despite this, some pre-service teachers reported challenges, and the survey took longer than expected in some classes.

This study complied with ethical standards, local legislation and institutional policies. As it used anonymized data from regular instruction, no additional ethics approval was required. Consent was obtained from parents and pre-service teachers, and data were linked only via students' classroom codes.

3.2. Measures and covariates

All measures were administered at both time points and referred to students' actions or motivations in physical education, the pre-service teachers' practices and the specific lesson activities. We used (translated) versions of validated questionnaires, using age- and subject-appropriate instruments whenever available. The scale measuring agentic defiance was self-invented. Standard response formats were retained for each validated instrument. All items in the analysis were scored on the same 4-point Likert scale that ranged from 1 (*not true*) to 4 (*exactly true*), except for the Agentic Engagement Scale (AES; Reeve, 2013), which used a 5-point scale (1 = *not true*, 5 = *exactly true*). Internal consistency was assessed using Cronbach's alpha at each measurement occasion. All items used in the analysis appear in Appendix B, Table B1.

¹ In Switzerland, primary school consists of six grades. The curriculum for primary school divides the eleven mandatory school years into three cycles. The first cycle comprises two years of kindergarten and the first two years of primary school (up to the end of 2nd grade). The second cycle encompasses four years of primary school (3rd to 6th grade), and the third cycle includes three years of lower secondary school (grades 7 to 9).

3.2.1. Autonomy support

Perceived autonomy support at T1 and T2 was measured using the three corresponding items of the German Students' Motivation in Physical Education (SMoPE) instrument. The SMoPE was specifically developed to assess need support, need satisfaction and types of motivation in physical education with younger children. It was preliminarily validated with students aged 8 to 13 (Kohake & Heemsoth, 2021). An example item is: "My teacher often lets me have a say in decisions." Consistent with the original validation, the internal consistencies in our sample were low at the first measurement ($\alpha = 0.60$) and increased to acceptable at T2 ($\alpha = 0.78$).

3.2.2. Agentic engagement

Agentic engagement was measured using a translated version of the Agentic Engagement Scale (AES; Reeve, 2013), the most widely used instrument for assessing agentic engagement (Reeve & Jang, 2022). An example item is: "I let my teacher know what I am interested in." The AES was measured on a 5-point Likert scale and showed acceptable internal consistencies in our sample (T1: $\alpha = 0.70$; T2: $\alpha = 0.76$).

3.2.3. Agentic defiance

Students' agentic defiance was measured using six newly developed items designed to capture assertive deviations from assigned tasks. Because, to the best of our knowledge, this is a newly conceptualized construct, we followed a principled approach. First, we used a stem that anchors responses in actual behavior: "*In physical education I sometimes do SOMETHING DIFFERENT than the teacher instructed me to do, because...*". This prompt, adapted from the scale of controlled motivated non-participation (Aelterman et al., 2016) was intended to elicit task-related deviations. Second, the reason clauses referred to the lesson activities ("...", because the tasks or games...") and reflected autonomous reasons for acting differently (e.g., "...were not interesting for me."). These reasons were adapted from intrinsic and identified motivation items in the SMoPE (Kohake & Heemsoth, 2021) and rephrased negatively to represent reasons for doing something other than the assigned task. While integrating behavioral and motivational elements within the same item entails some conceptual ambiguity (Reschly & Christenson, 2012), directly linking students' reasons to their actions was necessary to distinguish agentic defiance from other off-task behaviors.

Confirmatory factor analysis supported a unidimensional structure for the Agentic Defiance scale with good model fit. Factor loadings ranged from 0.39 to 0.81, with all but one item loading at 0.55 or higher (Appendix A, Table A1). A four-factor model separating agentic engagement, agentic defiance, autonomy support, and intrinsic motivation fit the data better than a three-factor model in which all agency items loaded on a single factor, indicating that the two constructs are empirically distinct ($\Delta\chi^2(3) = 1968.1, p < .001$). Internal consistency was good ($\alpha = 0.80$, T1; $\alpha = 0.84$, T2; see Appendix A, Table A1 for detailed item statistics and loadings).

3.2.4. Intrinsic motivation

Students' intrinsic motivation was measured at the topic level using adapted items from the interest/enjoyment subscale of the Intrinsic Motivation Inventory (Ryan, 1982) and topic-specific interest items from the PE focused SPRINT study (Gerlach et al., 2006). These items assess students' subjective motivation related to the lesson topic. Students were asked to refer to the past lesson, and all items included the phrase "the topic of today's PE lesson," for example: "I enjoyed the topic of today's physical education lesson." The four-item scale showed good to excellent internal consistency ($\alpha = 0.88$ at T1; $\alpha = 0.91$ at T2).

3.2.5. Covariates

Prior studies indicate that girls and students in higher grade levels show lower agentic engagement (Grazia et al., 2025; Jang et al., 2023; Patall et al., 2024), whereas boys and older students display more off-task behavior and maladaptive coping responses (Flamant et al., 2023;

Godwin et al., 2016), and intrinsic motivation declines with age (Gillet et al., 2012). In addition, half of the pre-service teachers who taught our participants were involved in a classroom management knowledge intervention (Baumgartner et al., 2025). We therefore included three covariates: gender (0 = male, 1 = female), student age (in years) and a dichotomous indicator for pre-service teachers' intervention status (1 = control, 2 = minimal intervention).

