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Longitudinal Reciprocal Effects of Agentic Engagement and Autonomy Support: Between- and Within-Person Perspectives

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Abstract

Autonomy-supportive teachers energize students' agency and initiative. However, few studies consider whether agentically-engaged students energize more autonomy-supporting teachers. We asked 2,908 middle and high school students in physical education courses to report their agentic engagement and the autonomy-supportiveness of their teachers. Data were collected at four-time points over one academic year. We tested two reciprocal effects models (REM) relating student perceptions of autonomy-supportive teaching and their agentic engagement; a between-person cross-lag-panel model (CLPM) and a within-person CLPM with random intercept (RI-CLPM). Both models supported the bidirectional reciprocal relations between perceived autonomy-supportive teaching and agentic engagement. Based on student perceptions, prior agentic engagement led to increased autonomy-supportive teaching and prior autonomy-supportive teaching led to greater agentic engagement. We discuss the practical implications of these findings for classroom research and recommend teachers to inform students early in the school year that they will welcome students' input and initiatives.

Keywords: Autonomy-supportive teaching; engagement; RI-CLPM; reciprocal relation; self-determination theory.

Educational Impact and Implications Statement

By being more autonomy supportive, teachers can enhance their students' classroom engagement. It is equally true that by being agentically engaged during classroom instruction, students can enhance their teachers' autonomy support. We showed this highly constructive mutual responsiveness between teachers and students in this study. The educational implications are that teachers who want more engaged students can practice greater autonomy-supportive teaching. Similarly, students who want more autonomy-supportive teachers can display greater agentic engagement. For practical reasons, we recommend teachers take the lead to jump-start this reciprocal process with more autonomy-supportive teaching.

Longitudinal Reciprocal Effects of Agentic Engagement and Autonomy Support: Between- and Within-Person Perspectives

In the ideal classroom, the teacher invites students' input and uses understanding language (e.g., "What would you like to learn about writing"), and the students respond by expressing their interests and goals (e.g., "I would like to learn how to write well. Could you give me an example of what good writing looks like?"). The former typifies autonomy-supportive teaching, while the latter typifies agentically engaged students. In addition, ideally, agentically-engaged students could invite teacher support by asking questions, participating proactively, and telling the teacher about their ideas and suggestions (e.g., "What is the best way to get started?"); the autonomy-supportive teacher would respond by listening to, accepting, and integrating those expressed preferences into the flow of the lesson ("Okay, so let's begin with that—the best way to get started."; Matos et al., 2018; Patall et al., 2019; Reeve & Shin, 2020). This back-and-forth mutual responsiveness is highly constructive, as teachers support students and students support teachers (Matos et al., 2018; Reeve et al., 2020). In the present paper, we suggest that this bidirectional relation between greater autonomy-supportive teaching and greater student agentic engagement is more than the ideal—it is actually the norm. However, we recognize that the reverse is equally normative—namely, that non-autonomy-supportive teaching tends to disable student agentic engagement, just as agentically disengaged students tend to disable autonomy-supportive teaching.

Numerous student benefits emerge when an autonomy-supportive teacher and agentically-engaged students interact reciprocally with each other, such as greater classroom engagement, skill development, and needs satisfaction (Reeve et al., 2020; Jang et al., 2016; Sameroff, 2009). Previous research showed that the teacher can initiate this process by being autonomy supportive (Benlahcene et al., 2022; Michou et al., 2023; Reeve et al., 2020).

Likewise, students can initiate it by being agentically engaged (Patall et al., 2019; Reeve, 2013; Reeve et al., 2022). Therefore, it is necessary to investigate the bidirectionality of agentic engagement and autonomy support in a more robust way.

Agentic engagement refers to students' active contribution into the flow of instruction they receive, typically by enriching that instruction in some important ways, such as by making it more interesting and personally relevant for themselves (Patall et al., 2019; Reeve, 2013). Agentic engagement represents one aspect of the multi-dimensional concept of student engagement. The four generally accepted aspects of student engagement are behavioral, cognitive, emotional, and agentic (Sinatra et al., 2015). Behavioral engagement refers to students' effort, attention, and persistence exerted during a learning activity (Skinner et al., 2009). Cognitive engagement refers to students' learning strategies and problem-solving during a learning activity (Senko & Miles, 2008). Emotional engagement refers to students' affective reactions, such as interest and enjoyment, during a learning activity (Skinner et al., 2009).

Although all four of these aspects of students' engagement are intercorrelated and complementary, agentic engagement possess the unique characteristic of giving students the means to create a more supportive and personalized learning environment for themselves (Reeve, 2013). To render a learning environment more interesting, personally relevant, and need-satisfying, agentically-engaged students speak up, ask questions, show initiative, make suggestions, offer their input, and communicate their interests and preferences to the teacher (Reeve, 2013; Reeve & Shin, 2020). Through their acts of agentic engagement, students help teachers become aware of what students want, need, and are interested in doing, and this awareness may change how the teacher interacts with students during instruction. Accordingly, such student agency tends to longitudinally increase the teacher's autonomy-supportive instructional behavior (Matos et al., 2018; Patall et al., 2021; Reeve et al., 2020).

Students' agentic engagement is educationally important not only because such acts of agency help students create a more supportive learning environment for themselves but also because they enable greater academic motivation, learning, and achievement (Patall et al., 2021; Reeve & Tseng, 2011; Reeve, 2013; Reeve et al., 2020, 2022).

Students can display high vs. low agentic engagement on a rank-order basis. Such rank ordering within a group conveys both high vs. low differences between students as well as the stable nature of those between student differences. Students can also display high vs. low agentic engagement on a moment-to-moment basis. Moment-to-moment and day-to-day changes in agentic engagement convey the state-like variability within students at different times. Consequently, students' agentic engagement can be conceptualized into both between- and within-students effects (Hamaker et al., 2015). Regarding the between-students (i.e., rank-order) effects, the extent of agentic engagement would be individually different between students in the same classroom (or school). Some students display more agentic engagement than do other students, while other students display less agentic engagement than do other students. Regarding the within-students (i.e., state-like) effects, the extent of agentic engagement would fluctuate or change from one moment or from one day to the next (state-like) around some baseline average (trait-like). The trait-like engagement represents a stable and usual level for the same student across time. In contrast, momentary rises and falls in agentic engagement are situationally enacted or triggered (Funder & Colvin, 1991; Gaspard & Lauermann, 2021). At any one moment of the day or at any one day of the week, some students display more or less agentic behaviors than they usually do, perhaps in response to changing motivational states, learning opportunities, or teaching practices.

Autonomy-supportive teaching is the adoption of a student-focused attitude and an understanding interpersonal tone. Adopting such an attitude and tone enables teachers to skillfully enact teaching practices that support students' intrinsic motivation and internalization of external regulations (Reeve & Cheon, 2021). These teaching practices include autonomy-need-satisfying instructional behaviors such as taking the students' perspective, offering choices, inviting students to pursue their personal interests, and providing explanatory rationales. Accordingly, such autonomy supportive teaching tends to longitudinally increase the students' agentic engagement behavior (Matos et al., 2018; Patall et al., 2022; Reeve et al., 2020). Autonomy-supportive teaching is educationally important because it facilitates students' engagement, learning, achievement, prosocial behavior, and well-being (Aelterman et al., 2016; Cheon et al., 2019; De Meyer et al., 2016). This approach to instruction increases these valued student outcomes because it first increases student autonomous motivations (e.g., autonomy-need satisfaction, intrinsic motivation, volitional internalization; Reeve et al., 2020).

Teachers can display high vs. low autonomy-supportive teaching on a rank-order basis. Such rank ordering conveys both high vs. low differences between teachers as well as the stable nature of those between teacher differences. Teachers can also display high vs. low autonomy support on a moment-to-moment basis. Moment-to-moment and day-to-day changes in autonomy support convey the state-like variability within teachers at different times. Consequently, just as students' agentic engagement can be conceptualized into between- and within-students effects, so can students' perceptions of their teachers' autonomy-supportive teaching (Hamaker et al., 2015). Regarding the between-students effects (i.e., rank-order effects), the extent of perceived autonomy-supportive teaching would be individually different between students in the same classroom (or school). Some students perceive greater autonomy-supportive teaching than do other students. Regarding the within-students (i.e., state-like) effects, the extent of perceived autonomy-supportive teaching would fluctuate or change from one moment or from one class or day to the next (state-like) around some baseline average (trait-like). While the trait-like perceived autonomy support represents a stable and usual level across time (Funder & Colvin, 1991; Gaspard & Lauermann, 2021), the within-students effect adds that the teacher may come across to students as more or less autonomy-supportive than usual, perhaps in response to changing classroom conditions or changes in the teacher, such as tone of voice, instructional goal, or testing day.

