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EMPIRICAL RESEARCH

How Needs-Supplies Fit Processes With Teachers, Peers, and Parents Relate to Youth Outcomes: A Theoretical and Methodological Extension of Self-Determination Theory

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Abstract
According to self-determination theory (SDT), relationships that support the needs for autonomy, competence, and relatedness are essential to youth development. It is yet unknown whether adolescents differ in what constitutes "optimal" supplies of support. This research proposes methodological extensions to analyze how the degree of fit or misfit between needs versus supplies in support (i.e., from teachers, parents, and peers) relates to engagement in class, academic achievement, and well-being. Data were collected on 389 adolescents (M(age) = 14.3, SD(age) = 2.1, 58% female, low to high SES). Extending SDT's contention that "the more supplies the better", results suggest that the impact of supplies actually depends on the level of needs, and that commensurate (for parents) or surplus supplies (for teachers, peers) are most optimal. Therefore, while some youth require strongly supportive relationships to experience optimal development, others require much lower support, and may even suffer from higher support.

Keywords Self-determination theory · Needs-supplies fit processes · Youth development · Social ecologies · Cubic response surface analysis

Introduction

During adolescence, youth undergo a critical stage of development where social agents such as peers, teachers, and parents play a pivotal formative role (Skinner et al., 2022). Self-determination theory (SDT) highlights that optimal youth development and learning require that such socialization processes contribute to satisfying psychological needs for autonomy, competence, and relatedness (Ryan & Deci, 2017). Accordingly, evidence shows that receiving needs-supportive behaviors from teachers, parents, and peers contributes to positive youth outcomes, including increased engagement in class, better learning, and more well-being (León & Núñez, 2013; Soenens & Vansteenkiste, 2005; Tian et al., 2016). But how much support is needed to ensure optimal development? Do students differ in their amounts of required support, due to individual differences in needs? This question has received little attention, but has strong implications for acknowledging individual differences in self-determined development, and for understanding which kinds of needs-supplies fit situations are most conducive to favorable academic and psychological functioning. The present research addresses this research gap by introducing new measurement and structural approaches to the analysis of relations between three socialization processes during adolescence (teachers, parents, peers) and key youth outcomes (engagement in class, academic achievement, subjective well-being).

How Psychological Needs Determine Youth Development: A Needs-Supplies Fit Approach

Basic Psychological Needs in Self-Determination Theory

Basic psychological needs theory (BPNT) stands as the fourth of six mini-theories forming the analytical framework of SDT (Deci & Ryan, 2000; Ryan & Deci, 2017). This

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theory assumes there are three psychological needs that are particularly fundamental to human functioning, namely the need to feel a sense of initiative and ownership in one's actions or "autonomy need", the need to feel a sense of mastery and confidence in being able to succeed and grow or "competence need", and the need to feel that one belongs and is connected to others or "relatedness need". Whereas early psychological traditions defined needs based on individualized experiences that drive behavior (dispositions, desires, drives, or any other experience motivating an action), SDT proposed a functionalist definition of needs based on how they objectively impact certain criteria. In other words, while early traditions focused on subjective experiences, SDT emphasizes the objective effects of these needs. This approach renders the identification and definition of psychological needs more firmly rooted in empirical evidence and testing. According to BPNT (Ryan & Deci, 2017, p. 242, Proposition Ia), psychological needs are identified if and only if it can be shown that their satisfaction predicts optimal individual functioning (i.e., in terms of physical or cognitive performance, or subjective well-being) and, at the same time, that their frustration predicts deteriorated functioning.

Extant evidence from meta-analyses has shown that according to these two functionalist criteria (i.e., needs-frustration leading to deterioration, needs-satisfaction leading to thriving), autonomy, competence, and relatedness are indeed valid psychological needs that explain optimal or suboptimal well-being over the life-span (from early adolescence to old age; Ryan et al., 2022). Literature reviews have also reported that needs satisfaction processes are essential to explain variations in adolescent learning and engagement with school activities (Núñez & León, 2015; Núñez-Regueiro, 2017; Ryan & Deci, 2020). For example, needs satisfaction processes in autonomy, competence, and relatedness have been shown to predict increases in the levels of motivational resilience and coping at school among young adolescents (Grade 3 through 6; Pitzer & Skinner, 2017), but also increases in the levels of engagement in class, subjective well-being, and achievement among older adolescents (i.e., middle school and high school students; Jang et al., 2012; León et al., 2015; León & Núñez, 2013; Núñez-Regueiro et al., 2022; Núñez-Regueiro & Wang, 2024).

Given the importance of needs satisfaction for optimal youth development, research has also shed light on the contextual determinants of needs satisfaction and, in particular, on social relationships that support basic psychological needs in the school context. Among many needs-supportive relationships, these include teachers providing students with choice, meaning, interest, ownership in the learning activities proposed in class to support feelings of autonomy (Jang et al., 2012; León & Núñez, 2013; Núñez-Regueiro, Juhel, et al., 2024; Soenens & Vansteenkiste, 2005; Wang et al., 2020), parents accompanying homework activities of their children by helping and talking about school assignments and personal interests to support feelings of competence and autonomy (Soenens & Vansteenkiste, 2005; Teuber et al., 2022; Xu et al., 2017), and peers acting friendly and helping out with school or personal issues to support feelings of relatedness (Fraina et al., 2020; Núñez-Regueiro & Núñez-Regueiro, 2021; Tian et al., 2016). Research has also shown that supplies in social support from teachers, parents, or peers have beneficial effects on academic functioning and subjective well-being, because of their positive effects on needs satisfaction (i.e., mediation process by needs satisfaction; Jang et al., 2012; León & Núñez, 2013; Soenens & Vansteenkiste, 2005; Tian et al., 2016).