3.3. Analysis

First, we calculated descriptive statistics, including means, standard deviations, skewness, kurtosis, and Cronbach's alpha coefficients for scale reliability. We screened indicators of non-normality (skew $|\gamma_1| > 3.0$ or kurtosis $|\gamma_2| > 10.0$; Kline, 2016) and evaluated internal consistencies.

Missing data ranged from 6.8% and 9.3% at T1, and from 20.5% and 22.5% at T2 (Table 2). Of the 44 pre-service teachers approached, 39 returned data from their students at T1 and 36 at T2. In total, 1268 student questionnaires were collected, representing 732 unique students: 685 (93.5%) at T1, 583 (79.6%) at T2 and 537 students (73.4%) at both measurement times. Little's test of missing completely at random (MCAR) conducted per construct across both waves indicated no evidence against MCAR for agentic engagement, autonomy support, or intrinsic motivation whereas agentic defiance deviated from MCAR. Follow-up analyses indicated that missingness was consistent with missing at random (MAR). At the teacher level, autonomy-support scores in all three dropout cases fell within ± 1 SD of the retained group ($|z| = 0.012, 0.23, 0.69$), indicating no systematic attrition bias.

Given that students were nested within classrooms, we calculated intra-class correlations (ICC) to estimate the proportion of variance attributable to class-level differences. ICC(1) values above 0.10 (Lüdtke et al., 2009) suggest meaningful between-classroom variation (Table 2). ICC(2) values above 0.70 indicate sufficient reliability to justify class-level aggregation (Lüdtke et al., 2009).

Measurement invariance was examined to ensure that measures represented the same latent constructs across both time points. We tested configural, metric, scalar, and strong invariance of the correlated factor model. The results indicate that the measurement model maintains consistent factor loadings (metric invariance) and intercepts (scalar invariance), across both measurement occasions. Scalar invariance allows for accurate assessments of latent state factor means and variances across various measurement instances (Geiser, 2021).

The hypothesized relationships were examined using a latent cross-lagged panel model (CLPM) estimated at the student level, accounting for the nested data structure. All four latent variables were included with all cross-lagged and within-time paths estimated across the two time points. Factor loadings and intercepts were constrained to equality across time, and residuals for identical items were correlated across time. Gender, age, and participation of the pre-service teacher in a classroom-management knowledge intervention were included as predictors at both time points.

Model fit was evaluated using the Comparative Fit Index (CFI), Root Mean Squared Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) with acceptable fit indicated by $CFI > 0.90$, $RMSEA < 0.06$, and $SRMR < 0.08$ (Hu & Bentler, 1999).

Analyses were performed in R (Version 4.0.2) using RStudio (2023.06.1 + 524) and the packages psych (v2.3.6), rstatix (v0.7.2), naniar (v1.1.0) and lavaan (v0.6.15). To maximize available information, we handled missing data using $na.rm = TRUE$ for descriptive analyses and Cronbach's alpha, and the full information maximum likelihood approach (missing = fiml) with robust maximum likelihood (MLR) in the CLPM.

4. Results

Preliminary analysis showed that all latent variables were

Table 2
Descriptive statistics of the latent variables at both time points.

Variable ^a	<i>n</i>	<i>M</i>	<i>SD</i>	Skew	Kurtosis	α	<i>ICC(1)</i>	<i>ICC(2)</i>	missing (%)
AE_1	682	3.58	0.85	-0.60	-0.07	0.70	0.12	0.70	6.83
AE_2	582	3.50	0.92	-0.53	-0.17	0.76	0.11	0.65	20.49
AD_1	682	1.54	0.63	1.32	1.51	0.80	0.08	0.60	6.83
AD_2	567	1.62	0.69	1.05	0.21	0.84	0.08	0.58	22.54
ASUP_1	664	2.48	0.74	-0.09	-0.48	0.60	0.16	0.77	9.28
ASUP_2	574	2.45	0.83	-0.03	-0.83	0.78	0.17	0.75	21.59
INTR_1	670	3.08	0.86	-0.73	-0.41	0.88	0.20	0.81	8.46
INTR_2	572	3.05	0.91	-0.77	-0.48	0.92	0.20	0.79	21.85

^a AE: Agentic Engagement, AD: Agentic Defiance, ASUP: Autonomy Support, INTR: Intrinsic Motivation; _1: Time 1, _2: Time 2.

sufficiently normally distributed. The factor structure remained consistent over time and, applying the recommended criterion ($\Delta CFI < 0.01$; Cheung & Rensvold, 2002), we found metric ($\Delta CFI = 0.001$) and scalar invariance (without covariates: $\Delta CFI = 0.001$; with covariate: $\Delta CFI = 0.009$) (Appendix A, Table A2). The CLPM with regressed covariates demonstrated a good model fit based on robust (MLR) estimation, $\chi^2(664) = 1103, p < .001$; $CFI = 0.936$; $TLI = 0.928$; $RMSEA = 0.030$ (90% CI [0.027, 0.033]); $SRMR = 0.051$.