Teacher-Facilitating and Student-Facilitating Paths

According to Self-Determination Theory (SDT; Ryan and Deci, 2017), an autonomy-supportive teacher is a critical catalyst to creating a growth-promoting classroom environment (e.g., Aelterman et al., 2014; Assor et al., 2002; Edmunds et al., 2008; Reeve, 2009). However, Reeve (2013) explained that agentically-engaged students can be a second critical catalyst to creating a growth-promoting classroom environment, at least when their acts of agency successfully energize greater autonomy-supportive teaching. Therefore, empirical research has identified two catalysts for more growth-promoting teacher-student relationships. Here we refer to the first pathway as the *teacher-facilitating path* and the second as the *student-facilitating path.*

The *teacher-facilitating path* model (see Figure 1A) investigates the effect of prior autonomy-supportive teaching on students' later agentic engagement (Bordbar, 2019, 2021; Matos et al., 2018; Michou et al., 2023; Jiang & Zhang, 2021; Reeve et al., 2020). Prior research has found this path to be positive and significant. For example, the cross-sectional study with university students reported autonomy support to positively predict agentic engagement (Bordbar, 2019, 2021; Jiang & Zhang, 2021). A longitudinal study across two-time waves revealed that student-reported autonomy support predicted greater agentic engagement after controlling for prior agentic engagement (Matos et al., 2018). Also, a weekly diary study using cross-informants of middle school teachers and students showed both informants agreed that early teacher autonomy support positively predicted later agentic engagement (Michou et al., 2023). In a randomized control trial intervention study, students of teachers who participated in an autonomy-supportive teaching professional workshop showed more agentic engagement compared to students of teachers who did not participate in this workshop (Reeve et al., 2020).

The teacher-facilitating path emphasizes how the teacher's autonomy-supportive instruction provides motivational and engagement support for students. When the teacher provides such support, students are more likely to actively engage in a class by showing initiative, expressing their preferences, and suggesting their ideas and opinions (Reeve et al., 2020).

The *student-facilitating path* model (see Figure 1B) investigates the effect of student initiative on autonomy-supportive teaching (Matos et al., 2018; Michou et al., 2023; Patall et al., 2019, 2021; Reeve, 2013; Reeve et al., 2022). Prior research has also found this path to be positive and significant. A longitudinal study with two-time waves showed that baseline student agency predicted end-of-semester autonomy-supportive teaching, after controlling for prior autonomy support and students' other baseline engagement components (e.g., behavioral, emotional, and cognitive engagements; Matos et al., 2018). An in-class daily diary study showed a similar result (Patall et al., 2019). In this daily diary study, on those days when students displayed a relatively high level of agentic engagement, they perceived that their teacher was more autonomy supportive. Also, students' baseline levels of agentic engagement positively predicted their later perceptions of autonomy-supportive teaching (Patall et al., 2019). In a laboratory study in which some students were trained to be highly agentically engaged during a forthcoming teaching-learning session, teachers displayed significantly greater autonomy-supportive teaching with the trained-to-be-agentic students than they did with the untrained students. The study used objective ratings from external trained raters who scored students' agentic engagement and teachers' autonomy support from video recordings of the teaching session (Reeve et al., 2022).

The student-facilitating path emphasizes how students' agentic behaviors recruit greater autonomy-supportive teaching. When students display such initiative, teachers become more likely to teach in ways that take the students' perspective, support intrinsic motivation, and support internalization (i.e., autonomy-supportive teaching; Matos et al., 2018; Michou et al., 2023; Patall et al., 2019, 2021; Reeve, 2013; Reeve et al., 2022).

Statistical Model to Examine Between and Within Person Causal Effects

Previous research supports both the teacher-facilitating and student-facilitating paths. Recent research now suggests that these two paths may go hand in hand. That is, autonomy supportive teaching and agentic engagement are likely to be positively and reciprocally associated over time (see Figure 1C). Further, these mutually facilitating and reciprocal effects likely occur at both the between-students and within-student levels.

Between-students effects occur when those students who show more agentic engagement over time *more than do other students* also then perceive greater autonomy-supportive teaching over time *more than do other students* (and vice versa). This between-person phenomenon represents individual differences and rank-order changes between students.

Within-students effects, on the other hand, occur when the same student who shows greater agentic engagement in the moment *than they usually do* also then perceives greater autonomy support *than they usually do,* and vice versa. This within-person phenomenon represents the individual student's within -person fluctuation relative to what that student usually experiences.

Statistically, between-person and within-person effects are examined by cross-lag-panel model (CLPM) and by CLPM with random intercept (RI-CLPM), respectively. As shown in Figure 2, a between-person perspective utilizes a cross-lag-panel model (CLPM). A CLPM is typical practice to estimate the effects of a prior variable on another in longitudinal data (Little, 2013; Marsh et al., 2005; Orth et al., 2021). CLPM includes cross-lagged effects and autoregressive effects. The cross-lag effects refer to the longitudinal effect that variable A has on variable B in the next time wave (e.g., T1 autonomy support to T2 agentic engagement, T1 agentic engagement to T2 autonomy support). Autoregressive effects refer to longitudinal rank-order stability influence of one prior variable on that same variable at the next time wave (e.g., T1 autonomy support to T2 autonomy support, T1 agentic engagement to T2 agentic engagement). When measured repeatedly over time, some students are highly agentically engaged, some are moderately agentically engaged, and others are lowly or not at all agentically engaged, compared to each other (i.e., rank order). In the CLPM, the cross-lag effects parameters tests whether students with high rank-order agentic engagement (relative to other students) experience a subsequent rank-order increase in perceived autonomy-supportive teaching compared to students with low rank-order agentic engagement (Orth et al., 2021).

As shown in Figure 3, a within-person perspective utilizes CLPM with random intercept (RI-CLPM) of the two variables. The difference between CLPM and RI-CLPM is that CLPM analyzes the cross-lagged and autoregressive paths, while the RI-CLPM analyzes the cross-lagged and autoregressive paths after capturing, separating, and removing the variance in both variables attributable to the traits-like effects. Basically, CLPM represents the compounded variances of trait-like effects and state-like effects (sometimes called temporal fluctuations). The RI-CLPM, on the other hand, decompounds the variables' variances into trait-like factors (i.e., accounted for by the random-intercept) vs. state-like fluctuations (i.e., within-person effect; Hamaker et al., 2015). When repeatedly measured over time, this model tests to what extent (after controlling for trait-like agentic engagement and trait-like perceived autonomy support) students' levels of agentic engagement and perceived autonomy support fluctuate around this trait-like agentic engagement and trait-like autonomy support, respectively. In the RI-CLPM, the cross-lag effects parameters test whether students state-like fluctuation in agentic engagement (compared to what is usual for that student; trait-like) lead to a subsequent state-like fluctuation in perceived autonomy-supportive teaching (Orth et al., 2021), or vice versa.

Present Study

The best way to establish causality is to use the scientific method to design randomized control trials, which is an experimental research design that features random assignment to experimental versus control conditions. In cases where an experimental research design is not possible, however, an alternative way to investigate causality is to estimate the predictive effect of a variable on the longitudinal change in an outcome at a later time point (i.e., cross-lagged effect). This approach can provide suggestive evidence of causality in nonexperimental designs. The current study was a correlational-based longitudinal study, so we followed Byrne (1984)'s guidance on optimal procedures to warrant a causal interpretation to our findings.

Byrne (1984) identified three prerequisites to establish causality: (a) statistically the relationship between two variables must be established, (b) a causal model must be specified, and (c) a clear time precedence must be evident.

Prerequisite a

Theoretically and empirically, the relationship between autonomy support and agentic engagement has been established (Bordbar, 2019, 2021; Matos et al., 2018; Michou et al., 2023; Jiang & Zhang, 2021; Patall et al., 2019, 2021, 2022; Reeve, 2013; Reeve et al, 2020, 2022). Previous research, however, has some limitations that need to be addressed to establish the causality between autonomy support and agentic engagement (prerequisites b & c).

Prerequisite b

Most research has thus far tested unidirectional paths independently (except Matos et al., 2018). These studies tested either the teacher-facilitating path or the student-facilitating path, through cross-sectional (Benlahcene et al., 2022; Bordbar, 2019, 2021; Jiang & Zhang, 2021), longitudinal (Michou et al., 2023; Patall et al., 2022; Reeve, 2013), experimental (Reeve et al., 2022), or intervention (Patall et al., 2019; Reeve et al., 2020) research strategies. Such an "either-or" approach precludes statistical tests of bidirectionality (i.e., reciprocal relations) between autonomy support and agentic engagement. As past research has provided support for both the teacher-facilitating and student-facilitating paths independently, it is important to integrate both paths and test whether these relations are indeed bidirectional in nature. Bidirectional relations can be tested simultaneously using reciprocal effects models (REM; Marsh, 1990).

