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Relational Vulnerability Across School Transitions: Longitudinal Profiles of Adolescent Social Connectedness

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Research Article

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Abstract

Background

Adolescent social connectedness is a multidimensional psychological construct that reflects the extent to which young people are embedded in meaningful relationships across family, peer, school, and broader social contexts. Although social connectedness is closely linked to psychosocial adjustment, little longitudinal research has examined how patterns of connectedness are configured within individuals and how they change across major school transitions. This study identified developmental profiles and transition patterns of adolescent social connectedness and examined factors associated with the sustained maintenance of high connectedness over time.

Methods

Data were drawn from 5,775 adolescents in the Korean Education Longitudinal Study 2013, a nationally representative panel study in South Korea. Social connectedness was assessed at three time points: fifth grade of elementary school, second grade of middle school, and second grade of high school. Latent Profile Analysis was used to identify distinct profiles of social connectedness at each wave, and Latent Transition Analysis was used to examine profile stability and change across school transitions. To identify predictors of sustained high connectedness, a Random Forest model was fitted using individual-, family-, and school-level variables, and SHapley Additive exPlanations were used to interpret predictor importance.

Results

Four profiles of adolescent social connectedness were identified across developmental stages: High, Average, Moderate, and Low. Over time, many adolescents showed convergence toward the Average profile, whereas a small subgroup remained persistently in the Low profile, indicating stable relational vulnerability across school transitions. The proportion of adolescents in the High profile declined from 33.8% in elementary school to 25.0% in high school, whereas the Average profile increased from 37.1% to 54.3%. Sustained high connectedness was most strongly associated with social self-concept, rule compliance, parental emotional support, self-understanding, and supportive school experiences.

Conclusions

Adolescent social connectedness follows heterogeneous developmental pathways across major school transitions. Although many adolescents tend to converge toward average levels of connectedness, a small subgroup experiences persistently low connectedness over time. These findings underscore the

importance of early identification of relational vulnerability and suggest that sustained connectedness is supported by both individual psychological assets and supportive family and school environments.

Introduction

Adolescence is a critical developmental period in which psychosocial adjustment is strongly shaped by how young people perceive and experience their relationships across multiple social contexts. As adolescents move beyond childhood, their relational worlds expand beyond the family to include peers, teachers, and broader social environments, and experiences within these domains become increasingly important for emotional well-being, identity formation, and school adjustment (Amati et al., 2018; Crockett & Crouter, 2014; Harris & Orth, 2020; Zhang et al., 2021). In this sense, social connectedness is not merely the presence of social ties, but a multidimensional psychological construct that reflects adolescents' sense of relational embeddedness, belonging, and interpersonal security across key developmental settings.

From this perspective, adolescent social connectedness is closely linked to both positive adaptation and relational vulnerability. Adolescents who experience stable connectedness across family, peer, and school contexts may be more likely to develop a secure sense of belonging and healthier psychosocial adjustment, whereas those with chronically weak connectedness may be at greater risk of relational and emotional difficulties. This issue becomes especially salient during major school transitions, such as the progression from elementary to middle school and from middle to high school, when adolescents' social worlds are reorganized and their relational experiences may be reshaped. School transitions are therefore more than institutional shifts; they represent developmentally sensitive periods during which patterns of connectedness may be maintained, weakened, or reconfigured over time.

Understanding adolescent social connectedness requires an integrative theoretical perspective. Bronfenbrenner's ecological systems theory (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2006) emphasizes that development unfolds through ongoing interactions within and across multiple microsystems, including family, school, peers, and the community. Attachment theory further highlights the emotional continuity and developmental significance of early relational experiences, suggesting that bonds with caregivers provide an important foundation for later interpersonal functioning (Howe, 2012; Sroufe, 2005). Belongingness theory complements these perspectives by proposing that human beings have a fundamental psychological need to establish and maintain stable social bonds (Baumeister & Leary, 1995; Lee & Robbins, 1995). Taken together, these frameworks suggest that adolescent social connectedness is multidimensional, developmentally embedded, and psychologically meaningful.

Despite its theoretical importance, prior research has often examined adolescent relationships in relatively isolated domains, such as parent, peer, or teacher relationships, or has relied on variable-centered approaches to identify associations between specific relational factors and developmental outcomes. Although such studies have yielded important insights, they are limited in their ability to explain how multiple relational experiences cluster within individuals and how these configurations

change over time. This limitation is particularly important during school transitions, when adolescents' social environments are reorganized and relationship patterns may shift substantially. Yet longitudinal research examining heterogeneous developmental patterns of social connectedness across these transition periods remains limited. As a result, less is known about how relational experiences are configured within adolescents and how early patterns may signal persistent relational vulnerability.

Adolescents also increasingly navigate social environments characterized by cultural diversity. As South Korea becomes more multicultural, adolescents' openness toward culturally diverse others may become increasingly relevant to how they perceive and form social relationships. In the present study, multicultural acceptance is not treated as a direct relational domain equivalent to parent, peer, or teacher relationships. Rather, it is conceptualized more cautiously as a socio-relational disposition that may be relevant to adolescents' openness to forming connections across diverse social contexts. From this perspective, multicultural acceptance may complement other dimensions of social connectedness while still requiring careful interpretation in relation to more direct indicators of relationship quality.