4.1. Descriptive statistics and between-classroom variation

Table 2 presents descriptive statistics, internal consistencies, and intra-class correlations for all variables. Initial analyses indicated that there was no meaningful overall change in students' self-reported measures across time. At T1, students reported the following mean levels: agentic engagement (AE_1: $M = 3.58, SD = 0.85$), intrinsic motivation (INTR_1: $M = 3.08, SD = 0.86$), perceived autonomy support (ASUP_1: $M = 2.48, SD = 0.74$) and agentic defiance (AD_1: $M = 1.54, SD = 0.63$). By T2, all constructs showed only minimal changes: agentic engagement (AE_2: $M = 3.50, SD = 0.92$), perception of teacher autonomy support (ASUP_2: $M = 2.45, SD = 0.83$) and intrinsic motivation (INTR_2: $M = 3.05, SD = 0.91$) slightly decreased, whereas agentic defiance (AD_2: $M = 1.62, SD = 0.69$) slightly increased.

ICC(1) values indicate modest between-classroom variation for agentic engagement (0.12 at T1, 0.11 at T2) and agentic defiance (0.08, 0.08), suggesting that these constructs are largely individual-level characteristics. In contrast, higher *ICC(1)* values for autonomy support (0.16, 0.17) and intrinsic motivation (0.20, 0.20) indicate greater between-classroom differences. *ICC(2)* values for agentic engagement (0.70, 0.65) and agentic defiance (0.60, 0.58) indicate that class-level mean scores are less reliable for these constructs.

4.2. Differentiating agentic engagement and agentic defiance

Consistent with the hypotheses, correlational results in Table 3 show that agentic engagement was positively related to autonomy support ($r_1 = 0.52$; $r_2 = 0.58$) and intrinsic motivation ($r_1 = 0.20$; $r_2 = 0.15$). Agentic defiance was negatively correlated with autonomy support ($r_1 = -0.23$; $r_2 = -0.24$) and intrinsic motivation ($r_1 = -0.32$; $r_2 = -0.35$). Autonomy support and intrinsic motivation were also positively correlated ($r_1 = 0.35$; $r_2 = 0.33$). Contrary to expectations, agentic engagement and agentic defiance were not significantly correlated at either time point.

4.3. Longitudinal cross-lagged effects

The primary finding was that perceived autonomy-supportive teaching positively predicted agentic engagement ($\beta = 0.229, SE = 0.126, p = .034$) and intrinsic motivation ($\beta = 0.202, SE = 0.088, p = .011$), and negatively predicted agentic defiance ($\beta = -0.152, SE = 0.093, p = .050$). These results correspond to large cross-lagged effects ($|\beta| > 0.12$) from teachers to students, as defined by Orth et al. (2022). Fig. 1 displays the estimated cross-lagged model.

Contrary to our expectations, none of the three student variables showed significant cross-lagged effects. Agentic engagement did not significantly predict perceived autonomy-supportive teaching ($\beta = 0.074, SE = 0.102, p = .218$) or intrinsic motivation ($\beta = -0.104, SE = 0.072, p = .073$). Agentic defiance did not significantly predict autonomy support ($\beta = -0.064, SE = 0.093, p = .246$) or intrinsic motivation ($\beta = 0.003, SE = 0.061, p = .478$). Topic-specific intrinsic motivation did not significantly predict autonomy support ($\beta = 0.028, SE = 0.064, p = .332$), agentic engagement ($\beta = 0.022, SE = 0.072, p = .381$), or agentic defiance ($\beta = -0.049, SE = 0.081, p = .224$).

Student age negatively predicted intrinsic motivation at both time points (T1: $\beta = -0.123, SE = 0.031, p < .001$, T2: $\beta = -0.082, SE = 0.021, p < .001$). Gender effects were inconsistent: Boys reported significantly higher expressions of agentic engagement only at T2 (T1: $\beta = 0.037, SE = 0.087, p = .674$; T2: $\beta = -0.139, SE = 0.068, p = .040$) and higher agentic defiance at both time points (T1: $\beta = -0.505, SE = 0.073, p < .001$; T2: $\beta = -0.195, SE = 0.084, p = .020$). Girls reported significantly higher perceived autonomy support at T1 (T1: $\beta = 0.338, SE = 0.071, p < .001$; T2: $\beta = -0.098, SE = 0.076, p = .201$) and intrinsic motivation at T1 (T1: $\beta = 0.385, SE = 0.078, p < .001$, T2: $\beta = 0.123, SE = 0.090, p = .171$). The intervention targeting classroom management-related knowledge showed no significant influences on any latent variable. Together all predictors explained substantial proportions of variance in the T2 latent variables (AE_2: $R^2 = 0.431$; AD_2: $R^2 = 0.350$; INTR_2: $R^2 = 0.270$; ASUP_2: $R^2 = 0.331$).

4.4. Exploratory interaction results

Given the absence of direct effects from students' agentic actions on later perceived autonomy support, we conducted post hoc exploratory analyses to examine whether these associations vary depending on initial autonomy support levels.² We extended our main CLPM by including latent interaction terms for *agentic engagement* \times *autonomy support* and *agentic defiance* \times *autonomy support* as predictors of autonomy support at T2. Both interactions approached, but did not reach conventional significance thresholds (AE_1 \times ASUP_1 \rightarrow ASUP_2: $\beta = 0.165, SE = 0.085, p = .052$; AD_1 \times ASUP_1 \rightarrow ASUP_2: $\beta = -0.160, SE = 0.083, p = .053$).