More formally, the positive association between social support of psychological needs and youth outcomes is stated in Proposition Ib of the BPNT (Ryan & Deci, 2017, p. 243):

> ***"BPNT Proposition Ib:*** *Psychological need satisfactions and frustrations vary within persons over time, contexts, and social interactions. Any factor or event that produces variations in need satisfaction or need frustration will also produce variations in wellness, and this principle extends from highly aggregated levels of analysis down to moment-to-moment or situation-to-situation variations in functioning."*

The "black box" of individual differences in needs in needs-supplies fit processes (N-S Fit)

Proposition Ib is usually interpreted as meaning that individual differences in needs satisfaction depend on individual differences in the level of social support supplied by the environment (depending on time, contexts, and social interactions). Yet, a complementary view is to consider individual differences in the level of needs, that is, variations in how much a person needs to be supported to feel satisfied. Just as individuals vary in the level of supplies in physical nutrients they need (e.g., caloric intake) depending on their bodily functioning (e.g., gender, physical activity, age), this view assumes that individuals also vary in the amount of psychological nutrients they need (i.e., social support) to fulfill their psychological functioning. For simplicity, we use the notion of "needs-supplies fit" (Edwards et al., 2006; Núñez-Regueiro, 2017) to encapsulate all combinations of congruent (fit) or incongruent (misfit) levels of needs and supplies, and how these

Table 1 Atomistic Measures of Needs and Supplies Relative to Teachers, Parents, and Peers

Scale	Dimension and item stem	Exemplary items
Needs-Supplies in Teacher Autonomy Support (NS-TAS)	Needs: *In my view, to help me learn in the best way, a good <discipline> teacher should…*	- Provide me with choices and options - Encourage me to ask questions - Listen to how I would like to do things
	Supplies: *In reality, the fact is that my <subject> teacher…*	- Provides me with choices and options - Encourages me to ask questions - Listens to how I would like to do things
Needs-Supplies in Parental Competence Support (NS-PCS)	Needs: *In my view, in order for me to learn <discipline> at my best, I think that my parents (my father or mother) should…*	- Often ask me how they can help me with my <discipline> homework - Always be with me to do my <discipline> homework - Always verify that I did my homework in <discipline>
	Supplies: *In reality, the fact is that my parents…*	- Often ask me how they can help me with my <discipline> homework - Are always with me to do my <discipline> homework - Always verify that I did my homework in <discipline>
Needs-Supplies in Peer Relatedness Support (NS-PRS)	Needs: *In my view, what matters most in relationships with peers, is that one should feel…*	- Supported - Understood - Valued
	Supplies: *In reality, when I am with my peers at school I feel…*	- Supported - Understood - Valued

The NS-TAS was adapted from the Learning Climate Questionnaire (Jang et al., 2012; Williams & Deci, 1996), the NS-PCS from the parental homework involvement scale (Xu et al., 2017), and the NS-PRS from the acceptance dimension of the perceived relatedness scale (Richer & Vallerand, 1998). All scales were validated for factorial invariance across needs and supplies measures (Núñez-Regueiro & Juhel, 2024a)

combinations relate to youth psychological and school functioning.[1]

Preliminary research using new measures differentiating needs versus supplies in teacher autonomy support (see Table 1) has indeed shown that student differences in needs modify the impact of supplies on two basic needs satisfaction (i.e., autonomy and competence satisfaction; Núñez-Regueiro, Juhel, et al., 2024). This was most evident in the form of nonlinear relations to needs satisfaction (i.e., cubic and interactive-quadratic effects), which underlined the importance of considering combinations of needs and supplies levels, that is, situations of needs-supplies fit or misfit. In this preliminary study, relative excess in supplies (i.e., positive misfit) appeared to induce more needs satisfaction than high levels of both needs and supplies (i.e., positive fit), although both states induced more needs satisfaction than the relative deficit in supplies (i.e., negative misfit) or low levels in both needs and supplies (i.e., negative fit).

The preliminary finding that needs satisfaction processes vary as a function of supplies and needs levels also suggests the existence of a "black box" in the positive relation of supplies to youth outcomes (see Fig. 1A). First, it is currently unknown whether individual differences in needs modify this relation in a nontrivial way, for example by curbing or enhancing the relation depending on the level of needs. Second, it is unknown which kind of needs-supplies combinations is most adaptive. It might be the case that excess supplies (relative to needs) are detrimental, just as excess calories may result in health issues in physiological processes. For example, receiving too much support from peers when one needs little (i.e., low need for peer relatedness) might result in excessive peer pressure and distract youth from engaging in school activities, as exemplified in adolescent-limited antisocial behavior (Moffitt, 1993). Similarly, excessive autonomy support from the teacher (or

[1] It should be noted that the issue of individual differences in needs differs substantively from the issue of universality of basic psychological needs in human beings, also assumed within SDT (i.e., Proposition III of BPNT; Ryan & Deci, 2017). The issue of universality relates to cross-cultural variations in the personal endorsement of needs satisfaction, that is, the degree to which one desires or seeks to satisfy these needs (i.e., needs strength, needs desire). Such cross-cultural variations in personal endorsement of needs have been shown not to affect the actual effects of needs satisfaction on wellness, thereby corroborating the universality of these needs for psychological functioning (Chen et al., 2015). The issue of individual differences in needs relates, instead, to the degree of support intake that is perceived to be necessary to create needs satisfaction, while assuming needs satisfaction effects are universal (i.e., independent from the personal endorsement of needs). Investigating individual differences in needs is therefore fully compatible with the universality assumption of BPNT (see also Núñez-Regueiro, Juhel, et al., 2024).