To address these theoretical and empirical gaps, the present study adopts a person-centered approach to examine how adolescent social connectedness is patterned across multiple relational contexts. Specifically, Latent Profile Analysis (LPA) is used to identify distinct subgroups characterized by different configurations of connectedness, and Latent Transition Analysis (LTA) is used to trace how these profiles change from elementary school through middle and high school. By moving beyond variable-centered associations, this approach makes it possible to examine developmental heterogeneity in adolescents' relational experiences and to identify profiles that may reflect either adaptive development or persistent vulnerability.

Beyond identifying developmental patterns, the present study further examines factors associated with the sustained maintenance of high social connectedness while considering the implications of persistent low connectedness as a marker of relational vulnerability. To this end, a machine learning approach combined with SHAP (SHapley Additive exPlanations) was used to identify the individual, family, and school factors most strongly associated with these patterns. This analytic strategy extends prior work by moving beyond descriptive classification to examine conditions that may support positive relational development over time. In addition, because the present analyses are based on adolescents' pre-COVID-19 face-to-face relational experiences, the findings provide a useful developmental baseline for interpreting subsequent changes in adolescent social relationships in the post-pandemic era.

The present study contributes to the psychological literature in three ways. First, it conceptualizes adolescent social connectedness as a multidimensional relational-psychological construct and identifies heterogeneous profiles of this construct across development. Second, it examines how these profiles are maintained or reorganized across major school transitions, thereby illuminating developmental heterogeneity in adolescents' relational adaptation. Third, it identifies psychological, familial, and school-related factors associated with the sustained maintenance of high connectedness, offering insight into the conditions that support positive relational development over time.

Based on these aims, this study addresses the following research questions:

1. How do patterns of adolescent social connectedness evolve across major school transition stages, from elementary to middle school and from middle to high school?
2. What individual and contextual factors are associated with the sustained maintenance of high social connectedness during adolescence?

Literature Review

Scope and Conceptualization of Social Connectedness

Social connectedness refers to the extent to which adolescents are embedded in meaningful relationships across multiple social contexts. From a psychological perspective, it reflects not only the presence of interpersonal ties, but also the perceived quality, integration, and emotional significance of those relationships across family, peer, school, and broader social environments. As such, social connectedness is closely linked to psychosocial adjustment during adolescence, a developmental period in which emotional well-being, identity formation, and school engagement are strongly shaped by relational experiences. Prior research has shown that stronger social relationships are associated with lower levels of depression and anxiety and with higher levels of self-esteem, academic self-concept, life satisfaction, and school adaptation (Amati et al., 2018; Chu et al., 2010; Harris & Orth, 2020; Yoon, 2015; Zhang et al., 2021). These findings suggest that social connectedness represents a meaningful relational-psychological dimension of adolescent development rather than a simple accumulation of social resources.

Understanding this construct requires an integrative theoretical perspective. Ecological systems theory emphasizes that adolescent development is shaped through ongoing interactions within and across multiple social contexts, including family, school, peers, and community settings (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2006). Attachment theory highlights the developmental continuity of early relational experiences, suggesting that bonds with caregivers shape later interpersonal expectations and functioning (Howe, 2012). Belongingness theory further underscores that stable social bonds are a basic psychological need (Baumeister & Leary, 1995; Lee & Robbins, 1995). Taken together, these perspectives suggest that adolescent social connectedness is inherently multidimensional, developmentally embedded, and psychologically significant. Rather than reflecting a single relationship domain, it captures how relational experiences across multiple contexts are integrated within the individual.

Within this broader framework, the present study focuses primarily on connectedness across parent, peer, and teacher relationships, while also considering multicultural acceptance as a related but conceptually distinct component. Unlike direct relationship indicators, multicultural acceptance is better understood as an attitudinal or socio-relational disposition reflecting openness toward culturally diverse others. In increasingly multicultural social environments, such openness may be relevant to adolescents' willingness to form connections across diverse contexts. Consistent with intergroup contact theory, it

may function as a contextual orientation that supports positive cross-group relationships rather than as a direct indicator of relationship quality itself (Pettigrew et al., 2011). For this reason, multicultural acceptance is interpreted more cautiously in the present study as a complementary socio-relational disposition within the broader conceptualization of social connectedness.

Despite growing interest in adolescent relationships, existing research has often focused on isolated relational domains, most commonly peer and teacher relationships, or has relied on variable-centered approaches to examine associations between specific relational factors and developmental outcomes (Cooper et al., 2021; Lenzi et al., 2013; Virtanen et al., 2020). Although these studies have made important contributions, they are limited in their ability to explain how multiple relational experiences cluster within adolescents and how such configurations shift across development. This limitation is particularly important during school transitions, when social environments are reorganized and relational patterns may be restructured. Yet longitudinal research on the heterogeneous developmental patterns of adolescent social connectedness across these transition periods remains limited. Addressing this gap is important not only for understanding relational development more comprehensively, but also for identifying adolescents who may show persistent relational vulnerability over time.

Factors Influencing Adolescents' Social Connectedness

Adolescent social connectedness is shaped by a complex interplay of individual, family, school, and broader social factors rather than by any single relational experience. This multidimensional nature suggests that connectedness may emerge in heterogeneous patterns across adolescents, depending on how psychological assets, family relationships, school experiences, and broader socio-relational orientations are configured within the individual. A person-centered perspective is therefore particularly useful for understanding why some adolescents maintain adaptive relational functioning across contexts, whereas others may experience persistent relational vulnerability.