Simple-slope patterns suggested that when initial autonomy support was high (+1 SD), higher agentic engagement at T1 (+1 SD) predicted higher perceived autonomy support at T2, whereas no meaningful association emerged when initial autonomy support was low (-1 SD; Fig. 2a). For agentic defiance, simple slopes showed a disordinal pattern

² Exploratory interaction analyses were conducted in Mplus 8.11 using a latent moderated structural equations approach (Klein & Moosbrugger, 2000). Building on the main CLPM from the main analyses, we added two latent product terms (AE_1 \times ASUP_1, AD_1 \times ASUP_1) via XWITH as additional predictors of autonomy support at T2. Models were estimated with MLR under TYPE = RANDOM COMPLEX (clustered by class) and Monte Carlo numerical integration. Interpretation relied on parameter estimates, confidence intervals, and simple-slope probes at ± 1 SD of the interacting variables.

Table 3
Correlations for the latent study variables at both time points.

Variable	1	2	3	4	5	6	7	8
1. Agentic Engagement (T1)	–							
2. Agentic Engagement (T2)	0.635***	–						
3. Agentic Defiance (T1)	0.003	0.036	–					
4. Agentic Defiance (T2)	–0.019	0.032	0.560***	–				
5. Autonomy Support (T1)	0.524***	0.439***	–0.230**	–0.256**	–			
6. Autonomy Support (T2)	0.341**	0.575***	–0.162*	–0.240**	0.565***	–		
7. Intrinsic Motivation (T1)	0.201***	0.155*	–0.317***	–0.256***	0.348***	0.206***	–	
8. Intrinsic Motivation (T2)	0.074	0.150*	–0.172**	–0.348***	0.258***	0.332***	0.474***	–

* $p < .05$.
** $p < .01$.
*** $p < .001$.

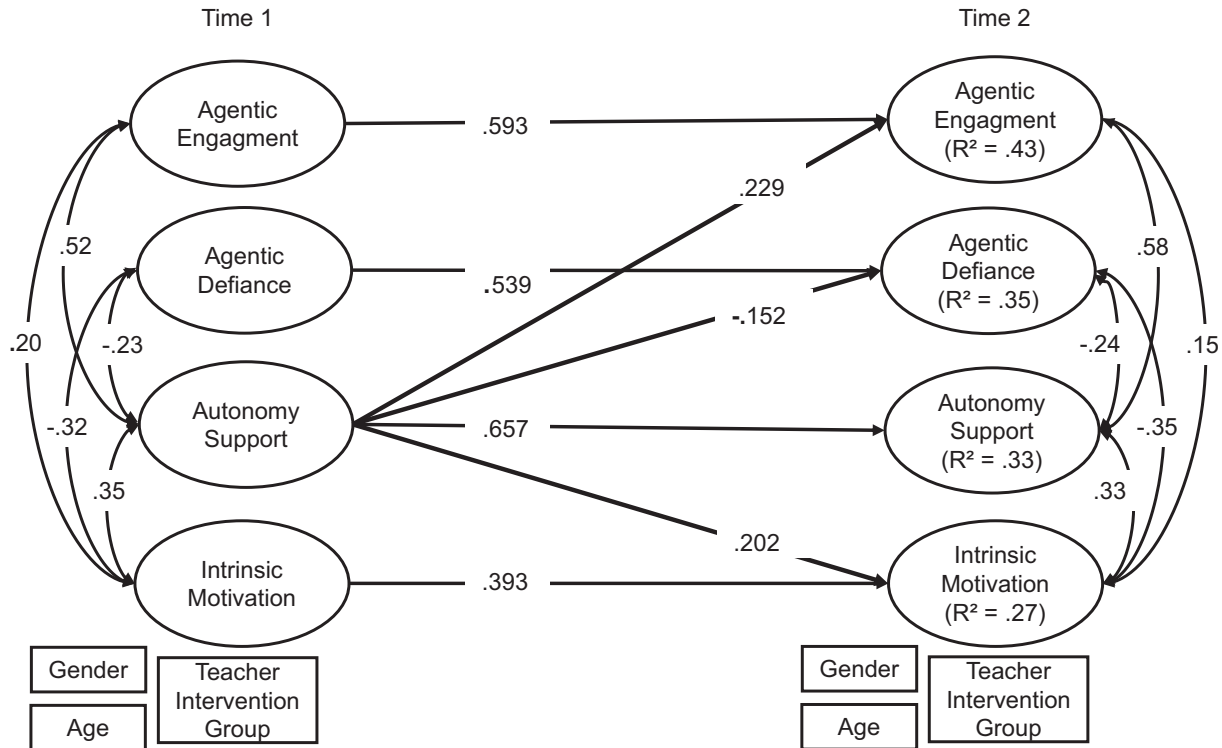


Fig. 1. Estimated cross-lagged panel model. Only significant paths are shown. Covariates are regressed on the latent variables at each time point. Full results are found in the supplementary materials.

(Fig. 2b): when initial autonomy support was low (–1 SD), higher agentic defiance was associated with slightly higher autonomy support at T2. In contrast, when initial autonomy support was high (+1 SD), higher agentic defiance was associated with slightly lower autonomy support at T2. Given the marginal significance levels, these findings should be interpreted as exploratory.

5. Discussion

This study examined the interplay between student agentic actions, perceived autonomy support, and topic-specific intrinsic motivation in physical education. Focusing on a three-week period in which students were taught by pre-service teachers, we emphasized students' active role in shaping their learning environment by contrasting two forms of agentic action: agentic engagement and agentic defiance.

Descriptively, students reported high agentic engagement and intrinsic motivation, low agentic defiance, and moderate perceived autonomy support. Minimal changes over time further suggest an overall positive and stable classroom environment.