REM (see Figure 1C) is an appropriate technique to longitudinally estimate the bidirectional paths between two variables, after controlling for correlations within time points and stability of the same variable across time. If both teacher-facilitating and student-facilitating paths are statistically significant, then autonomy support and agentic engagement can be considered to be reciprocally related. However, if one path is statistically significant but the other path is not, then the relation of autonomy support and agentic engagement can be considered to be unidirectional (e.g., teacher-facilitating path is significant, but student-facilitating path is not).

In addition, the unidirectional models limit the capacity to address directional predominance. Directional predominance indicates whether one cross-lag path is larger than the other (Bentler & Speckart, 1981). For instance, a reciprocal effects model could find that the paths leading both from prior teacher autonomy support to subsequent student agentic engagement and from prior agentic engagement to subsequent autonomy support are significant. However, if the former path is statistically larger in size than the latter, it indicates that teacher autonomy support predicts students' agentic engagement more than student agentic engagement predicts teacher autonomy support.

Previous research on the relation of autonomy support and agentic engagement has primarily utilized only a between-person perspective (i.e., rank-order). Such an analysis tests only for individual difference effects among students (i.e., those high in A also become high in B). However, it is equally important to utilize a within-person perspective (i.e., state-like fluctuation). Such an analysis discriminates and investigates the variances in both variables attributable to rank-order effects (individual difference) and state-like effects within the same student. If the between-person effects are significant (in a CLPM analysis), while the within-person effects are not significant (in a RI-CLPM analysis), this means that the cross-lagged effects are a function of students' traits-like factor. If the within-person and between-person effects are both significant, this means that the cross-lagged effects are robust and occur as a function of both students' trait-like factors and state-like fluctuations.

Prerequisite c

Most studies have tested the causal relations of autonomy support and agentic engagement using only one- or two-time waves. Two waves of data represent a minimum number of time waves to test causality between two variables. Although Matos et al. (2018) tested the bidirectional nature of autonomy support and agentic engagement across two-time waves, they did so with only one-time lag (i.e., the time gap between the two waves of data). Hence, directional ordering cannot be robustly established. For more robust tests of causal ordering, three or more time points are preferred to test consistent causal effects of two variables over time (Marsh et al., 2022). According to Marsh and colleagues (2022), the best way to confirm causality is to demonstrate repeated causal effects over multiple time waves.

In addition, the RI-CLPM model requires at least three-time waves to be correctly specified (Mulder & Hamaker, 2021; Hamaker et al., 2015; Orth et al., 2021). To account for this issue, the present research tested reciprocal relations of autonomy support and agentic engagement over four-time points during a full academic year.

Hypotheses

We hypothesize that students' perceived autonomy support will be positively and reciprocally related to their experience of agentic engagement. That is, both the series of paths from prior autonomy support to subsequent agentic engagement (*teacher-facilitating path)* and the series of paths from prior agentic engagement to subsequent autonomy support (*student-facilitating path)* will be significantly positive. However, we do not offer specific hypotheses about the causal predominance of one path over the other, and we do not offer specific hypotheses to differentiate between- (CLPM) and within-level (RI-CLPM) effects (i.e., rank-order effects vs. state change effects). This is because Hamaker et al. (2015) emphasized that there is no a priori rationale for predicting either different causal estimation or the magnitude of effect sizes between a CLPM and a RI-CLPM. Instead, each model investigates a unique research question: the CLPM examines rank-order individual differences (between-person), while the RI-CLPM examines state-like fluctuations (within-person).

Method

Participants and Procedure

The present study was part of a large-scale longitudinal research project that investigated students' engagement and teachers' motivating styles in the physical education (PE) context. Participants were 2,908 secondary grade level students from 98 different classes (average size = 31.23, range = 15 to 46) in Korea (2,154 middle schoolers, 754 high schoolers). There were 1,445 males, 1,461 females, and two individuals with unreported genders.

The data were collected across four-time waves during a full academic school year: The beginning of the spring semester (T1; week 1); the middle of the spring semester (T2; week 10); the end of the spring semester (T3; week 18); and the end of the fall semester (T4; week 43). In the Korean educational system, the new academic year begins in early March. At this time, new teachers and new students meet as students advance to the next grade level. This first semester ends in late July, followed by a 1-month summer break. The second semester begins in early September and the academic year ends in late December. For each data collection time point, the research team visited the classrooms at the beginning of the PE class and asked students to complete the questionnaire regarding their experiences in that particular class. The research team read the participation information on the top of the first page of the questionnaire, including the purposes of data collection, voluntary participation, deidentified dataset, and possibility of withdrawal at any time. The research team member told the students that their survey data would be treated confidentially and used for research purposes only. Then, students completed a consent form. Compared to all 2,908 students who completed the questionnaire at T1, 2,743 students completed the questionnaire at T2 (retention rate = 94.3%), 2,683 completed the questionnaire at T3 (retention rate = 92.3%), and 2,601 students completed the questionnaire at T4 (retention rate = 89.4%).

The PE Class in Korean Secondary School

The physical education (PE) class is a mandatory course for all students in Korean secondary school (grades 7-12). PE classes are held two or three days a week, and the average class size is about 30 students who are all in the same grade. The Korean National and Educational Curriculum determines the content of the PE class. The curriculum content consists of knowledge about physical fitness, nutrition, health, and wellness and various sporting activities. Some classes occur in a traditional classroom setting, but the majority of classes take place in an inside gymnasium or an outdoor field. In general, PE teachers teach one particular grade. That means, students are likely taught by different PE teachers depending on their grade.

The daily PE class is, generally, structured around a four-part routine: class overview and warm-up exercise; "how to" instruction in a specific skill; engagement in a sporting activity (e.g., basketball, rope jumping, badminton); and wrap-up feedback and review. The first 10 minutes of class typically involves a warm-up exercise, such as stretching and heartrate acceleration. During class instruction, the teacher introduces the lesson plan and provides guidance on skills related to the activity (e.g., using a badminton racket). The rest of the class time is dedicated to a daily sporting activity. Typically, the teacher circulates to join individuals and small-groups to offer face-to face instruction, personalized feedback, and various assessments during this time. This characteristic of the PE class—teachers providing recurring opportunities for face-to-face instruction and mentoring with small groups of students—provided an ideal context to investigate our research questions. Other subject matters offer somewhat similar conversational opportunities, but the PE class seems especially good at offering students such opportunities for reciprocal interaction with their teacher. The last 5-10 minutes of class reflect a more traditional classroom structure, as the teacher summarizes the lesson, provides students with feedback, and prepares students for the next PE class.

Transparency and Openness

This study was not pre-registered. However, all data, analysis syntax (including all Mplus programs), and measures (including the full study questionnaire) are publicly available at our OSF project site: https://osf.io/xejbm/?view_only=0070375b385946fd80e051ba0313c415. We report all data inclusions and all measures in the study, and we followed JARS (Kazak, 2018).

Measures

Both the agentic engagement and autonomy support measures used the same 7-point Likert scale that ranged from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*). We utilized the Korean version of both questionnaires that were originally developed in English and back-translated professionally to Korean. These Korean-language questionnaires have been previously validated and widely used (e.g., Jang et al., 2016; Michou et al., 2023; Reeve, 2013). All items used to measure agentic engagement and autonomy support appear in Table 1.

Autonomy Support

To assess perceived teacher autonomy support at T1, T2, T3, and T4, we used the six-item Learning Climate Questionnaire (LCQ; Black & Deci, 2000). The LCQ is the most widely used measure of autonomy support (Jang et al., 2016; Parrisius et al, 2021; Patall et al., 2016). Internal consistencies of the 6-item scale were reasonably high across all waves of data collection: α = .90 (T1), α = .92 (T2), α = .94 (T3), and α = .94 (T4).

Agentic Engagement

To assess students' agentic engagement at T1, T2, T3, and T4, we used the five-item Agentic Engagement Scale (AES; Reeve, 2013). The AES is the most-widely used measure of students' agentic engagement (Benlahcene et al., 2022; Patall et al., 2016; Reeve et al., 2020). Internal consistencies of the 5-item scale were reasonably high across all waves of data collection: α = .92 (T1), α = .92 (T2), α = .93 (T3) and α = .92 (T4).

We conducted confirmatory factor analysis (CFA) to confirm that students' perceived autonomy-supportive teaching and their classroom experiences of agentic engagement were two distinct experiences. Standardized parameter estimates (beta coefficients) for the 11 items from 2 factor CFA model appear in Supplement Figure S1. The model fit the data reasonably well, χ^2 (43) = 351.501, p <.001, *RMSEA*= .050, *CFI* = .976, *TLI* = .969, *SRMR* = .024. All individual items loaded significantly and substantially on their respective factors

($p < .001$). The CFA confirms that the two factors were positively correlated ($r = .490$) but separate constructs.