At the individual level, social connectedness is closely associated with psychological and behavioral characteristics that support interpersonal functioning. Prior research has linked stronger social relationships to higher self-esteem, self-efficacy, self-concept, and other adaptive psychological resources, while difficulties in self-regulation or behavioral adjustment may undermine relational functioning (Céspedes et al., 2021; Chung & Jang, 2021; Kim et al., 2019; Marion et al., 2013; Rogers et al., 2012). In adolescence, these internal characteristics are especially important because they shape how young people perceive themselves in relation to others, respond to social demands, and navigate increasingly complex interpersonal environments. Such findings suggest that connectedness is supported not only by external relationship opportunities, but also by individual psychological assets that facilitate stable and positive social engagement.

Family context also plays a foundational role in the development of adolescent social connectedness. From an attachment perspective, parent–child relationships provide an early relational foundation that continues to influence interpersonal expectations and relational functioning during adolescence.

Supportive parenting, parental emotional support, and positive family interactions have been associated with stronger peer relationships, better school adjustment, and more positive teacher–student relationships, whereas family conflict, neglect, and other adverse family experiences may undermine adolescents' relational security (Azam & Hanif, 2011; Goldberg & Carlson, 2014; Koh et al., 2017; McGrath & Van Bergen, 2015; Silinskas et al., 2015; Updegraff et al., 2020). These findings indicate that family relationships do not operate in isolation, but instead shape adolescents' connectedness across multiple relational contexts.

School experiences further contribute to adolescent social connectedness through both peer and teacher relationships. Peers become increasingly central during adolescence as sources of social support, identity formation, and belonging, whereas teachers represent an important institutional source of emotional and academic support. Prior research suggests that positive school climate, learner-centered instruction, communication-oriented teaching, and adherence to school norms are associated with stronger peer and teacher relationships, whereas experiences such as school violence, peer stress, and negative school environments may weaken relational functioning (Choi, 2017; Coplan et al., 2019; Durlak et al., 2022; Kim et al., 2019; Lester & Mander, 2020; Roorda et al., 2017). Together, these findings suggest that connectedness during adolescence is shaped not only by dyadic relationships, but also by broader institutional and classroom contexts that support or constrain interpersonal engagement.

In addition to these more direct relational contexts, adolescents' openness toward culturally diverse others may also be relevant to how they orient themselves toward broader social relationships. In the present study, multicultural acceptance is conceptualized not as a direct indicator of relationship quality, but as a socio-relational disposition that may be associated with openness to forming connections across diverse contexts. Prior studies have shown that multicultural acceptance is associated with adolescents' social connectedness in proximal contexts, as well as with prosocial behavior, civic engagement, and self-understanding (Kim & Kim, 2018; Kim, 2017; Kwon & Lee, 2015; Schwartz et al., 2011; Thijs & Verkuyten, 2014; Wiersma-Mosley and Garrison, 2022). Although conceptually distinct from direct relationship measures, this orientation may provide a broader contextual lens for understanding adolescents' relational adaptation in increasingly diverse social environments.

Taken together, prior research indicates that adolescent social connectedness is shaped by multiple interacting influences, yet most studies have examined these correlates separately or within variable-centered frameworks. As a result, less is known about how these factors combine within individuals to form distinct relational profiles, how such profiles are maintained or transformed over time, and which characteristics are associated with sustained connectedness or persistent relational vulnerability. Addressing these questions is important for clarifying the developmental heterogeneity of adolescent social connectedness and for identifying factors that may support adaptive relational functioning across key school transitions.

Method

Data Collection and Participants

This study used data from the Korean Education Longitudinal Study 2013 (KELS 2013) to examine developmental trajectories of adolescent social connectedness. KELS 2013 is a large-scale, nationally representative panel study designed to investigate students' developmental processes and school contexts in South Korea (Kim et al., 2014). The original KELS 2013 data collection was approved by the Institutional Review Board of the Korean Educational Development Institute, and informed consent was obtained from both students and their guardians during the original data collection process in accordance with relevant ethical guidelines. The survey was administered using Tablet-Assisted Personal Interviewing (TAPI) to enhance data quality and reliability (Namgung et al., 2023). The present study used fully anonymized secondary data released by the data provider; therefore, additional institutional review board approval was not required for the current analysis.

The original sample consisted of 7,324 fifth-grade students from 242 elementary schools nationwide in 2013. The present study used data from three waves in which the key social connectedness variables were measured: Wave 1 (fifth grade of elementary school), Wave 4 (second grade of middle school), and Wave 7 (second grade of high school). These time points were selected to capture major school transitions from elementary to middle school and from middle to high school, during which adolescents' relational experiences may be substantially reorganized.

To ensure comparability of latent profile membership and transition patterns across the three waves, the longitudinal profile analyses were restricted to adolescents with valid responses on all social connectedness indicators at each time point. Accordingly, missing data in the LPA and LTA analyses were handled using complete-case selection. This approach was adopted because the latent transition analysis required a common analytic sample with observed indicator values at all waves in order to estimate profile membership and transitions consistently across time. To assess potential attrition bias, the final analytic sample was compared with excluded cases on gender, parental education level, and baseline levels of social connectedness. No significant differences were observed on these characteristics. Nevertheless, the possibility of bias associated with complete-case selection cannot be entirely ruled out and should be considered when interpreting the findings.

The final sample included 5,775 adolescents, of whom 2,953 were female (51.1%) and 2,822 were male (48.9%). Although the data have a hierarchical structure, with students nested within schools, the analyses primarily focused on the individual level. This approach was adopted because students did not remain within the same school clusters across elementary, middle, and high school, making it difficult to model school-level clustering consistently over time. Accordingly, the study focused on person-level developmental patterns across the three waves.