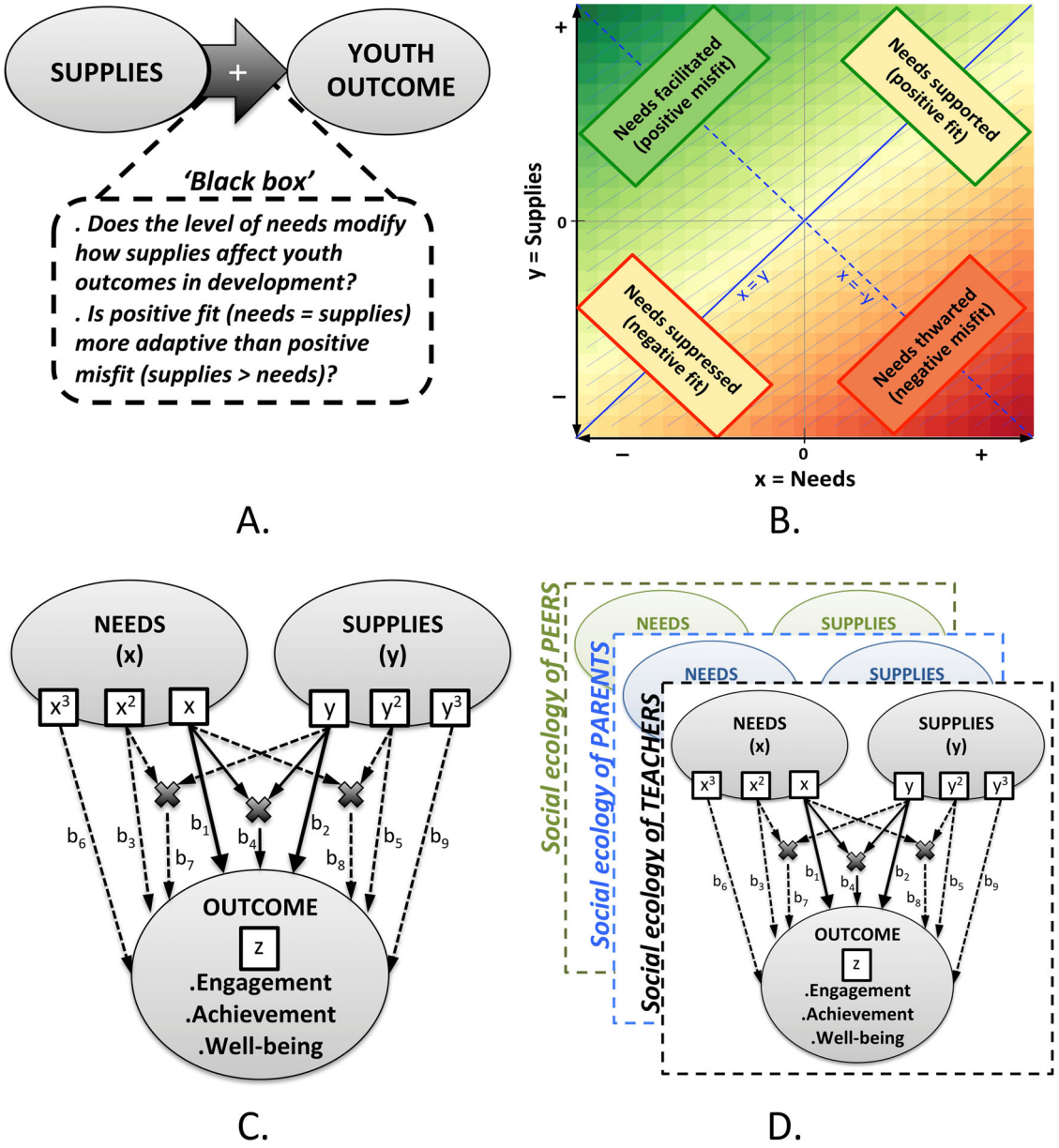

Fig. 1 A New Look at Self-Determined Development: Introducing Needs-Supplies Fit Processes Across Diverse Social Ecologies and Adolescent Outcomes. Note. The "black box" of needs-supplies fit processes in self-determined behavior (**A**; Ryan & Deci, 2017) is opened in the form of a bidimensional needs-supplies spectrum (**B**), and related to self-determined behavior using cubic polynomial regression modeling (**C**; Núñez-Regueiro & Juhel, 2022, 2024b). This modeling strategy is explored for needs-supplies fit processes across diverse social ecologies, including teachers, parents, and peers (**D**). Research hypotheses are presented in Fig. 2

other educators) might be maladaptive if the student does not feel ready to learn at high levels of autonomy (low needs for autonomy support), as suggested by person-environment fit theories (Eccles et al., 1993; Hunt, 1975). Conversely, it might be the case that large amounts of needs-supportive behavior are well regulated by the motivational system by taking the required amount to meet needs and ignoring the excess supplies, just as the body would dispose of excess nutrients. In this case, excess supplies in need-supportive behavior might be more beneficial. In either case, individual differences in needs would play an important role as benchmarks against which the provision of supplies should be contrasted. Yet, no study has tested these alternative claims, leaving the theoretical debate open: Are youth outcomes highest when high levels of supplies in social support match an equivalently high level of needs, that is, in cases of positive needs-supplies fit? Or is positive misfit—i.e., higher supplies relative to needs—more adaptive (see Fig. 1B)? Answering this requires measurement and structural extensions to SDT, to which we turn next.

Measurement and Structural Extensions to the Analysis of Self-Determined Behavior

To open the black box of needs-supplies fit processes undergirding youth outcomes, the present research proposes two extensions to SDT, one relative to the measurement of needs and supplies across three social ecologies (i.e., teachers, parents, peers; Núñez-Regueiro & Juhel, 2024a; see also Núñez-Regueiro, 2017; Skinner et al., 2022), and another relative to the modeling of their combinatory effects on youth outcomes using cubic response surface analysis (Núñez-Regueiro & Juhel, 2022, 2024d, 2024b, 2024c).