Data Analysis

We applied three methods to optimally prepare the longitudinal data for analysis. We provide an in-depth explanation of these procedures in the Appendix, and we provide the Mplus syntax used on the OSF project site. First, all items for autonomy support and agentic engagement were standardized to a common metric ($M = 0$, $SD = 1$) in relation to participants' T1 responses (i.e., Week 1, the beginning of the 1st semester). This procedure facilitates interpretation as all effects are relative to their baseline scores (Marsh et al., 2022; Marsh et al., 2023). Second, we imposed the item factor loadings of each agentic engagement and autonomy support latent variable (see Supplemental Figure S1) to a constant value across all four waves of data. This procedure ensures that the measurement model underlying the hypothesized model is robust and consistent over time (Marsh et al., 2022; Marsh et al., 2023). Third, to account for the nested nature of the data, we centered all individual responses at the classroom level (i.e., group mean centering). This procedure removes class effects (Wang & Maxwell, 2015). For the covariates, grade level and class size were group mean centered and gender was grand mean centered.

We analyzed the data with the "Model = Complex" command with Mplus version 8.3 (Muthén, & Muthén, 2019), using the maximum likelihood robust estimator (MLR) and the full information maximum likelihood (FIML; Enders, 2010) estimation procedure to handle missing data (6.8% of the data).

Longitudinal Structural Invariance

To investigate reciprocal relations of autonomy support and agentic engagement over the full academic year, we employed a longitudinal equilibrium test by constraining the structural paths. We did this because the present study was interested in the directionality of two variables, rather than in time specific effects. This technique is useful to test invariance for the stability paths and the cross-lagged paths over time waves. It greatly facilitates the interpretation of results in reciprocal relations (Marsh et al., 2018; Mulder & Hamaker, 2021). This pattern of constraints applied to both CLPM and RI-CLPM to see if reciprocal relations of autonomy support and agentic engagement were invariant in rank order across students and in state change (i.e., temporal fluctuations) within students. As shown in Figures 2 and 3, we constrained the two stability paths (β_{xx} & β_{yy}) and the two cross-lag paths (β_{xy} & β_{yx}) to be invariant over time. β_{xx} represents the invariance in stability paths of autonomy support over time, and β_{yy} represents the invariance in stability paths of agentic engagement over time. β_{xy} represents the invariance in the cross-lag paths of teacher-facilitating paths (from autonomy support to agentic engagement) over time, and β_{yx} represents the invariance in the cross-lag paths of student-facilitating paths (from agentic engagement to autonomy support) over time.

Cross-Lag-Panel Model (CLPM, Between Perspective)

To develop the CLPM, we first needed to build latent variables. At each time point, the six items from the LCQ scale served as individual indicators for the perceived autonomy support latent variable. Similarly, the five items from the agentic engagement scale served as individual indicators for the agentic engagement latent variable. Next, we identified structural relations among these two latent variables. Auto-regressive stability paths were regressed on the same latent variable in each adjacent wave (e.g., T1 agentic engagement → T2 agentic engagement, T2 agentic engagement → T3 agentic engagement, T3 agentic engagement → T4 agentic engagement). Covariances were included between the two latent variables at the same time wave (e.g., T1 agentic engagement with T1 autonomy support). We specified hypothesized cross-lagged paths between the latent variables of perceived autonomy support and agentic engagement across four-time waves. Considering the longitudinal nature of the data, we correlated the error terms of the same item for all 11 indicators between time waves (correlated uniquenesses, Marsh et al., 2013), because a model without correlated uniqunenesses typically undermines goodness-of-fit and shows biased parameter estimates. The covariates of gender (0 = Male, 1 = Female), grade level (0 = Middle, 1 = High), and class size were regressed on the T1 variables and correlated with each other. Lastly, we constrained the two stability paths (autonomy support to autonomy support; agentic engagement to agentic engagement) and the two cross-lag paths (autonomy support to agentic engagement; agentic engagement to autonomy support) to be invariant over time.

Random Intercept-Cross-Lag-Panel Model (RI-CLPM, Within Person Perspective)

To develop the RI-CLPM, we again needed to build latent variables. The first latent variables were the same as created for the CLPM and represented the measurement model (one latent variable with 6 indicators for autonomy-supportive teaching and one latent variable with 5 indicators for agentic engagement). All measurement error variances and intercepts were constrained to 0. We called these latent variables as basic latent variable. Next, we decomposed students' autonomy-supportive teaching and agentic engagement variances into two parts—one component to represent the trait-like component (i.e., the random intercept) and one component to represent the state-like component (i.e., within-person fluctuations over time).

For the trait-like component, we developed random intercepts for both variables. For the trait-like perceived autonomy support, the four basic latent variables (one for each time wave) served as the indicators. In the same way, for the trait-like agentic engagement, the four basic latent variables served as the indicators. All factor loadings of the basic latent variables on these trait-like variables were fixed to 1. These random intercepts represent time invariant, trait-like components.

For the state-like component (within-person fluctuation), we developed a second order factor. For perceived autonomy support, the higher order factor was loaded on the basic latent variable of perceived autonomy support at each time wave. In the same way, for agentic engagement, the higher order factor was loaded on the basic latent variable of agentic engagement at each time wave. All loadings of the higher order factor on latent variables were fixed to 1. These higher order factors represent state-like component. This is the within-person fluctuations.

Next, we identified structural relations among the variables in the within level to test the reciprocal relations. Auto-regressive stability paths were regressed on the same temporal variable at each adjacent wave (e.g., T1 → T2, T2 → T3, T3 →T4), at the within level. Correlations were included between the two state-like components at the same time wave (e.g., T1 autonomy support with T1 agentic engagement). Then, we specified the hypothesized cross-lagged paths between the variables of state-like autonomy support and state-like agentic engagement across the four-time waves at the within level. Covariances were included in the error terms of the same item for all 11 indicators across time waves (correlated uniquenesses, Marsh et al., 2013). The covariates of gender, grade level, and class size were regressed on the trait-like variables of perceived autonomy support and agentic engagement and correlated with each other. One merit of RI-CLPM is to provide better control for truly time-invariant covariates that are unmeasured. This is because trait-like factors (i.e., random intercept factors) largely absorb time-invariant covariates' effects. Lastly, we constrained the two stability paths (autonomy support to autonomy support; agentic engagement to agentic engagement) and the two cross-lag paths (autonomy support to agentic engagement; agentic engagement to autonomy support) to be invariant over time.

Sensitivity Test for Robustness Check

Given that our model has more than two time waves (four waves), we examined the rigorous relations of autonomy support and agentic engagement by including additional lag-2 paths (T1 → T3, T2 → T4) in the current models. Including lag-2 paths allows for more robust control for unmeasured potential covariates and prior effects in CLPM and RI- CLPM (Lüdtke & Robitzsch, 2021; Marsh et al., 2018). Lag-2 strongly controls time-varying unmeasured potential covariates (also see Marsh, Pekrun, et al., 2018, 2022; VanderWeele et al., 2019; 2020) and effectively corrects biased effects. Because after accounting for the effects of Wave - T and Wave - T+1, it is less probable that a covariate specific to Wave - T will have an impact on variables at Wave - T+2 (VanderWeele et al., 2020). The reason we included and constrained these additional auto-regressed lag-2 paths and two cross-lagged lag-2 paths was to test whether including lag-2 paths supported/replicated or changed the reciprocal relations of autonomy support and agentic engagement. Therefore, the two results complement each other, and when combined, their similarity is stronger than when they are considered separately. The specific technique to control lag-2 paths and visualization may be found in the added dashed lines that can be seen in Supplemental Figures S2-A and S2-B.

Results

Data were normally distributed on the two measures across all four-time waves of data collection (total 8 measures, skewness < |0.53| and kurtosis < |0.54|). Table 1 shows the descriptive statistics and standardized coefficients associated with the 44 indicators included in the measurement model. Table 2 shows the goodness-of-fit statistics from the confirmatory factor analysis (CFA) testing for measurement invariance across the factor structure over four waves. Table 3 shows the latent correlations between agentic engagement and autonomy support across four waves and covariates.

Measurement Invariant Test

The purpose of the invariance test was to examine whether the measurement model had a well-defined structure (i.e., the measurement model was the same at T1, T2, T3, and T4). It means that the measures used to assess autonomy support and agentic engagement remain stable over time and can be used to make valid comparisons across different time points. Measurement invariance enables appropriate interpretations of the hypothesized reciprocal relations in the between and within perspectives (i.e., CLPM and RI-CLPM). These tests do not evaluate a particular model. Instead, they evaluate the extent to which the measures used to assess autonomy support and agentic engagement remain the same over time and can be used to make valid comparisons across different time points.