Instruments

Social Connectedness Indicators

To identify latent profiles of adolescent social connectedness, this study used measures collected at three waves (Wave 1, Wave 4, and Wave 7). The indicators included parent–child, teacher–student, and peer relationships, as well as multicultural orientation. For each domain, item scores were averaged to generate composite indicators for the Latent Profile Analysis (LPA). All items were rated on a 5-point Likert scale ranging from 1 (not at all) to 5 (very much), with higher scores indicating stronger perceived connectedness.

Parent–child relationships were measured with five items assessing parental interest and involvement (e.g., “My parents take an interest in and ask about my school life”). Teacher–student relationships were assessed using six items reflecting perceived teacher receptivity and support (e.g., “My teacher listens carefully to what I have to say”). Peer relationships were measured with six items capturing reciprocal respect and interaction among peers (e.g., “My friends respect my opinions”). Multicultural orientation was measured with six items reflecting attitudinal openness toward social and cultural diversity (e.g., “I can accept people from different cultures as neighbors”). In the present study, multicultural orientation was not treated as a direct indicator of relationship quality comparable to parent, peer, or teacher relationships. Rather, it was conceptualized as a related but distinct socio-relational disposition relevant to adolescents’ openness to forming connections across broader social contexts, and was therefore interpreted more cautiously than the direct relationship indicators.

All indicators were derived from instruments used within the KELS 2013 framework. Descriptive statistics and internal consistency coefficients (Cronbach’s α) for each wave are presented in Table 1. Across all four domains, internal consistency was acceptable to high across the three waves.

Table 1
Descriptive Statistics and Reliability of Social Connectedness Indicators

Variables	**Cronbach’s α**			**Mean**			**Standard Deviation**		
(number of items)	**Wave 1**	**Wave 4**	**Wave 7**	**Wave 1**	**Wave 4**	**Wave 7**	**Wave 1**	**Wave 4**	**Wave 7**
Parent–Child Relationships (5)	0.79	0.83	0.81	3.50	3.60	3.50	0.88	0.86	0.87
Peer Relationships (6)	0.93	0.92	0.91	3.92	3.77	3.77	0.84	0.77	0.74
Teacher–Student Relationships (6)	0.91	0.93	0.92	3.77	3.99	3.99	0.83	0.74	0.72
Multicultural Orientation (6)	0.91	0.93	0.93	4.06	4.13	4.19	0.74	0.68	0.66

Predictive Variables

To examine factors associated with the sustained maintenance of high social connectedness, this study included a broad set of predictors at the individual, family, and school levels. Predictor selection was guided by prior literature suggesting that adolescent connectedness is shaped by the interplay of psychological resources, family relationships, learning experiences, and school environments (Breeman et al., 2015; Bronfenbrenner, 1979; Casas et al., 2016; Kim et al., 2019; Updegraff et al., 2020; Wentzel et al., 2017). Rather than treating these variables as isolated correlates, they were organized to capture multiple ecological layers relevant to adolescent relational development.

At the individual level, the predictors included demographic characteristics, psychological traits, learning-related variables, school experiences, and after-school activities. At the family level, indicators of socioeconomic background and parental support were included. At the school level, variables describing school background and school life, such as classroom climate, instructional methods, teacher-related factors, and school violence, were incorporated. As summarized in Table 2, these variables were included to represent the broader ecological conditions within which adolescent social connectedness develops.

Table 2
Summary of Individual-, Home-, and School-Level Predictors

Domain	Sub-construct	Variables
Individual-Level Characteristics	Student Backgrounds	Gender (1)
	Psychological Traits	Self-concept (16), Creativity (5), Self-Management (5), Rule Compliance (5), Multicultural Acceptance (5), Mental Health (7), Stress (8), Career Maturity (15),
	Learning	Classroom Concentration (3), Classroom Behavior (11), Lesson Comprehension (3), Study Time (1), Educational Aspiration (1), Private Tutoring Participation (1), Academic Achievement (3)
	School Experience	Experience of School Violence Victimization (8), Participation in Autonomous Activities (1), Experience with Career and Vocational Programs (7), Participation in After-School Programs (5), Participation in Club Activities (11), School Transfer Experience (1)
	After-school Time (Leisure)	Volunteer Activity Participation (1), Perception and Attitude Toward Volunteer Activities (4), Reading Frequency (1), Reading Enjoyment Level (5), Participation in Cultural Activities (7), Time Spent on Physical Activity (1), After-School Learning and Leisure Activities (9), Time Spent on Computer and Smart Media Use (5), Smartphone Dependency (5), Part-time Job Experience (1)
Home- Level Characteristics	Home Background	logarithm of monthly average household income (1), Parental Education Level (2)
	Parental Support	Parental Expectations of Education (1), Parental Emotional Support (9), Parental Educational Support (7), Parental Attachment (6), Parent-Child Interaction (4), Parents' Engagement in School Committees (5), Parental Satisfaction with School (14), Parental Involvement in School Activities (5)
School-Level Characteristics	School Background	Region (1), Co-ed School (1)
	School Life	Classroom Climate (4), Instructional Methods (8), Teacher Expectations and Pressure for Achievement (5), Teacher Enthusiasm (4), Prevalence of School Violence (4), Degree of Student Voice in School Decision-Making (5)

Note. Numbers in parentheses indicate the number of questionnaire items used for each variable.