Across the cross-lagged analyses, three central results emerged. First,

agentic engagement and agentic defiance showed distinct relations with perceived autonomy support and intrinsic motivation. Second, perceived teacher autonomy support predicted increases in agentic engagement and intrinsic motivation while decreasing agentic defiance, with large effects. Third, students' agentic actions did not predict later perceptions of autonomy support. Together, these findings point to the central role of autonomy-supportive teaching and raise important questions about how student agency operates within classroom dynamics.

5.1. Distinguishing agentic engagement and agentic defiance

The correlational results largely aligned with our hypothesized pattern that agentic engagement would show positive associations with indicators of adaptive classroom functioning, whereas agentic defiance would show negative associations. Agentic engagement was positively associated with perceived autonomy support and intrinsic motivation. This is consistent with its theorized role as constructive, intrinsically driven, and teacher-directed action (Reeve, 2013) and aligns with its interpretation as a collaborative form of engagement that is strongly

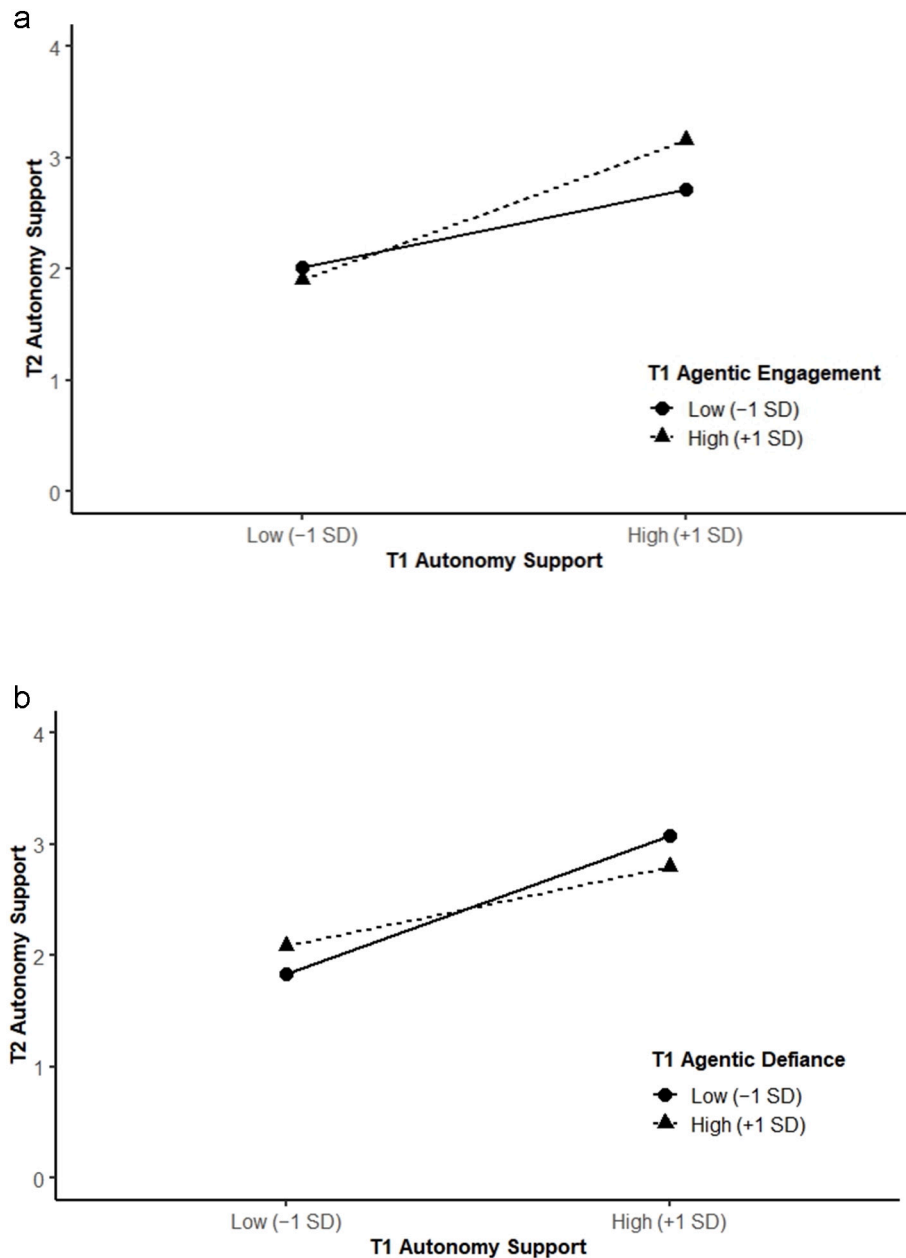


Fig. 2. Simple slopes illustrating the association between perceived autonomy support at Time 1 and perceived autonomy support at Time 2 at low (-1 SD) and high ($+1$ SD) levels of agentic engagement (Fig. 2a) and agentic defiance (Fig. 2b) at Time 1.

associated with teacher support (Reeve et al., 2025).

In contrast, agentic defiance showed negative correlations with perceived autonomy support and intrinsic motivation. Although this construct has not yet been formally defined or empirically established in literature, these associations are consistent with our hypotheses. We interpret agentic defiance as students' deliberate departures from or modification of tasks when these feel insufficiently relevant or uninteresting, potentially arising more frequently under conditions of low perceived autonomy support. This interpretation aligns with related notions such as asserted autonomy (Legault et al., 2017), reflective defiance (Haerens et al., 2016), and autonomously motivated off-task behavior (Aelterman et al., 2016).