Distinguishing individual needs versus environmental supplies

The lack of research on needs-supplies fit processes in SDT can be explained by a lack of measurement approaches specific to BPNT needs-supplies processes. For example, scales exist that measure person-environment fit processes in the classroom (e.g., preferred versus actual class participation; Fraser & Rentoul, 1980) or in the workplace (e.g., preferred versus actual workload; Edwards & Parry, 1993), but none has been specifically developed in relation to adolescents' basic psychological needs and their corresponding environmental supplies. To address this issue, we recently developed and validated three needs-supplies scales of teacher autonomy support (NS-TAS), parental competence support (NS-PCS), and peer relatedness support (NS-PRS; see Table 1).

These scales measure needs and supplies using the same set of items drawn from preexisting scales on teacher autonomy support (Jang et al., 2012; Williams & Deci, 1996), parental competence support (Xu et al., 2017), and peer relatedness support (Richer & Vallerand, 1998). Building on the repeated-measures design (Fraser & Rentoul, 1980), needs and supplies are measured with the same items while using different rating systems. For needs, students are asked to report the amount of the specific facet of social support tapped by each item (e.g., being given choices and options by the teacher) they would feel is adequate to meet their needs. By contrast, supplies are measured by asking students to report the amount they actually perceive about that same facet. This measurement approach therefore enables the comparison of ideal levels versus actual levels of supplies perceived by youth, following "atomistic" or parallel measures of personal and environmental characteristics (Edwards et al., 2006).

Based on these measures of needs and supplies, it becomes possible to quantify how adolescents experience congruent or incongruent amounts of personal needs and contextual supplies for each kind of social support (see Fig. 1B). For example, experiences of positive fit and misfit will reflect, respectively, situations where high levels of needs are met with high levels of supplies (needs supported), and where high levels of supplies exceed low levels of needs (needs facilitated; Fig. 1B). Conversely, experiences of negative fit or misfit will reflect situations of little (needs suppressed) or insufficient support of psychological needs (needs thwarting), respectively. More generally, thinking in terms of needs versus supplies offers a complementary functionalist definition of basic psychological needs. Over and above the level of supplies (Fig. 1A), it would be expected that positive (mis)fit and negative (mis)fit relate positively and negatively to youth outcomes, respectively. As explained next, cubic response surface analysis offers an optimal approach to testing such hypotheses.

A cubic response surface analysis of needs-supplies fit processes on youth outcomes

For each kind of social support, the bidimensional spectrum of needs-supplies intensities (Fig. 1B) can be related to youth outcomes by specifying a regression model that includes the combinatory effects of needs and supplies (see Fig. 1C). Whereas combinatory effects in person-environment fit at school are usually conceived or investigated using interaction effects models (see solid arrows in Fig. 1C; Fraser & Rentoul, 1980; Núñez-Regueiro, 2017, 2018; Núñez-Regueiro et al., 2016; Skinner et al., 2022), a more complete specification can be obtained by allowing for higher-order effects, including quadratic, cubic, and interactive-quadratic effects of needs (x) and supplies (y) on youth outcomes (z) (see dashed arrows, Fig. 1C; Núñez-Regueiro, 2024; Núñez-Regueiro, Juhel, et al., 2024; Núñez-Regueiro & Wang, 2024). This takes the form of a cubic polynomial model (i.e., $z = b_0 + b_1x + b_2y + b_3x^2 + b_4xy + b_5y^2 + b_6x^3 + b\ 7x^2y + b_8xy^2 + b_9y^3$).

One difficulty in using cubic polynomial models is the risk of obtaining overly complex solutions, which are difficult to characterize mathematically and to interpret substantively. To overcome this difficulty, a new framework was recently developed (Núñez-Regueiro & Juhel, 2022) that enables identifying best-fitting solutions from 37 polynomial families defined by zero or proportionality constraints applied to the polynomial parameters b_1 to b_9 (Núñez-Regueiro & Juhel, 2024b); but also interpreting the obtained solutions using mathematical derivatives to identify reversal or acceleration points in the response surface (Núñez-Regueiro & Juhel, 2024c). More precisely, this comparative approach builds on previously defined families of quadratic polynomials (e.g., congruence effect; Edwards & Parry, 1993) or cubic polynomials (e.g., level-dependent congruence effect, asymmetric congruence effect; Humberg et al., 2020), and extends them with new families to provide an integrative and quasi-exhaustive test of all possible