Data Analysis

To examine patterns of adolescent social connectedness, their developmental trajectories, and factors associated with sustained high connectedness, this study used a four-step analytic strategy.

First, Latent Profile Analysis (LPA) was conducted separately at Wave 1, Wave 4, and Wave 7 to identify heterogeneous profiles of social connectedness. The indicators included parent–child, teacher–student, and peer relationships, as well as multicultural orientation. The number of latent profiles was determined by considering the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), sample-size adjusted BIC (SABIC), entropy, and the interpretability and parsimony of the profile solutions (Muthén & Muthén, 2012).

Second, Latent Transition Analysis (LTA) was used to examine transitions in profile membership across school stages, from elementary to middle school and from middle to high school. LTA estimates the probability of movement between latent profiles over time and is therefore useful for capturing developmental change in person-centered patterns (Collins & Lanza, 2010). To improve longitudinal comparability, the same four-profile structure was retained across the three waves, and the measurement parameters of the profile indicators were constrained to be comparable across time. This invariance-oriented approach allowed profile transitions to be interpreted on a common measurement basis and reduced the possibility that observed changes reflected shifts in profile meaning rather than substantive developmental change.

Third, a machine learning approach was used to identify factors associated with the sustained maintenance of high social connectedness. For this analysis, the outcome variable was defined as membership in the group of adolescents who remained in the High social connectedness profile across all three waves, in contrast to those who followed other profile trajectories. Predictors were drawn from individual, family, and school domains to capture the broader ecological contexts relevant to adolescent relational development. Before model estimation, variables with more than 20% missing data and identification variables not relevant to the study aims were excluded. To reduce redundancy among predictors, variables with a Variance Inflation Factor (VIF) of 10 or higher or a correlation coefficient of .80 or higher were removed, resulting in a final set of 245 predictors.

Because preserving the full predictor set was important for the predictive analysis, missing values in the machine learning dataset were handled after sample selection using Random Forest proximity-based imputation. This approach was chosen to retain cases for prediction while accommodating the large number of mixed and potentially nonlinear predictors. In contrast, complete-case selection was retained for the longitudinal latent profile analyses because those analyses required consistent measurement across repeated waves and direct estimation of profile membership and transitions based on observed indicator values. The dataset was then randomly split into a training set (70%) and a validation set (30%). Because the outcome classes were imbalanced, SMOTE + ENN (Synthetic Minority Over-sampling Technique combined with Edited Nearest Neighbors) was applied to the training data only.

A Random Forest (RF) classifier was then fitted as the primary predictive model because it is well suited to high-dimensional data, can accommodate nonlinear associations and higher-order interactions, is relatively robust to multicollinearity and overfitting, and provides stable variable-importance estimates for exploratory predictive purposes (Breiman, 2001). Given the large number of candidate predictors and

the study's emphasis on prediction rather than causal estimation, RF was considered an appropriate and flexible modeling approach. Model performance was evaluated using accuracy, macro F1-score, macro precision, and ROC-AUC.

Fourth, SHAP (SHapley Additive exPlanations) was used to interpret the fitted Random Forest model by estimating the contribution of each predictor to the model output (Lundberg & Lee, 2017). To avoid distortion from synthetically generated observations, SHAP values were calculated using only the original validation data rather than the resampled training data. This made it possible to examine the relative direction and magnitude of each predictor's contribution to the probability of belonging to the sustained high connectedness group. The machine learning analysis was intended for prediction rather than causal inference; accordingly, the findings should be interpreted as associational rather than causal.

Results

Developmental Profiles of Adolescent Social Connectedness

Latent Profile Analysis (LPA) identified four distinct profiles of adolescent social connectedness: High, Average, Moderate, and Low. This four-profile structure was observed consistently across all three waves. Based on the fit indices (AIC, BIC, and SABIC), entropy, and the interpretability of the profile solutions, the four-profile solution was retained for subsequent analyses. The entropy value for the selected solution was high (0.916), indicating good profile separation (Clark & Muthén, 2009). Although the Low connectedness group represented a relatively small proportion of the sample (approximately 2–3%), its size remained within an interpretable range for mixture modeling (Hipp & Bauer, 2006).

The High social connectedness profile was characterized by high levels of connectedness across parent, teacher, peer, and multicultural domains. The proportion of adolescents in this group decreased over time, from 33.8% in elementary school to 26.8% in middle school and 25.0% in high school (see Table A1 in the Appendix).

The Average social connectedness profile showed relatively balanced, mid-level connectedness across all domains. This group increased steadily over time, accounting for 37.1% of the sample in elementary school, 50.4% in middle school, and 54.3% in high school. Within this profile, teacher-related and multicultural connectedness were relatively stronger in elementary school, whereas peer connectedness appeared more prominent from middle school onward.

The Moderate social connectedness profile was characterized by somewhat lower overall connectedness, particularly in parent and teacher relationships, relative to the Average profile. In contrast, multicultural orientation remained comparatively higher than the other relational domains. The proportion of this group declined over time, from 25.9% in elementary school to 20.5% in middle school and 18.5% in high school.

The Low social connectedness profile showed the lowest levels of connectedness across domains and accounted for approximately 2–3% of the sample across waves. Within this group, teacher connectedness was especially low in elementary school, whereas peer connectedness was particularly low from middle school onward. Multicultural orientation remained relatively higher than the other domains across time.