Based on the evaluation criterion (Δ *CFI* < .01; Cheung & Rensvold, 2002), we found that the factor structures were well defined across four-time waves and that, as shown in Table 2, the measurement model showed strong metric (Δ *CFI* = .001) and scalar (without covariates: Δ *CFI* = .001; with covariate: Δ *CFI* = .004) invariance. Therefore, the fit of measurement model in the current research allows for the examination of the relationships between two variables using the reciprocal effects model (REM).

Longitudinal Equilibrium Over Time

Cross-Lag-Panel Model (CLPM, Between Perspective)

The hypothesized CLPM fit the data reasonably well, χ^2 (1,014) = 4,163.028, *p* < .001, *RMSEA* = .033, *CFI* =. 954, *TLI* =.951, *SRMR* = .058. The relation between autonomy support and agentic engagement was reciprocal and invariant over the four-time waves. All autoregressive paths showed invariance across the four-time waves: autonomy support, β_{xx} = .46, *SE* = .02, *p* < .001, and agentic engagement β_{yy} = .45, *SE* = .02, *p* < .001.

All cross-lag paths showed invariance across the four-time waves. Teacher-facilitating path (β_{xy}) was invariant. Prior autonomy support led to subsequently greater agentic engagement invariantly across all time waves during the academic year, β_{xy} = .14, *SE*

= .02, $p < .001$. Thus, students who ranked higher in autonomy support compared to other students at a previous time point, ranked higher in agentic engagement compared to other students at a later time point. Similarly, student-facilitating path (β_{yx}) was invariant. Prior agentic engagement led to subsequently greater autonomy support invariantly across all time waves during the academic year, $\beta_{yx} = .18$, $SE = .02$, $p < .001$. Thus, students who ranked higher in agentic engagement compared to the other students at a previous time point, ranked higher in autonomy support compared to other students at a later time point.

Regarding covariates, grade did not predict T1 autonomy support ($\beta = -.03$, $SE = .96$, $p = .974$) or T1 agentic engagement ($\beta = -.13$, $SE = .51$, $p = .805$); class size did not predict T1 autonomy support ($\beta = .06$, $SE = .07$, $p = .351$) or T1 agentic engagement ($\beta = .02$, $SE = .04$, $p = .669$); and gender did not predict T1 autonomy support ($\beta = .00$, $SE = .04$, $p = .974$) but it did predict T1 agentic engagement ($\beta = -.15$, $SE = .03$, $p <$ 001), as boys scored higher than girls.

As to directional predominance, the magnitude of the teacher-facilitating path and the magnitude of the student-facilitating path did not significantly differ. We statistically tested for differences between two beta coefficients (z-test). Neither the teacher-facilitating path nor the student-facilitating path showed predominance (.14 vs .18, $z = -1.56$, $p = .119$). For those interested in seeing the magnitude of the freely estimated cross-lagged paths across all time points (T1 → T2; T2 → T3, and T3 → T4), these standardized beta weights appear in Supplemental Table S1.

Sensitivity test for robustness check. The hypothesized CLPM that included the additional lag-2 paths also fit the data reasonably well: χ^2 (1,010) = 3,835.580, $p < .001$, *RMSEA* = .031, *CFI* =. 958, *TLI* =.956, SRMR = .033. Overall model fit was better than the hypothesized CLPM without lag-2 paths, $\Delta\chi^2$ (Δ 4 *df*) = 327.45, $p < .001$. In the sensitivity test, the relation between autonomy support and agentic engagement was rigorously reciprocal. Again, all autoregressive paths showed invariance across the four-time waves: autonomy support, β_{xx} = .39, *SE* = .02, $p < .001$, and agentic engagement β_{yy} = .38, *SE* = .02, $p < .001$. Also, all cross-lag paths showed invariance across the four-time waves. The teacher-facilitating path was β_{xy} = .11, *SE* = .02, $p < .001$, and the student facilitates path was β_{yx} = .15, *SE* = .02, $p < .001$. Further, neither path showed predominance (.11 vs .15, z = -1.55, p = .121).

Random Intercept-Cross-Lag-Panel Model (RI-CLPM, Within Perspective)

The hypothesized RI-CLPM fit the data reasonably well, χ^2 (999) = 3,790.012, $p < .001$, *RMSEA* = .031, *CFI* =. 959, *TLI* =.956, *SRMR* = .033. The correlation of stable traits between autonomy support and agentic engagement was r =.28, *SE* = .03, $p < .001$. After controlling for these stable trait factors, the within relation between autonomy support and agentic engagement was reciprocal and invariant over the four-time waves. All autoregressive paths showed invariance across the four-time waves: autonomy support, β_{xx} = .26, *SE* = .05, $p < .001$, and agentic engagement β_{yy} = .12, *SE* = .03, $p < .001$. Values for the auto-regressive stability paths were smaller in the RI-CLPM compared to those from the CLPM. This is likely because the stable trait factors in the RI-CLPM account for some of the stability path variance.

All cross-lag paths showed invariance across the four-time waves. Teacher-facilitating path (β_{xy}) was invariant. Prior autonomy support led to subsequently greater agentic engagement invariantly across all time waves during the academic year, β_{xy} = .12, *SE* = .03, $p < .001$. Thus, high levels of autonomy support for a given student at a prior time point led to greater levels of agentic engagement for that student at a later time. Similarly, student-facilitating path (β_{yx}) was invariant. Prior agentic engagement led to subsequently greater autonomy support invariantly across all time waves during the academic year, β_{yx}

= .11, SE = .03, p < .001. Thus, high levels of agentic engagement for a given student at a prior time point led to greater levels of autonomy support for that student at a later time.

Regarding covariates, grade did not predict trait-like autonomy support (β = .98, SE = 1.04, p = .348) or trait-like agentic engagement (β = .34, SE = .38, p = .368); class size did not predict trait-like autonomy support (β = .09, SE = .10, p = .369) or trait-like agentic engagement (β = .04, SE = .04, p = .343); and gender did not predict trait-like autonomy support (β = -.04, SE = .04, p = .310) but it did predict trait-like agentic engagement (β = -.15, SE = .03, p < 001), as boys scored higher than girls.

As to directional predominance, the magnitude of the teacher-facilitating path and the magnitude of the student-facilitating path did not significantly differ. Once again using the z-test, we found that the effect of prior autonomy support to later agentic engagement was not significantly different in magnitude, as compared to the other path (.12 vs .11, z = 0.39, p = .697). For those interested in seeing the magnitude of the freely estimated cross-lagged paths across all time points (T1 → T2; T2 → T3, and T3 → T4), these standardized beta weights appear in Supplemental Table S1.

Sensitivity test for robustness check. The hypothesized RI-CLPM including lag-2 paths fit the data reasonably well: χ^2 (995) = 3,722.675, p < .001, $RMSEA$ = .031, CFI =. 960, TLI =.956, $SRMR$ = .026. Overall model fit improved significantly, compared to the hypothesized RI-CLPM without the additional lag-2 paths, $\Delta \chi^2$ (Δ 4 df) = 67.34, p < .001. In the sensitivity test, the relation between autonomy support and agentic engagement was rigorously reciprocal. The correlation of stable traits between autonomy support and agentic engagement was r =.16, SE = .05, p = .001. After controlling for the stable trait factors, again, all autoregressive paths showed invariance across the four-time waves: autonomy support, β_{xx} = .38, SE = .04, p < .001, and agentic engagement β_{yy} = .12, SE = .05, p < .001. Also, all cross-lag paths showed invariance across the four-time waves. The teacher-facilitating path was β_{xy} = .17, SE = .03, p < .001, and the student-facilitating path was β_{yx} = .11, SE = .04, p < .001. Unlike the previous test for directional predominance, predominance did emerge when comparing two paths, as the teacher-facilitating path was predominant over the student-facilitating path (.17 vs .11, z = 2.33, p = .019).

The Effects Size Comparison between CLPM and RI-CLPM

Orth et al. (2022) suggested the effect size guidelines: .03 indicates a small effect, .07 indicates a medium effect, and .12 indicates a large effect. The same guidelines were applied to both CLPM and RI-CLPM, and that allows to direct comparison of effect size between CLPM vs. RI-CLPM. Comparing the effect sizes between CLPM vs. RI-CLPM, teacher-facilitating paths (b_{xy}) were .14 vs. .12 (p =.435), and student-facilitating paths (b_{yx}) were .18 vs. .11 (p =.006). Overall, all paths showed a large effect. In student-facilitating path, CLPM showed a larger effect than RI-CLPM.