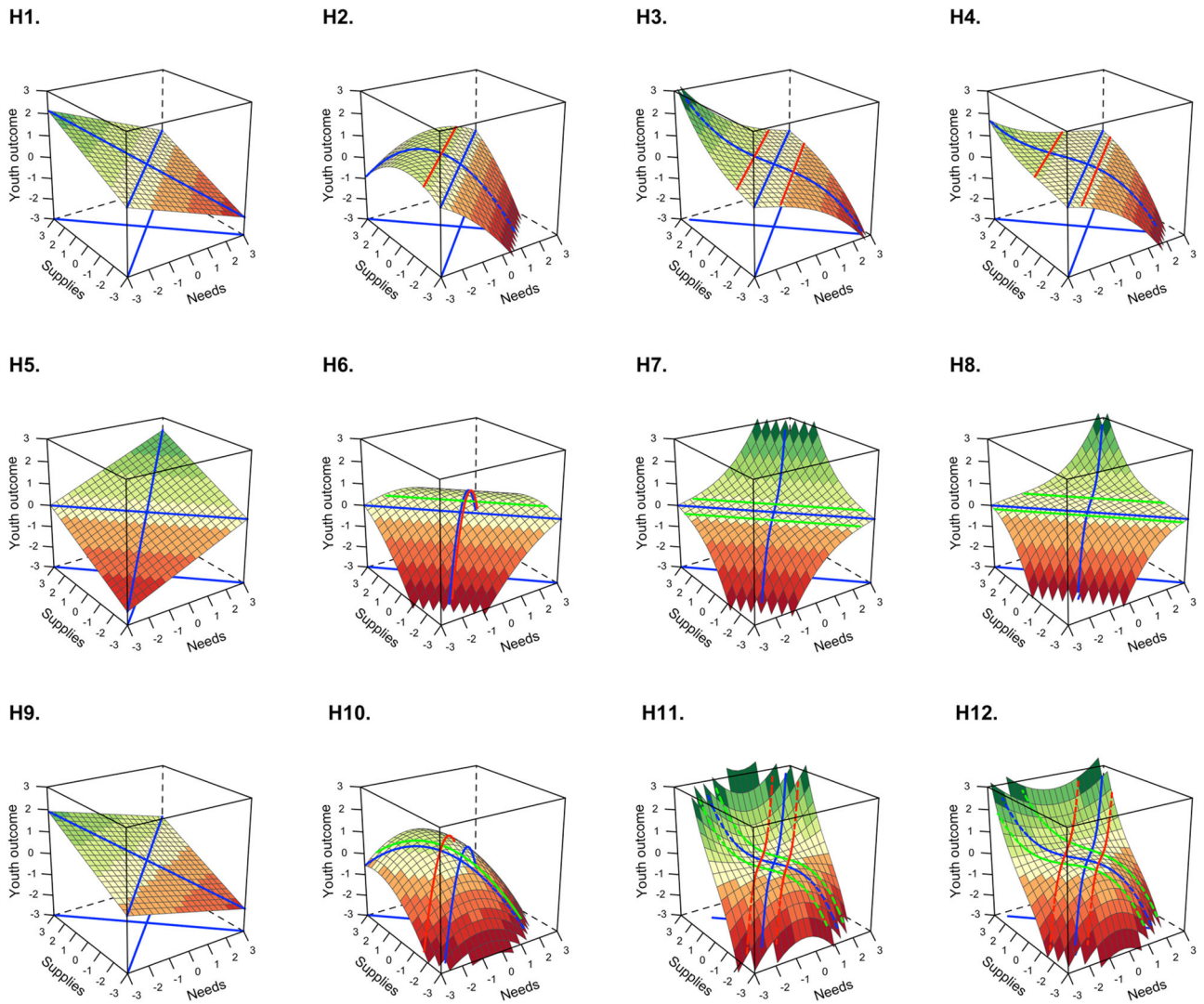

Fig. 2 Twelve Hypotheses About Needs-Supplies Fit Processes Undergirding Youth Outcomes. Note. x = needs; y = supplies. Lines correspond to hypotheses assuming a beneficial effect of positive misfit ($x < y$; line 1), positive fit ($x = y$; line 2), and positive fit or misfit ($x \leq y$; line 3). Columns correspond to linear (1), linear-quadratic (2), linear-cubic (3), and linear-quadratic-cubic (4) variants of the hypotheses. Dashed and solid lines describe the response surface above the line of congruence (LOC, x = y) and line of incongruence (LOIC, x = −y), respectively. Lines in green and red intersect reversal or acceleration points on the LOC and LOIC, respectively

linear, quadratic or cubic polynomials. This new framework therefore allows testing anticipated hypotheses about needs-supplies fit (confirmatory hypotheses) while also exploring other known families of polynomials (exploratory hypotheses), thus ensuring that the best-fitting polynomial and response surface is identified.

The present study will use this cubic RSA framework across three distinct social ecologies (teachers, parents, peers) and several academic and developmental outcomes (engagement, achievement, well-being; see Fig. 1D). To guide the analyses, we formulate 12 prototypical hypotheses about N-S fit processes (see Fig. 2). Technical details on each hypothesis are reported in the Supplemental Material (SM-A), but their defining features are as follows. In these hypotheses, fit and misfit processes correspond, respectively, to the behavior of the response along the lines of congruence (LOC, *needs* = *supplies*) and incongruence (LOIC,*needs* = −*supplies*). Thus, a positive (negative) effect along the LOC indicates that, for students experiencing similar amounts of needs and supplies, experiencing high levels on both predictors increases (decreases) their outcome levels. By contrast, a negative (positive) effect along the LOIC indicates that, for students who experience opposite amounts, experiencing more supplies than needed increases (decreases) their engagement levels. Based on SDT, it is assumed that situations of positive fit or misfit are associated with increased outcomes, and situations of negative fit or misfit with decreased outcomes (see Fig. 1B).

The hypotheses in Fig. 2 differ with respect to the kind of process involved, assuming that only variations in degrees

of misfit (H1 through H4), fit (H5 through H8), or both fit or misfit (H9 through H12) are related to youth outcomes. These 3 kinds of processes are effectively compared against the data to understand whether youth outcomes are really determined by needs being met with commensurate supplies (fit), being surpassed by or falling short of supplies (misfit), or both. If only one of these processes actually matters to explain the data (e.g., misfit), then the most parsimonious solution ignoring the other process (e.g., fit) should stand out as most relevant to expand knowledge on SDT's needs-supplies fit processes.