Notably, agentic engagement and agentic defiance were not significantly negatively correlated. Together with the superior fit of a model that distinguishes between these two constructs, this absence of correlation suggests that these behaviors represent distinct expressions of agency rather than opposite ends of a single continuum. Evidence that

different combinations of teacher support and student motivation can elicit multiple forms of agentic action (Legault et al., 2017; Reeve et al., 2020), together with the divergent relations of agentic engagement and agentic defiance to autonomy support and intrinsic motivation, reinforces the value of treating them as distinct constructs. However, the correlational data do not clarify whether students' choice of agentic action is primarily driven by relational or activity-related factors, a question taken up in the longitudinal analyses below.

5.2. Dynamics between teacher autonomy support, student agentic action and motivation

The cross-lagged results partially supported our hypotheses. Perceived autonomy-supportive teaching predicted higher agentic engagement, intrinsic motivation, and lower agentic defiance at T2. These effects were large in magnitude and align with previous research (Jang et al., 2023; Matos et al., 2018), reinforcing the importance of

autonomy-supportive teaching practices (Reeve & Cheon, 2021; Vasconcellos et al., 2020). The negative path to agentic defiance may indicate a potential cross-over pattern, in which autonomy support may help students remain engaged with assigned tasks or engage in more collaborative forms of agentic action rather than task deviations.

In contrast, we found no evidence for the hypothesized reciprocal effects from students' agentic actions to later perceptions of autonomy support. To examine whether these effects varied depending on students' initial perceptions of autonomy support, we conducted exploratory interaction analyses. The interaction effects were marginal and should be interpreted cautiously. Simple-slope patterns indicated that high agentic engagement predicted higher autonomy support at T2 under high initial autonomy support, whereas under low initial autonomy support no such difference was observed. For agentic defiance, a disordinal pattern emerged: when initial autonomy support was low, higher defiance predicted slightly higher perceived autonomy support at T2, whereas under high initial autonomy support, higher defiance predicted lower autonomy support.

For agentic engagement, the absence of a reciprocal effect on later autonomy support was unexpected. However, the exploratory simple-slope finding is consistent with the idea that agentic engagement is most effective when paired with autonomy-supportive teaching (Patall et al., 2019).

For agentic defiance, autonomy-supportive teaching predicted lower defiance, and exploratory simple-slope patterns indicated that its prediction of later autonomy support may vary depending on students' initial perceptions of autonomy support. Legault et al.'s (2017) distinction between assisted and asserted autonomy provides a useful lens for interpreting these results: teacher-directed actions like agentic engagement may flourish in relationally supportive contexts, while task-directed expressions such as agentic defiance may represent autonomy-seeking efforts that arise despite limited support. Importantly, we found no evidence that agentic defiance reduced later perceptions of autonomy support. This is encouraging, given prior work showing that resistant or ambiguous student behaviors can be difficult for teachers to interpret and may elicit more controlling responses (Rainio, 2008; Rajala et al., 2016). Task-directed actions may be particularly susceptible to such misinterpretations.

However, it is crucial to note that changes in autonomy-support scores do not imply parallel changes in controlling or need-thwarting practices, as these interpersonal styles operate independently (Bartholomew et al., 2011; Haerens et al., 2015). Controlling and autonomy-supportive behaviors can co-occur, and controlling practices have been observed alongside higher levels of agentic engagement (the "backfire" effect; Patall et al., 2019).

Finally, intrinsic motivation did not predict changes in agentic engagement, agentic defiance, or perceived autonomy support. Related research within physical education demonstrates that autonomy-supportive teaching reduces resistant student behavior irrespective of students' baseline motivation (De Meyer et al., 2016). This indicates that teaching practices might play a stronger role in shaping students' agentic actions than their initial topic-specific interest.

Several factors may help explain the absence of reciprocal effects from students' agentic actions to later perceptions of autonomy support and intrinsic motivation. The study design required both observed lessons to focus on the same instructional topic, which may have constrained adaptive processes. Although this approach minimized variation in topic-specific intrinsic motivation, it may also have limited teachers' opportunities to respond flexibly to student initiatives. The impact of agentic engagement on perceived autonomy support may be stronger among certain student subgroups (e.g., high-achieving students; Patall, Kennedy, et al., 2022), potentially diluting effects at the sample level. Moreover, even when teachers notice students' initiatives, they often report time pressure or competing instructional demands as barriers to responding (Zambrano et al., 2023). Taken together, these considerations highlight the importance of interpreting student agency

within the broader ecology of classroom dynamics.

5.3. Limitations and future research directions

Several limitations should be acknowledged regarding our theoretical framework, methodology, and generalizability. Conceptually, while we focused on agentic engagement and agentic defiance, we did not consider other dimensions of student engagement. Related constructs such as teacher control and need frustration play a central role in maladaptive classroom pathways and operate independently from autonomy support (Bartholomew et al., 2011; Reeve et al., 2023). Our proposed distinction between agentic engagement and agentic defiance offers a useful starting point, yet whether they align with adaptive or maladaptive pathways requires further empirical elaboration.