Transition Patterns of Social Connectedness

Table 3 presents the model fit indices for the Latent Transition Analysis (LTA). Among the candidate models, the four-class solution across all three time points (4,4,4) showed the best overall fit, with the lowest AIC, BIC, and SA-BIC values and the highest entropy (0.916). Accordingly, the four-profile solution was retained for the transition analyses.

The LTA revealed distinct developmental shifts in adolescent social connectedness across school transitions. Overall, the High profile decreased in size over time, whereas the Average profile expanded steadily and became the most prevalent profile in middle and high school. Transition probabilities showed that many adolescents initially belonging to the High and Moderate profiles transitioned to the Average profile across waves. The Moderate profile, in particular, showed a declining pattern, with many adolescents moving into the Average profile over time.

In contrast, the Low profile remained relatively stable despite its small proportion in the sample, with limited movement into other profiles. This finding indicates that a small subgroup of adolescents continued to experience persistently low connectedness across developmental stages. Overall, the transition patterns suggest both increasing concentration in the Average profile and relative stability in the Low profile, highlighting heterogeneity in the developmental course of adolescent social connectedness. Appendix Tables A2–A5 provide profile-specific transition probabilities based on adolescents' initial social connectedness status in elementary school. For those initially identified as belonging to the High profile, subsequent membership was concentrated primarily in the High and Average profiles (Table A2). Adolescents who began in the Average profile showed the greatest continuity in that same profile across waves (Table A3). Those initially in the Moderate profile were likely to shift to the Average profile, although continuity in the Moderate profile also remained evident (Table A4). By comparison, the Low profile was marked by relatively limited upward mobility and a continued probability of remaining in the same low-connectedness status over time (Table A5).

Table 3
Model Fit Indices for Latent Transition Analysis

Number of class	AIC	BIC	SA-BIC	Entropy
(3,3,2)	149399.477	149725.880	149570.172	0.668
(3,3,3)	148087.373	148447.083	148275.487	0.735
(3,3,4)	146757.910	147150.926	146963.442	0.774
(3,4,2)	148144.050	148503.760	148332.164	0.762
(3,4,3)	146831.947	147224.963	147037.479	0.813
(3,4,4)	145502.484	145928.807	145725.433	0.843
(4,3,2)	148798.896	149158.606	148987.010	0.779
(4,3,3)	147486.793	147879.809	147692.324	0.828
(4,3,4)	146157.330	146583.652	146380.279	0.857
(4,4,2)	147543.470	147936.486	147749.001	0.856
(4,4,3)	146522.130	146948.453	146745.080	0.825
(4,4,4)	144901.903	145361.533	145142.271	0.916

Note. Number of classes at different time points (elementary school, middle school, high school)

Predictors of Sustained High Social Connectedness

The final predictive model showed good overall performance in identifying adolescents who consistently maintained high social connectedness, with an accuracy of 0.88, a macro F1-score of 0.70, a macro precision of 0.67, and an ROC-AUC of 0.91. These results suggest that sustained high connectedness can be reasonably differentiated using a broad set of individual, family, and school-level predictors.

SHAP analysis (Table 4; Fig. 1) indicated that influential predictors were distributed across multiple ecological domains. Individual-level psychosocial characteristics contributed most strongly to the model, particularly social self-concept variables such as peer trust, peer acceptance, social engagement, and group participation. Additional individual-level predictors included rule compliance and self-understanding, reflected in variables such as promise keeping, rule adherence, value clarity, and career clarity.

Family-related variables also showed meaningful contributions, especially parental emotional support, including parental encouragement and understanding. Several school-related predictors likewise contributed to the model, including classroom participation, school enjoyment, instructional checking, individualized teaching, explanation support, and teacher enthusiasm. Overall, these findings indicate that sustained high social connectedness was associated with a combination of psychological, familial,

and school-related factors. As these results are based on predictive modeling, they should be interpreted as associational rather than causal.

Table 4
Key Predictors of Sustained High Social Connectedness

Rank	Domain	Predictor (Example Item)	SHAP Value
1	Social Self-Concept	Peer trust (“My friends trust me”)	0.0461
2	Social Self-Concept	Peer acceptance (“My friends like to play with me”)	0.0406
3	Rule Compliance	Promise keeping (“I always keep promises made with others”)	0.0289
4	Social Self-Concept	Social engagement (“I enjoy spending time with others”)	0.0274
5	Parental Emotional Support	Parental encouragement (“My parents encourage me”)	0.0269
6	Social Self-Concept	Group participation (“I work well in group activities”)	0.0234
7	Academic Self-Concept	Classroom participation (“I participate in class with ease”)	0.0202
8	Family Self-Concept	Family well-being (“I live in a happy family”)	0.0176
9	Self-Understanding	Value clarity (“I have values that I cherish”)	0.0174
10	Rule Compliance	Rule adherence (“I don’t break the rules when playing with friends”)	0.0169
11	Self-Understanding	Career clarity (“I know what kind of work I enjoy”)	0.0145
12	Parental Emotional Support	Parental understanding (“My parents understand me”)	0.0144
13	Academic Self-Concept	School enjoyment (“I like going to school”)	0.0131
14	Teaching Approach	Instructional checking (“The teacher checks my level of understanding during class”)	0.0129
15	Teaching Approach	Individualized teaching (“The teacher understands my strengths and weaknesses”)	0.0129
16	Teacher Enthusiasm	Teaching diligence (“The teacher teaches students diligently”)	0.0112
17	Teaching Approach	Explanation support (“When I ask questions, the teacher kindly explains”)	0.0112

Note. SHAP values indicate the relative contribution of each predictor to model predictions for membership in the sustained high connectedness group. Original variable codes are available upon request.