These hypotheses also differ by specifying whether the effects of fit or misfit are constant (linear; H1, H5, H9), whether they reverse in sign after a certain degree of positive fit or misfit (linear-quadratic; H2, H6, H10), whether they accelerate beyond certain degrees of positive or negative (mis)fit (linear-cubic; H3, H7, H11), and whether the acceleration is non-proportional, being more marked for situations of negative (mis)fit than positive (mis)fit (linear-quadratic-cubic; H4, H8, H12). Allowing for nonlinearities in the response surface (i.e., reversals, accelerations) is important from a substantive point of view because it informs on the existence of optimal or suboptimal degrees of fit or misfit between needs and supplies, which would otherwise be overlooked. For example, experiencing commensurate amounts of needs and supplies (e.g., in teacher autonomy support) might support engagement in class at moderate levels (moderate N-S positive fit), but might become deleterious at higher levels if, for example, very high needs reflect a dysfunctional situation where no amount of high supplies is enough for satisfying those needs. In such a situation (see H6), the nonlinearity (i.e., a reversal) would enable uncovering a "functional frontier" beyond which needs satisfaction processes do not function according to SDT, with important implications on how to target extreme N-S fit processes (see Implications). From a more methodological point of view, allowing for nonlinearities is also crucial to overcome spurious findings about null results (e.g., null effect of N-S positive fit). For example, an apparent nonsignificant effect of N-S misfit (H5) might be hiding a truly significant effect only apparent once the accelerations along the line of misfit are taken into account (as in H4). More generally, ignoring symmetric (quadratic) or asymmetric (cubic) patterns of variations in the data can result in spurious findings about N-S fit or misfit processes, which is why a cubic polynomial approach inclusive of all such patterns is warranted.

The 12 hypotheses in Fig. 2 provide conceptual guidelines to anticipate complex nonlinearities that might arise in combinatory effects of needs and supplies on youth outcomes, but by no means are they exhaustive. For example, accelerations of effects could be replaced by reversals of effects, whereas nonproportionalities could be specified to reinforce situations of positive instead of negative (mis)fit (see, for alternative hypotheses, Núñez-Regueiro, Juhel, et al., 2024). This is why a mixed confirmatory-exploratory identification strategy is required to identify the polynomial solution and response surface that best approximates the data (see Method). Nevertheless, from SDT's functionalist definition of basic psychological needs (BPNT) and the needs-supplies spectrum (Fig. 1B), one would expect situations characterized by needs-facilitation or needs-support (positive misfit or fit) and needs-thwarting or needs-suppression (negative misfit or fit) to be positively and negatively related to youth outcomes, respectively. Response surfaces aligning with such expectations would therefore corroborate the assumption that needs-supportive social relations lead to optimal youth development (Proposition Ib of BPNT).

Current Study

This study sought to explore needs-supplies fit processes in the prediction of major outcomes during adolescence (i.e., engagement in class, academic achievement, subjective well-being), by investigating how individual differences in the needs for support across three social agents (i.e., teacher autonomy support, parental competence support, peer relatedness support) modify the impact of supplies in such support on adolescent outcomes. This exploration of needs-supplies processes offered a new operationalization and test of the functionalist definition of basic psychological needs, by providing explicit modeling of needs-satisfaction (positive misfit or fit) and needs-frustration processes (negative misfit or fit; see Fig. 1B). Two research questions were addressed. First, the study sought to explore whether youth outcomes (engagement, achievement, well-being) depended not only on the level of supplies but also on the level of need for support across different social agents (teachers, parents, peers; RQ1). Second, the goal was to understand how the interplay between needs and supplies related to youth outcomes, with the expectation that situations of positive fit and misfit would be associated with higher levels of youth outcomes and situations of negative fit and misfit with lower levels (RQ2).

Method

Participants

Participants were 398 students [M(age) = 14.3, SD(age) = 2.1, 58% female adolescents] from 3 schools (37 classes) in the urban area of Grenoble, in the French Alps. Data collection was conducted as part of a teacher education

Table 2 Means, Standard Deviations, and Intercorrelations of Study Variables

	M	SD	Range	1	2	3	4	5	6	7	8
1. Needs TAS	4.178	0.632	[1, 5]								
2. Supplies TAS	3.217	1.082	[1, 5]	0.126*							
3. Needs PCS	2.777	1.084	[1, 5]	0.226*	0.041						
4. Supplies PCS	2.559	1.129	[1, 5]	0.148*	0.153*	0.447*					
5. Needs PRS	4.249	0.659	[1, 5]	0.342*	0.002	0.236*	0.199*				
6. Supplies PRS	3.442	1.057	[1, 5]	0.045	0.181*	0.075	0.188*	0.318*			
7. Engagement	3.552	0.998	[1, 5]	0.160*	0.317*	0.141*	0.151*	0.055	0.006		
8. Achievement	14.066	3.647	[0, 20]	0.061	−0.022	−0.001	−0.148*	0.058	0.018	0.196*	
9. Well-being	3.857	0.913	[1, 5]	0.122*	0.172*	0.113*	0.158*	0.088	0.309*	0.089	0.077

$N = 389$ secondary school students, 37 classes. *TAS* teacher autonomy support, *PCS* parental competence support, *PRS* peer relatedness support. TAS, PRS, engagement and achievement measures apply to the same specific discipline (see Method)

*$p < 0.05$

program (ethics approval exempted for training) via an online questionnaire. The sample covered all grade levels of secondary school (i.e., grades 6 through 12, $n = [57, 68]$), and was from low or intermediate (school 1, $n = 96$), intermediate (school 2, $n = 191$), and high SES background (school 3, $n = 111$). After the exclusion of 2% of careless respondents identified by excessively rapid and inconsistent responses (Ward & Meade, 2023), the final sample comprised 389 students.

Measures

Statistics for students' needs, supplies, and youth outcomes are reported in Table 2.

Needs and supplies in social support

Levels of needs and supplies across social agents were measured using the NS-TAS scale, the NS-PCS, and the NS-PRS scales (Núñez-Regueiro & Juhel, 2024a). These scales use a parallel set of items characterizing teachers' autonomy support ($\omega_{needs,TAS} = 0.710$, $\omega_{supplies,TAS} = 0.885$, 5 items from the short version of the Learning Climate Questionnaire; Jang et al., 2012; Williams & Deci, 1996), parental competence support ($\omega_{needs,PCS} = 0.813$, $\omega_{supplies,PCS} = 0.797$, 4 items from the Parental Homework Involvement scale; Xu et al., 2017), and peer relatedness support ($\omega_{needs,PRS} = 0.754$, $\omega_{supplies,PRS} = 0.896$, 5 items from the perceived relatedness scale; Richer & Vallerand, 1998). Based on a 5-point Likert scale (1 = do not agree at all, 5 = very strongly agree), each item was answered once in relation to ideal levels reflecting needs, and once in relation to actual levels perceived reflecting supplies (see Table 1). In a validation study using the present data, factors of needs and supplies from each scale were shown to be metric- and scalar-invariant (i.e., invariant in factor loadings and item intercepts), thus suggesting they provided parallel measures of the same phenomenon of social support, which could be used for needs-supplies fit modeling (Núñez-Regueiro & Juhel, 2024a).