Methodically, the two-wave longitudinal design over a three-week period limits our ability to capture gradual changes in student and teacher behavior. The internship context may also have induced perceived pressure that influenced pre-service teachers' motivational practices (Escriva-Boulley et al., 2021; Pelletier et al., 2002). Moreover, all data relied on student self-report. Despite the use of read-aloud procedures to support comprehension among young learners, developmental constraints may have affected response accuracy (Borgers et al., 2000). These self-report measures are also susceptible to social desirability bias, particularly because the surveys were administered by the pre-service teachers themselves. Furthermore, using a single reporter is a limitation because behaviors in transactional processes depend on individuals' perceptions (Nickel, 1976; Skinner & Belmont, 1993). Students' perceptions are essential as we focus on their behavior, yet relying solely on their reports means that teachers' practices should not be interpreted independently. Incorporating additional sources, such as teacher reports, could help limit this bias (e.g., Patall et al., 2024).

Analytically, the CLPM relied on two time points, which constrains its ability to disentangle between-person differences from within-person changes (Hamaker et al., 2015; Usami et al., 2019). The newly developed measure of agentic defiance integrates motivational appraisals with behavioral deviations, which may introduce interpretive ambiguity. Future adaptations should provide clearer behavioral references. Reliability estimates for autonomy support and agentic engagement were at the lower end of acceptable, although factor analyses supported the adequacy of the measurement models.

Finally, in terms of generalizability, although the linkage between autonomy-supportive instruction and students' agentic actions has been documented across classroom-based subjects, including science (Bae et al., 2024; Patall et al., 2019), the PE-specific context of this study limits the transferability of our findings. Subject-specific conditions that shape how agency is enacted warrant systematic examination, as classroom-based subjects may require greater teacher involvement, whereas PE may offer more opportunities for direct task-level agency. Additionally, the absence of a validated German version of the AES represents an additional limitation. Moreover, relations among agentic actions, autonomy support, and achievement were not examined, despite evidence that such associations may differ across student subgroups (e.g. high-achieving students; Patall, Kennedy, et al., 2022). Future work should also examine gender-related patterns more systematically, given emerging evidence of divergent trajectories in agentic behavior (Grazia et al., 2025), possibly exaggerated by the PE context in our study (Jang et al., 2023).

5.4. Implications for educational practices

Our findings highlight teachers' critical role in supporting student motivation and agentic engagement. Although we found no reciprocal effects from students' agentic actions to later autonomy support, this does not diminish the practical importance of recognizing and responding to student initiatives.

A key educational implication concerns teachers' awareness and

interpretation of different forms of agency. Research shows that teachers do not always acknowledge agentic engagement (Zambrano et al., 2023), and when they do they tend to respond more positively to aligned or compliant expressions of agency than to resistant ones (Mameli et al., 2025; Zambrano et al., 2023). Given that our results indicate that agentic defiance does not undermine later perceptions of autonomy support, resistant or task-modifying actions may not necessarily be detrimental. Instead, they may reflect students' attempts to maintain autonomy in situations they experience as less supportive. Helping teachers differentiate between destructive off-task behavior and meaningful, task-directed expressions of agency could prevent misinterpretations and promote more adaptive interactions.

Professional development programs should focus on strengthening autonomy-supportive practices (Großmann et al., 2023), as these reliably predict more adaptive student behaviors. In addition, they should enhance teachers' sensitivity to diverse forms of student agency (Vaughn, 2020; Zambrano et al., 2023), including ambiguous or resistant expressions that may signal unmet needs rather than opposition.

Finally, although our study did not test student-focused interventions, prior work shows that providing learners with concrete strategies for expressing their interests can increase agentic engagement (Patall, Zambrano, et al., 2022; Reeve, Jang, et al., 2022). Such approaches may complement teacher-focused efforts by supporting students in contributing constructively to classroom interactions.

6. Conclusion

This study examined how perceived teacher autonomy support, agentic engagement, agentic defiance, and topic-specific intrinsic motivation relate to one another over time in primary school PE lessons taught by pre-service teachers during three weeks of a full-time internship. Autonomy-supportive teaching predicted higher agentic engagement and intrinsic motivation and reduced agentic defiance, underscoring its central role in fostering adaptive student functioning. In contrast, students' agentic actions did not predict later perceptions of autonomy support, suggesting that, within this context, changes in students' behavior alone may not be sufficient to alter teachers' practices. Future work should examine how students enact different agentic actions in everyday classroom practice, how teachers perceive and interpret these diverse expressions, the conditions under which teachers respond constructively, and how students can be supported in expressing their agency in ways that promote mutually adaptive classroom dynamics.

Appendix A. Statistics

Table A1

Item statistics, corrected item–total correlations, Cronbach’s α if deleted, and standardized factor loadings for the Agentic Defiance scale (T1).

Item	<i>M</i>	<i>SD</i>	Corrected item–total <i>r</i>	α if deleted	Std. loading (λ)
defiance_1_1	1.60	0.92	0.64	0.75	0.71
defiance_2_1	1.65	0.95	0.69	0.74	0.81
defiance_3_1	1.45	0.84	0.58	0.77	0.68
defiance_4_1	1.40	0.81	0.51	0.78	0.55
defiance_5_1	1.84	1.04	0.59	0.77	0.67
defiance_6_1	1.33	0.72	0.37	0.81	0.39
Scale $\alpha = 0.80$					

Corrected item–total correlations (*r*) and α -if-deleted values were derived using `psych::alpha()` with robust maximum-likelihood estimation (MLR). Standardized loadings (λ) are from the single factor confirmatory factor analysis ($\chi^2(9) = 20.63, p = .014, CFI = 0.964, TLI = 0.940, RMSEA = 0.044 [0.029, 0.058], SRMR = 0.035$). All loadings were significant ($p < .001$).