Rank	Domain	Predictor (Example Item)	SHAP Value
18	Teacher Enthusiasm	Teaching enjoyment (“The teacher enjoys teaching”)	0.0107
19	Rule Compliance	Classroom rule adherence (“I follow classroom rules well”)	0.0101
20	Teacher Enthusiasm	Subject expertise (“The teacher is knowledgeable about the subject”)	0.0094

Note. SHAP values indicate the relative contribution of each predictor to model predictions for membership in the sustained high connectedness group. Original variable codes are available upon request.

Discussion

Using longitudinal data spanning from elementary school to high school, this study examined developmental patterns of adolescent social connectedness and identified factors associated with sustained high connectedness. By combining a person-centered approach with machine learning, the study extends prior research that has often relied on cross-sectional or variable-centered designs and offers an integrated perspective on how relational experiences are configured and change over time.

The findings suggest that adolescent social connectedness is not static, but develops through identifiable patterns across school transitions. In particular, many adolescents in the High and Moderate profiles moved into the Average profile over time, indicating a general tendency toward increased concentration in the middle range of connectedness. This pattern may reflect developmental reorganization in adolescents’ social worlds as peer relationships become more central and school contexts change across developmental stages, and is broadly consistent with prior work on school transitions and adolescent social development (Eccles et al., 2018). At the same time, a small subgroup of adolescents remained in the Low profile across waves. Although this group represented only a small proportion of the sample, its relative stability suggests that persistently low connectedness may characterize a subgroup of adolescents whose relational vulnerability remains stable across major school transitions, rather than reflecting a temporary fluctuation in social adaptation. This finding is important given prior evidence linking low social connectedness to poorer psychosocial adjustment and well-being (Carrizales et al., 2023).

The predictive analyses further showed that sustained high connectedness was associated with multiple ecological domains, with individual psychosocial characteristics emerging as especially prominent predictors. Social self-concept variables, such as peer trust, peer acceptance, social engagement, and group participation, were among the strongest contributors to the model. Other individual-level characteristics, including rule compliance and self-understanding, also showed notable associations with sustained high connectedness. Overall, these findings suggest that adolescents who sustain strong social connectedness over time may also possess psychological resources that facilitate positive interpersonal functioning. At the same time, these characteristics should not be interpreted as

independent causal drivers, but rather as correlates that accompany sustained connectedness within a broader developmental context. Several of the strongest predictors were also conceptually close to relational functioning itself. Accordingly, they are best understood not as isolated determinants, but as part of a broader psychosocial profile that co-occurs with the sustained maintenance of high connectedness. This interpretation suggests that adolescent social connectedness reflects an integrated pattern of relational and psychological adaptation rather than the influence of any single factor.

Family and school contexts also contributed meaningfully to the prediction of sustained high connectedness. Parental emotional support, including encouragement and understanding, emerged as an important family-related predictor, while school-related variables such as classroom participation, instructional support, and teacher enthusiasm also showed meaningful contributions. These findings are consistent with ecological perspectives suggesting that adolescent development is shaped through interactions between individual characteristics and relational contexts (Bronfenbrenner & Morris, 2006). Rather than indicating that connectedness is driven primarily by internal or external factors alone, the results point to the joint importance of psychological resources and supportive relational environments.

Finally, multicultural orientation appeared to remain relatively distinct from the more direct relationship indicators across profiles, particularly in the Moderate and Low groups. This pattern suggests that openness toward cultural diversity may represent a conceptually related but partially distinct socio-relational orientation rather than a direct indicator of interpersonal connectedness. In this sense, multicultural orientation may still be relevant for understanding adolescents' broader relational adaptation in increasingly diverse social settings, but its role should be interpreted cautiously in relation to parent, peer, and teacher relationships. Rather than reflecting a core interpersonal bond in the same sense as family, peer, or teacher connectedness, it may capture a complementary orientation toward diverse others that broadens the relational context in which adolescent connectedness is understood.

Limitations and Future Directions

Several limitations should be considered when interpreting the findings. First, the study relied primarily on self-report measures, which may not fully capture social connectedness at the level of actual interaction patterns or observed behavior. Self-reported responses may also be affected by social desirability and shared method variance. Second, although the study used longitudinal data, the analyses remain observational and cannot establish causal relationships among the variables. Third, the machine learning results should be interpreted with caution: variable importance reflects relative contribution to prediction within the model, not an independent effect in the inferential sense. Fourth, multicultural orientation was included as a complementary socio-relational disposition rather than a direct relationship indicator, which may limit comparability with studies that conceptualize it as a separate construct. Finally, because the data were collected prior to the COVID-19 pandemic, the findings do not fully reflect more recent changes in adolescent social interaction, particularly those involving digital and hybrid relational environments.

Future research could build on these findings in several ways. Studies incorporating behavioral or network-based indicators of social connectedness would help extend beyond self-reported perceptions. Research using stronger causal designs may also clarify the temporal and reciprocal relationships between connectedness and its correlates. In addition, future work should examine how digital forms of interaction shape connectedness across developmental stages and whether similar profile patterns emerge in post-pandemic contexts. Further attention is also needed to identify adolescents showing persistent relational vulnerability at earlier stages and to develop interventions tailored to their relational and psychosocial needs.