Discussion

The purpose of the present study was to investigate the causal, bidirectional relations of agentic engagement and perceived autonomy support. We tested a reciprocal effects model (REM) by integrating the teacher-facilitating path and the student-facilitating path into a single comprehensive model using both between- (CLPM) and within- (RI-CLPM) person perspectives over a full academic year. Overall, the findings showed that agentic engagement and perceived autonomy support were reciprocal. Specifically, perceived autonomy support led to higher agentic engagement, controlling for the reciprocal student-facilitating path, and agentic engagement led to higher perceived autonomy support, controlling for the reciprocal teacher-facilitating path. While previous research has examined the unidirectionality of student-facilitating and teacher-facilitating paths independently, the present findings confirm that these effects are significantly and positively bidirectional even when examining both paths simultaneously. As to directional predominance, neither the teacher-facilitating path nor the student-facilitating path showed predominance over the other in the original analyses. The supplemental sensitivity analyses involving the lag-2 paths in the CLPM showed no predominance, but this same test applied to the RI-CLPM did show that the teacher-facilitating path was predominant over the student-facilitating path.

Reciprocal Relation in Between-and-Within Person Perspectives

The present findings showed the importance of examining both the between- and within-person perspectives for the generalizability of the reciprocal effects. Overall, the reciprocal relation of perceived autonomy support and agentic engagement was invariantly shown in both the between (rank-order effects) - and within (state-like fluctuations) - person analyses.

In the between person perspective, students who showed higher agentic engagement at one point in the flow of instruction subsequently reported greater perceived autonomy support from the teacher at a later point in the flow of instruction, compared to their less agentically engaged counterparts. Similarly, students who perceived higher autonomy-supportive teaching at one point in the flow of instruction subsequently reported greater agentic engagement at a later point in the flow of instruction, compared to other students who perceived a lower level of autonomy-supportive teaching. This result replicated and confirmed existing findings from two-wave longitudinal studies, experimental studies, and an overall group of studies testing the unidirectionality of the teacher-facilitating path or the student-facilitating path (Bordbar, 2019, 2021; Matos et al., 2018; Michou et al., 2023; Jiang & Zhang, 2021; Patall et al., 2019, 2021; Reeve, 2013; Reeve et al, 2020, 2022). This reciprocal interplay was invariant over the four-time waves.

In the within person perspective, it is first noteworthy that students' trait-like agentic engagement and trait-like perceived autonomy support were positively correlated. This means that high (or low) levels agentic engagement tends to co-occur with high (or low) levels of perceived autonomy-supportive teaching. However, what the within person analyses showed further was that when the same individual student displayed more agentic behaviors than usual, that individual student then perceived their teacher as more autonomy supportive than usual. Similarly, when that same individual student perceived their teacher as more autonomy-supportive than usual, that individual student then displayed more agentic behaviors than usual. This means that (1) agentic engagement tends to recruit greater autonomy-supportive teaching—regardless of students' trait-like levels of agentic engagement, and (2) autonomy-supportive teaching tends to recruit greater agentic engagement—regardless of students' trait-like levels of perceived autonomy-supportive teaching.

Practical Applications

The primary educational implications of these findings are the following:

- Teachers can (and do) affect how agentically engaged their students will be during future classroom instruction, irrespective of whether students are agentically engaged or not during current instruction. Teachers do this by being more (or less) autonomy supportive during today's classroom instruction.
- Students can (and do) affect how autonomy supportive they perceive their teacher to be during future classroom instruction, irrespective of whether students perceived their teacher to be autonomy supportive or not during current instruction. Students do this by being more (or less) agentically engaged during today's classroom instruction.
- These two classroom effects co-occur and are reciprocal. Over the course of an academic year, students and teacher either move together toward a constructive synergy (the more autonomy-supportive I am, the more agentically engaged you become, and vice versa) or move together toward a counter-productive spiral (the less autonomy-supportive I am, the less agentically engaged you become, and vice versa).

Past research confirms the capacity of autonomy-supportive teaching to produce longitudinal gains in student outcomes (Reeve & Cheon, 2021), including agentic engagement (Matos et al., 2018; Reeve et al., 2020). The current findings testing the RI-CLPM confirmed that these benefits apply robustly not only for students who usually ask questions and communicate their interests and preferences, but also for students who are usually silent and do not show such initiative. Past research also confirms the capacity of an agentically-engaged learner to produce longitudinal gains in the quality of teaching they receive, especially how autonomy supportive teacher is toward them (Matos et al., 2018; Michou et al, 2023; Reeve, 2013; Reeve et al., 2020). The current findings testing the RI-CLPM confirmed that these benefits apply robustly not only for teachers perceived to be highly autonomy supportive, but also for teachers who are perceived to be not autonomy supportive. These findings suggest two additional classroom implications.

One additional classroom implication is this: If autonomy-supportive teachers encourage more agentically-engaged students and if agentically-engaged students encourage more autonomy-supportive teachers, then both levels of autonomy support and agentic engagement should rise over time. The current data supported such a positive trend in both agentic engagement and autonomy-supportive teaching over time (over the course of an academic year). Table 3 showed that students did report somewhat rising perceived autonomy support (Ms, 4.63 rose to 4.78) and agentic engagement (Ms, 3.72 rose to 3.99). The same positive rising trend has also appeared in previous research (Reeve, 2013; Table 6, p. 590).

This expectation for both agentic engagement and autonomy-supportive teaching to rise together over time gets a little tricky for two reasons. First, highly autonomy-supportive teaching leads to longitudinal gains in agentic engagement (and vice versa), but it is equally true that low autonomy-supportive teaching leads to longitudinal declines in agentic engagement (and vice versa). This means that students and teachers can come together in a constructive upward spiral, but it also means that students and teachers can come together in a counter-productive downward spiral. Second, as the academic year progresses, pressures and constraints can build up over time to move some teachers away from autonomy-supportive teaching and some students away from agentic engagement (e.g., end-of-semester summative examinations, time pressures to cover all course material). This suggests that this reciprocal causation might benefit from a little constructive management (discussed next).

The second additional classroom implication is a practical, reflective question: Who should jump start this constructive upward spiral of greater agentic engagement and greater autonomy-supportive teaching—the student or the teacher? Our findings suggest the answer is “either one”, but practical considerations may qualify this general conclusion in important ways.

Irrespective of whether the student first offers greater agentic engagement or the student first perceives greater autonomy-supportive teaching, the end-of-year result is likely to be the same upward spiral. But there are two practical constrains to consider. The first constraint is the ever-present power differential between teachers and students in the typical classroom environment. Typically, the role of teacher is to provide information and to give assignments while the role of the student is to receive information and to receive assignments. These relational and role dynamics suggest that, in some cases, it could be awkward or logistically difficult for the student to take the initiative without explicit guidance or invitation from the teacher (Schrodt et al., 2008; Sproston, 2008). This lack of empowerment may result in the teacher bearing the greater responsibility for encouraging and facilitating student engagement. The second constraint is that when objective classroom raters observe teachers trying to influence students and students trying to influence teachers, it is clear that teachers typically miss more student influence attempts than students miss teacher influence attempts (using the Hit-Steer Observation System; Fiedler, 1975; Koenigs et al., 1977; Reeve & Tseng, 2011). This suggests that much of the breakdown in teacher-student reciprocity lies with the teacher—because he or she is constrained by multitasking and 30 or so simultaneous interaction partners.

What is clear is that if one partner (the teacher or the student) will make a special effort to become more autonomy-supportive (by participating in an autonomy support workshop; Reeve et al., 2020) or more agentically engaged (by participating in an experimental intervention; Reeve et al., 2022; Patall et al., 2021), then it becomes likely that the pair will enter into a constructive upward spiral together. Nevertheless, we are inclined to suggest that the professional in the room (the teacher) take on this responsibility, partly for practical reasons and constraints but also because the benefits of greater autonomy-supportive teaching are so consistent and robust (Reeve & Cheon, 2021). Numerous intervention studies have shown that teachers who participate in a well-designed, skill-based autonomy-supportive teaching professional development experience become increasingly able to produce numerous student benefits (Cheon & Reeve, 2013; Cheon et al., 2020; Reeve & Cheon, 2021). This same professional development can also decrease students' maladaptive motivational and behavioral functioning that otherwise tends to interfere with a constructive teacher-student synergy, such as amotivation (Rouse et al., 2011; Gillet et al., 2012), disengagement (Patall et al., 2018), and antisocial behavior (Mallia et al., 2019). We can also suggest a simpler way that teachers can jump start this constructive upward spiral. During the first week of class, teachers could simply make a special effort to make it clear to students that they have a highly autonomy-supportive teacher. Once the student receives the message that their input and initiatives are both welcomed and encouraged, then the teacher and students have an open runway to interact reciprocally and constructively together.