Engagement in class

Engagement in class was measured using the behavioral dimension of the Engagement with Learning scale adapted to a specific discipline (3-item scale; Núñez & León, 2019), which corresponded to the discipline used for NS-TAS and NS-PCS scales (i.e., language arts or mathematics). Items were measured on a 5-point scale (1 = "do not agree at all", 5 = "very strongly agree"). The resulting measure showed satisfactory reliability (3 items, sample item = *In class of <discipline>, I work as hard as I can*; $\omega_{engagement} = 0.761$).

Academic achievement

Achievement was measured by GPA in the same discipline as the one tapped by NS-TAS and NS-PCS scales (i.e., language arts or mathematics), using the school rating scale of 21 points (0 to 20 points scale), with higher scores indicating higher achievement.

Well-being

Students' well-being was operationalized by the scale of Happiness for adolescent well-being (4 items, $\omega_{happy} = 0.877$, sample item = *I feel happy;* Kern et al., 2016). This scale measures both affective and cognitive features of subjective well-being, aligning with a hedonic approach to life satisfaction and wellness.

Covariates

The analyses also controlled for potential confounding factors of youth outcomes, including adolescents' age,

gender, parental education level (primary school to higher education), grade point average across all courses considered (21-point scale), and educational level (middle school vs. high school).

Analytic Strategy

Response surface analysis

Needs-supplies fit processes of needs satisfaction were identified using a confirmatory-exploratory framework for response surface analysis, based on a 3-step identification strategy (Núñez-Regueiro & Juhel, 2022). In this approach, Step 1 consists in selecting the best-fitting solution among 37 families of polynomials characterized by constraints applied on first-order (b_1, b_2, with $b_3$tob_9 fixed to zero), second-order (b_3, b_4, b_5, with $b_6$tob_9 fixed to zero), or third-order polynomial parameters (b_6, b_7, b_8, b_9) of the cubic model (Núñez-Regueiro & Juhel, 2024b). Lower-order parameters specific to each family are freely estimated, which allows for higher-order families (third-order, second-order) to combine with lower-order families (second-order, first-order) across thousands of possible processes, either expected (confirmatory hypothesis, as in Fig. 2) or unexpected (exploratory hypothesis). Best-fitting solutions are selected based on tests of absolute fit against the saturated cubic model (to select candidates families), on AIC weights (to select most parsimonious solutions), on explained variance accounting for model complexity (i.e., adjusted R2), on the significance of the family-specific parameters, and on evidence of good fit to the data (e.g., CFI ≥ 0.95, TLI ≥ 0.95, RMSEA ≤ 0.06, SRMR ≤ 0.08). Step 2 then identifies the best-fitting variant within the best-fitting family, by testing equality or zero constraints on lower-order polynomial parameters in that family using likelihood ratio tests between nested models (see full results in SM-C). Finally, Step 3 consists in probing the robustness of results to the model-selection process conducted in Steps 1 and 2, by using bootstrapped samples and verifying that the obtained 95% CI of non-null parameters in the best-fitting variant does not contain the value zero (SM-D). In this study, we also integrated covariates into the final model (Step 4), to assess its robustness to student background characteristics (SM-E).

The best-fitting variant was then interpreted by probing the curvatures of the response surface, using rationales for combining cubic polynomials (Núñez-Regueiro & Juhel, 2024c). These rationales allow characterizing the response behavior along the lines of fit (or line of congruence, LOC) and misfit (or line of incongruence, LOIC), by defining reversal points "r" where the behavior changes sign ($\frac{\partial z}{\partial x} = 0$), and acceleration points "a" where the behavior changes substantially (Núñez-Regueiro & Juhel, 2024c). Accelerations were identified for rates of change of moderate effect size, i.e., $\left|\frac{\partial z}{\partial x}\right| = 0.30$, or large effect sizes, i.e., $\left|\frac{\partial z}{\partial x}\right| = 0.50$ if the main effect was already above 0.30.

To limit parametric bias, variables were standardized to zero means and unit variance prior to analysis (Núñez-Regueiro & Juhel, 2024e), and parameters were estimated with a data clustering correction accounting for class-level variance (Muthén & Satorra, 1995). Missing data was accounted for using full information maximum likelihood (Graham, 2012). Following guidelines in behavioral sciences (Cohen, 1988; Lenhard & Lenhard, 2022), N-S fit processes were considered nontrivial when the model contributed to explaining more than 2% of the outcome variance. Due to space limitations, the main text focuses on results for nontrivial models of N-S fit processes (complementary results are reported in the SM). Data analyses were conducted on R (R Core Team, 2024) using the package *RSAtools* (Núñez-Regueiro & Juhel, 2024d). *RSAtools* implements the aforementioned comparative framework for response surface analysis, using the package *lavaan* for polynomial modeling (Rosseel, 2012) and the package *ggplot2* for the graphical interpretation of response surfaces (Wickham, 2016).