CRedit authorship contribution statement

Clemens Berthold: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Richard Göllner:** Writing – review & editing, Writing – original draft, Supervision, Methodology.

Compliance with ethical standards

This study was planned and conducted in accordance with the ethical requirements of the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

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

During the preparation of this work the author(s) used Chat GPT (o1 mini & 5) to improve the readability and language of the manuscript. 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 published article.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research is part of the primary researchers' ongoing doctoral thesis funded by the Swiss National Science Foundation (SNSF). The grant 192397 has been awarded to Dr. Matthias Baumgartner (Pädagogische Hochschule St. Gallen). For further information see: <https://p3.snf.ch/project-192397>

Declaration of competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

Acknowledgements

The authors would like to thank Matthias Baumgartner, Eric Jeisy and Dominik Zulian for their support during this research process.

Table A2

Goodness of fit for confirmatory factor analysis (CFA) measurement model: invariance of the measurement factor structure across both time points.

CFA Model	χ^2	df	CFI	RMSEA	SRMR	Δ SBS χ^2	Δ df	p	Δ CFI
Configural	1130.128	548	0.937	0.038	0.051				–
Metric (Weak)	1151.147	562	0.936	0.038	0.051	13.481	14	.489	0.001
Scalar (Strong)	1179.855	580	0.935	0.038	0.052	17.549	18	.486	0.001
Strict	1262.340	598	0.928	0.039	0.053	39.494	18	<.01	0.007
Scalar + Cov	1372.039	664	0.926	0.038	0.052	162.280	84	<.001	0.009

χ^2 = chi-square statistic; df = degrees of freedom; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual; Δ SBS χ^2 = Satorra–Bentler scaled chi-square difference; Δ df = difference in degrees of freedom; p = p-value for chi-square difference test; Δ CFI = change in Comparative Fit Index.

Appendix B. Items in the student questionnaire

Table B1

German (as used in the distributed questionnaire)	English (translation or <i>original scale</i>)
Agentic Engagement (AES, Reeve, 2013)	
1. Im Sportunterricht sage ich, was ich mag und denke.	<i>During this class, I express my preferences and opinions.</i>
2. Ich sage meiner Lehrperson im Sportunterricht, was ich brauche und will.	<i>I let my teacher know what I need and want.</i>
3. Ich sage meiner Lehrperson im Sportunterricht, was mich interessiert.	<i>I let my teacher know what I am interested in.</i>
4. Wenn ich etwas im Sportunterricht brauche, frage ich meine Lehrperson.	<i>When I need something in this class, I'll ask the teacher for it.</i>
5. Im Sportunterricht stelle ich Fragen, um besser zu lernen.	<i>During class, I ask questions to help me learn.</i>
Agentic Defiance	
Ich mache im Sportunterricht manchmal ETWAS ANDERES als meine Lehrperson von mir verlangt...	
6. ...weil ich die Übungen oder Spiele nicht interessant finde.	I sometimes do SOMETHING DIFFERENT in physical education than my teacher asks me to... <i>6. ...because I don't find the exercises or games interesting.</i>
7. ...weil ich die Übungen oder Spiele langweilig finde.	<i>7. ...because I find the exercises or games boring.</i>
8. ...weil die Übungen oder Spiele für mich nicht wichtig sind.	<i>8. ...because the exercises or games are not important to me.</i>
9. ...weil ich mich bei den Übungen oder Spielen nicht mehr verbessern will.	<i>9. ...because I no longer want to improve at the exercises or games.</i>
10. ...weil ich lieber andere Übungen oder Spiele machen möchte.	<i>10. ...because I would prefer to do other exercises or games.</i>
11. ...weil mir die Übungen oder Spiele zu anstrengend sind.	<i>11. ...because the exercises or games are too exhausting for me.</i>
Teacher Autonomy Support (SMoPE, Kohake & Heemsoth, 2021)	
12. Meine Lehrperson lässt mich oft mitentscheiden.	12. My teacher often lets me have a say in decisions.
13. Meine Lehrperson lässt mich im Sportunterricht das machen, was mir Spass macht.	13. My teacher lets me do what I enjoy in physical education.
14. Meine Lehrperson hört mir wirklich zu, wenn ich etwas anders haben möchte.	14. My teacher truly listens to me when I want something to be different.
Intrinsic Motivation (adapted from Intrinsic Motivation Inventory; Ryan, 1982, and Gerlach et al., 2006)	
15. Das Thema der heutigen Sportstunde hat mir Spass gemacht.	15. I enjoyed the topic of today's physical education lesson.
16. Das Thema der heutigen Sportstunde mag ich einfach.	16. I simply like the topic of today's physical education lesson.
17. Ich wünschte, wir hätten das Thema der heutigen Sportstunde häufiger in der Schule.	17. I wish we had the topic of today's physical education lesson more often at school.
18. Bei dem Thema der heutigen Sportstunde mach ich gerne mit.	18. I enjoy participating in the topic of today's physical education lesson.

Appendix C. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.lindif.2026.102889>.

Data availability

The datasets presented in this article are not readily available due to a data embargo until the completion of qualification work within the context of the project by December 2026. Requests to access the datasets should be directed to the corresponding author, and from December 2026, they will be available on SWISSUBase.

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