Generalizability of the Present Findings

We obtained the present findings from a large sample of Korean secondary grade students taking the PE course. The nature of this sample raises a question of generalizability. As to whether our findings might generalize beyond the PE subject matter, studies of agentic engagement have sampled students from multiple subject matters (Reeve & Tseng, 2011) as well from single subject matter courses, such as science (Patall et al., 2022), foreign language (Dincer et al., 2019), and PE (Reeve, 2013). When Matos and colleagues (2020) compared agentic engagement, perceived autonomy support, and the correlation between agentic engagement and perceived autonomy support for students taking science classes versus students taking humanities classes, they found no subject matter differences. As to the Korean educational context, one group of researchers compared the correlation between agentic engagement and perceived autonomy support for samples of students in Korea vs. samples of students in all other countries (Reeve et al., 2023). The bivariate correlation was no different for the 10 samples of Korean students ($M\ r = .48$) than it was for the 26 samples of non-Korean samples ($M\ r = .44$), $t(34) = 0.83$, $p = .410$, $d = 0.13$. The one area of concern regarding generalizability might be in relation to gender. In our sample, boys reported a higher mean level of agentic engagement than did girls, a gender difference that likely reflects the sport-related nature of some PE classroom activities. That said, boys and girls did not differ on either perceived autonomy support or the correlation between agentic engagement and perceived autonomy support. Overall, the bivariate relation between these two variables seems fairly robust across contexts (i.e., subject matter, nationality, gender). As to whether their reciprocal relation is similarly robust across these contexts, this is a question that will need to be tested and evaluated in future research.

Limitations

We note two limitations of the present research. First, the present research rigorously investigated individual-level perception (variances) through students' self-reports. The findings are limited to the extent that we did not assess actual teacher and student behavioral interaction (e.g., see Michou et al., 2023; Sameroff, 2009). Future study needs to examine whether actual behavioral data would produce similar reciprocal relations as individual-level perception data, as through raters' observation of autonomy-supportive instructional behaviors (Cheon et al., 2018) and students' publicly expressed agentic behaviors (Reeve et al., 2004; Reeve & Tseng, 2011).

Second, we could not control for some unmeasured covariates. For example, school context, student achievement level, student evaluations of teaching effectiveness, the school's social ethos, and students' prior experiences might influence these teacher-student interactions and relationships. However, we were able to somewhat address this concern for unmeasured covariates by including the test for lag-2 paths in the model (for more robust control of unmeasured potential covariates and prior effects in CLPM and RI- CLPM; Marsh et al., 2018; Lüdtke & Robitzsch, 2021).

Conclusion

The present research showed that the longitudinal relation of agentic engagement and autonomy support is reciprocal. This finding was relatively robust in both the between-and the within-person perspectives. Both of these effects produce highly beneficially educational effects, as agentically engaged students benefit their teachers (they become more autonomy supportive) and autonomy-supportive teachers benefit their students (they become more agentically engaged).

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Appendix A

Three methods to prepare longitudinal dataset.

To optimally prepare the longitudinal data for analysis, we applied three methods.

1. We standardized all item responses to a common metric based on participants' T1 responses. This common metric score can be obtained by the following formula: (x at T1 – mean of x at T1) / SD of x at T1, (x at T2 – mean of x at T1) / SD of x at T1, (x at T3 – mean of x at T1) / SD of x at T1, (x at T4 – mean of x at T1) / SD of x at T1. By doing so, the values measured at different time waves indicate distributions around T1 responses. This procedure is useful to interpret the magnitude of change in a longitudinal study (Marsh et al., 2022; Marsh et al., 2023).

2. We built an invariant measurement model by fixing parameter estimates to the standardized factor loading in the scalar invariance solution. Specifically, we fixed the first factor loading of each latent variable to the standardized factor loading value obtained in the scalar invariance solution at Time 1, instead of fixing each value to 1.0. This model represents factor loadings that are standardized and invariant across time waves (Marsh et al., 2022; Marsh et al., 2023).

3. Group mean centering is a useful method for comparing values measured from different classes of students. It can be obtained by subtracting the mean score of a group of scores from each individual score in that group. This way, the values measured at different classes indicate distributions around the group mean responses, making it easier to interpret the data results (Wang & Maxwell, 2015).

Table 1

Descriptive Statistics and Standardized Coefficients Associated With the 44 Indicators Included in the Measurement Model.

	Time 1		Time 2		Time 3		Time 4	
	B	*M (SD)*	*B*	*M (SD)*	*B*	*M (SD)*	*B*	*M (SD)*
Agentic Engagement								
I let my teacher know what I need and want	0.79	4.34 (1.42)	0.79	4.52 (1.45)	0.79	4.63 (1.43)	0.79	4.70(1.41)
I let my teacher know what I'm interested in	0.89	4.34 (1.48)	0.84	4.53 (1.50)	0.83	4.63 (1.45)	0.82	4.71(1.40)
During this PE class, I express my preferences and opinions	0.92	4.26 (1.47)	0.84	4.47 (1.48)	0.85	4.59 (1.45)	0.84	4.68(1.41)
During PE class, I ask questions to help me learn	0.88	4.23 (1.45)	0.85	4.42 (1.51)	0.84	4.55 (1.47)	0.82	4.64(1.42)
When I need something in this PE class, I'll ask the teacher for it	0.72	4.09 (1.46)	0.73	3.87 (1.50)	0.65	4.09 (1.41)	0.69	4.20(1.51)
Autonomy Support								
My teacher provides me with choices and options	0.64	4.66 (1.21)	0.64	4.76 (1.27)	0.64	4.76 (1.28)	0.64	4.80(1.25)
I feel understood by my teacher	0.73	4.69(1.25)	0.70	4.74 (1.30)	0.69	4.72 (1.34)	0.69	4.80(1.29)
My teacher conveys confidence in my ability to do well in the course	0.82	4.64 (1.24)	0.77	4.70 (1.28)	0.68	4.72 (1.32)	0.72	4.78(1.25)
My teacher encourages me to ask questions	0.85	4.62 (1.20)	0.83	4.70 (1.26)	0.75	4.72 (1.27)	0.80	4.78(1.25)
My teacher listens to how I would like to do things	0.82	4.51 (1.19)	0.81	4.63 (1.25)	0.74	4.67 (1.27)	0.77	4.72(1.22)
My teacher tries to understand how I see things before suggesting a new way to do things	0.81	4.64 (1.16)	0.77	4.71 (1.22)	0.73	4.75 (1.25)	0.75	4.78(1.22)

Table 2

Goodness of Fit for Confirmatory Factor Analysis (CFA) Measurement Model: Invariance of the Measurement Factor Structure Over 4-Waves.

CFA Model	*Chi-SQ*	*df*	*RMSEA*	*CFI*	*TLI*	*SRMR*	*Δ CFI*
Configural invariance: Correlated Uniquenesses (Base Model)	3,121.28	808	.031	.963	.956	.023	-
Metric invariance: Constrain factor loadings	3,177.98	835	.031	.962	.957	.023	.001
Scalar invariance: Constrain intercept	3,303.46	868	.031	.961	.957	.023	.001
Scalar invariance: Including Covariates (gender, grade, & class size)	6350.483	986	.043	.924	.916	.033	.004

Table 3

Latent correlations between Autonomy Support (AS) and Agentic Engagement (AE) over Four Waves and Covariates.

	Autonomy Support				Agentic Engagement			
	T1	T2	T3	T4	T1	T2	T3	T4
T1 Autonomy Support								
T2 Autonomy Support	**.49**							
T3 Autonomy Support	**.28**	**.54**						
T4 Autonomy Support	**.17**	**.31**	**.56**					
T1 Agentic Engagement	**.53**	**.37**	**.24**	**.16**				
T2 Agentic Engagement	**.37**	**.57**	**.41**	**.27**	**.51**			
T3 Agentic Engagement	**.24**	**.41**	**.58**	**.43**	**.28**	**.53**		
T4 Agentic Engagement	**.15**	**.27**	**.42**	**.62**	**.17**	**.31**	**.54**	
Covariates								
Gender (0 = Male, 1= Female)	.01	-.01	-.10	-.01	**-.08**	**-.03**	**-.02**	-.01
Grade (0 = Middle, 1= High)	-.03	-.01	-.01	-.01	-.01	-.01	-.01	-.01
Class Size	**.03**	**.02**	.01	.01	**.01**	**.01**	**.01**	.01
Mean	4.63	4.71	4.72	4.78	3.72	3.62	3.85	3.99
SD	0.99	1.07	1.12	1.08	1.26	1.29	1.27	1.32

Note. $p < .05$. Correlations between autonomy support (AS), agentic engagement (AE), and covariates (Gender, Grade) from the Time 1 to Time 4. In the confirmatory factor analyses (CFA), autonomy support is latent variables based on responses to six items and agentic engagement are latent variables based on five items. Gender and grade are single-variable constructs.