Conclusion

This study examined adolescent social connectedness as a multidimensional and developmentally dynamic construct across major school transitions. Using longitudinal person-centered analyses, the findings showed both a general shift toward the Average profile and the relative persistence of a small Low connectedness subgroup. Predictive analyses further indicated that sustained high connectedness was associated with a combination of individual psychological assets, parental support, and supportive school experiences. Overall, these findings highlight the heterogeneity of adolescent relational development and underscore the importance of identifying both adaptive and vulnerable patterns of connectedness across development.

Declarations

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Competing interests

The author declares that there are no competing interests.

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Ethics approval and consent to participate

This study used secondary data from the Korean Education Longitudinal Study 2013 (KELS 2013), a large-scale panel survey conducted by the Korean Educational Development Institute (approval no. 2022-13-05-N). The original KELS 2013 data collection was approved by the Institutional Review Board of the Korean Educational Development Institute, and informed consent was obtained during the original data collection process in accordance with relevant ethical guidelines. The dataset was anonymized by the data provider prior to release and contained no personally identifiable information. Because this study was based on fully anonymized secondary data, additional institutional review board approval was not required for the present analysis.

Consent for publication

Not applicable.

Availability of data and materials

The data used in this study are not publicly available due to institutional restrictions. However, they may be available from the Korean Educational Development Institute, subject to the institute's data access policies and appropriate approval procedures.

Authors' contributions

The author conceptualized the study, conducted the formal analysis, interpreted the data, and wrote the manuscript. The author read and approved the final manuscript.

Authors' information

Not applicable.

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Figures

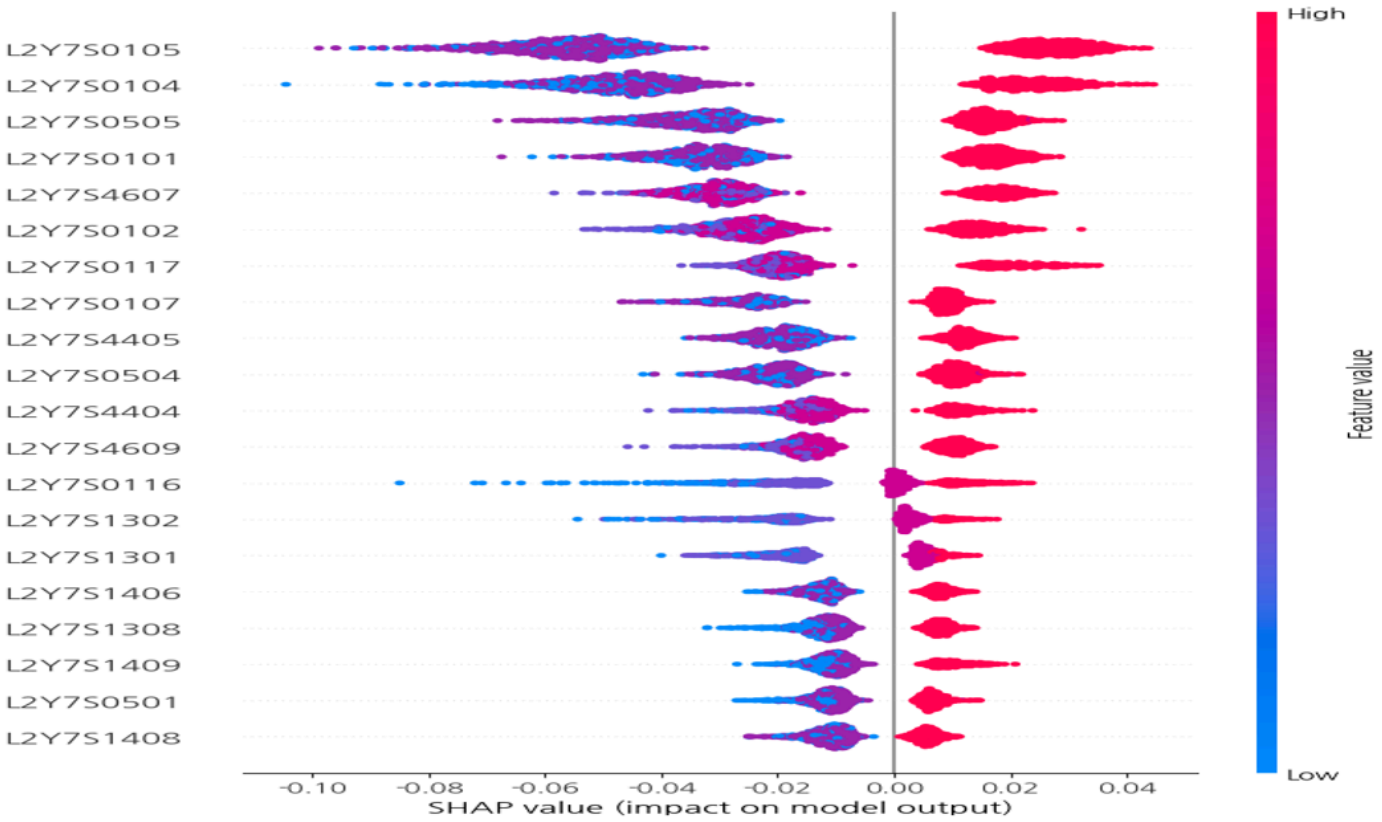


Figure 1

Feature Importance in Predicting High Social Connectedness Using SHAP Values

Note. Variable codes shown on the y-axis are mapped to descriptive labels in Table A6.

Supplementary Files

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- Appendices.docx