Figure 1

Teacher-facilitating path model (A), student-facilitating path model (B), and reciprocal effects model (REM) (C). Bold faced downward lines represent teacher-facilitating paths and boldfaced upward lines represent student-facilitating paths.

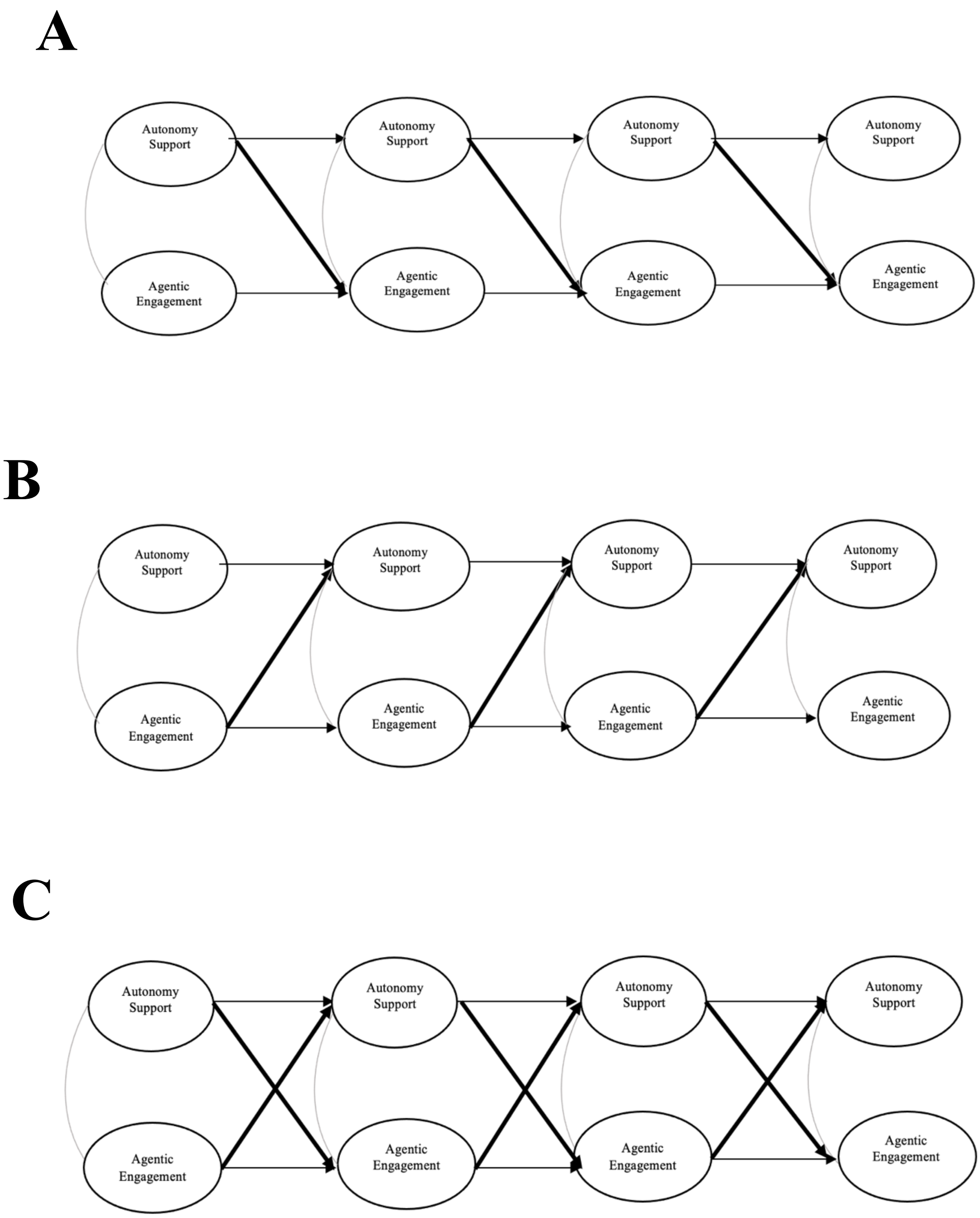

Figure 2. The hypothesized CLPM. Bold faced downward line represents teacher-facilitating paths and boldfaced upward line represents student-facilitating paths. β_{xx} represents the invariance in stability paths of autonomy support over time, and β_{yy} represents the invariance in stability paths of agentic engagement over time. β_{xy} represents the invariance in the cross-lag path from autonomy support to agentic engagement (teacher-facilitating path), and β_{yx} represents the invariance in the cross-lag path from agentic engagement to autonomy support (student -facilitating paths).

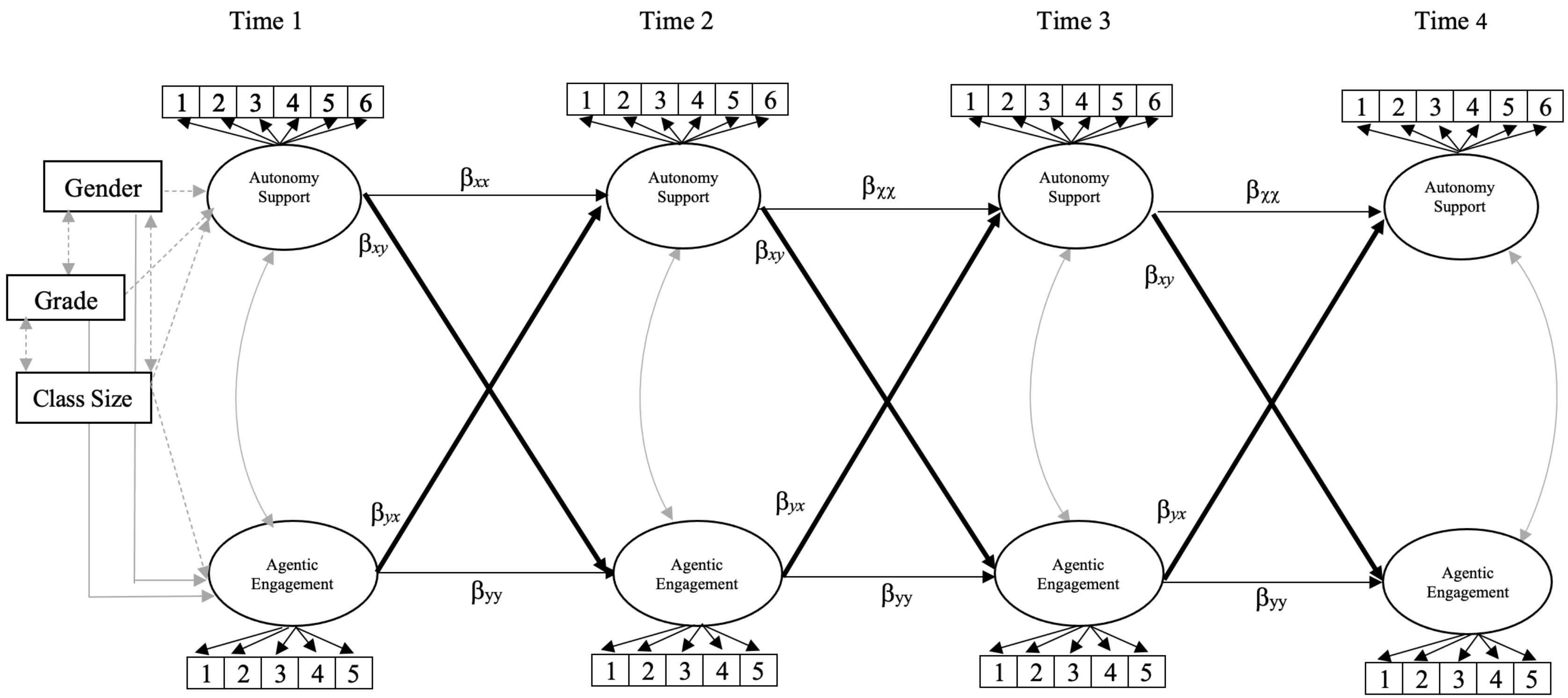

Figure 3. The hypothesized RI-CLPM. Bold faced downward line represents teacher-facilitating paths and boldfaced upward line represents student-facilitating paths. β_{xx} represents the invariance in stability paths of autonomy support over time, and β_{yy} represents the invariance in stability paths of agentic engagement over time. β_{xy} represents the invariance in the cross-lag path from autonomy support to agentic engagement (teacher-facilitating path), and β_{yx} represents the invariance in the cross-lag path from agentic engagement to autonomy support (student-facilitating paths).