Results

Needs-Supplies Fit Processes With Teachers

Model identification

For needs-supplies fit processes in teacher autonomy support, the best-fitting polynomials specified linear-cubic (well-being) or linear-quadratic-cubic effects (engagement, achievement) in needs-supplies fit and misfit processes, in the form of three polynomial families (i.e., FM32, FM26, FM27; see Table 3). The explained variance was largest for engagement (R2 = 11.8%), and was nontrivial for achievement (R2 = 4.9%) and well-being (R2 = 4.8%; R2 > 2%). Ignoring the effects of needs resulted in models that explained 34% (engagement) to 182% (wellbeing) less variance in outcomes (see Table 5).

Interpretation of response surfaces

For all three outcomes (Fig. 3), situations of needs-support (positive fit) and needs-facilitation (positive misfit) were generally associated with increased engagement, achievement, and well-being, whereas needs-suppression (negative fit) and needs-thwarting (negative misfit) were generally associated with decreased youth outcomes. These features made the surfaces similar to H9

Table 3 Fit Indices of Models of Needs-Supplies Fit Processes

Polynomial Model	χ^2	DF	p	R2adj	CFI	RMSEA	SRMR
Needs-Supplies Fit in Teacher Autonomy Support							
ENG: Asymmetric incong. effect rotated by Y (FM32)	0.7	5	0.984	0.118	1.000	<0.001	0.002
ACH: Parallel, asymmetric weak congruence and strong incongruence effects (FM26)	2.3	6	0.893	0.049	1.000	<0.001	0.005
WELL: Parallel, asymmetric strong congruence and weak incongruence effects (FM27)	1.5	7	0.984	0.048	1.000	<0.001	0.006
Needs-Supplies Fit in Parental Competence Support							
ENG: Congruence effect (FM7)	3.7	7	0.809	0.075	1.000	<0.001	0.012
ACH: Congruence effect rotated by Y (FM10)	5.9	7	0.554	0.031	1.000	<0.001	0.012
WELL: Main effect of Y (FM2)	5.8	8	0.665	0.035	1.000	<0.001	0.014
Needs-Supplies Fit in Peer Relatedness Support							
ENG: Interaction effect between X and Y (FM4)	3.8	7	0.797	0.020	1.000	<0.001	0.010
ACH: Quadratic effect of Y (FM6)	3.7	7	0.819	0.048	1.000	<0.001	0.013
WELL: Parallel, asymmetric strong congruence and weak incongruence effects (FM27)	2.0	5	0.855	0.120	1.000	<0.001	0.004

ENG engagement in class, *ACH* academic achievement, *WELL* well-being, *X* needs, *Y* supplies, *FM* family of polynomial models. Numbered models correspond to the best-fitting family identified after comparison across 37 families (for complete lists, see SM). Parameters and response surfaces for N-S fit processes (when applicable) are reported in Table 4 and Figs. 3 and 4

through H12. However, nonlinearities characterizing N-S fit processes differed between outcomes. For engagement (Fig. 3B), the generally positive effects of N-S fit reversed in sign and became detrimental for students with high values of needs and supplies, situated above 1SD (i.e., the second reversal point situated at $needs\ TAS_{r2} = 1.172$)[2]. By contrast, for achievement (Fig. 3E) and well-being (Fig. 3H), reversal effects occurred both at low and high congruent values of needs and supplies. More precisely, the detrimental effect of experiencing low needs and supplies (i.e., negative N-S fit) reversed and became beneficial for predictors values approximately 1 SD below the mean (i.e., first reversal point situated at $needs\ TAS_{r1} = -0.970$ for achievement, and $needs\ TAS_{r1} = -1.090$ for well-being). Conversely, the beneficial effect of experiencing high needs and supplies (positive N-S fit) became detrimental for predictor values 1/3 SD or 1 SD above the mean (i.e., second reversal point situated at $needs\ TAS_{r2} = 0.368$ for engagement and $needs\ TAS_{r2} = 1.090$ for well-being).

Similarly, processes of N-S misfit differed across outcomes. For well-being (Fig. 3I), the beneficial and detrimental effects of experiencing positive and negative misfit were observed for all students and increased with the size of the misfit (single reversal point situated at $needs\ TAS = 0$). On the contrary, these effects were only observed for a certain range of N-S values in engagement and achievement processes. For N-S misfit relating to engagement (Fig. 3C), needs-facilitation occurred when supplies levels strictly exceeded needs levels (i.e., $supplies\ TAS_{r1} = -needs\ TAS_{r1} > 0$), but needs-thwarting only occurred at large levels of misfit of 2 ½ SDs or more (i.e., $needs\ TAS_{r2} = -supplies\ TAS_{r2} > 1.291$, $\Delta(N - S) = 1.291 * 2 = 2.582$ SD). For N-S misfit relating to achievement (Fig. 3F), similar features as those for engagement occurred, but with a more symmetric nonlinearity which concerned less students. Thus, needs-facilitation for achievement occurred for students experiencing a 1 SD or more excess in supplies relative to needs levels ($needs\ TAS_{r1} = -supplies\ TAS_{r1} < -0.466$, $\Delta(S - N) = 0.466 * 2 = 0.932$ SD), whereas needs-thwarting occurred for students experiencing a 1 ½ SD or more deficit in supplies relative to needs levels ($needs\ TAS_{r2} = -supplies\ TAS_{r2} > 0.767$, $\Delta(S - N) = -0.767 * 2 = -1.534$ SD).

Needs-Supplies Fit Processes With Parents

Model identification

For academic outcomes of needs-supplies fit in parental competence support, the best-fitting polynomials specified linear and linear-quadratic effects along the lines of fit and misfit (FM7, FM10; Table 3). The explained variance was large for engagement (7.5%), but was almost trivial for achievement (3.1%). Also, the latter model was not robust to bootstrapped sampling, meaning its external validity to other samples was uncertain (see SM-D). Yet, relative to a model including only the effects of supplies, the significant effects of needs (i.e., main, interactive, and quadratic effects; see Table 4) increased the explained variance by over 180% for both academic outcomes (see Table 5). On the contrary, well-being was not

[2] The first reversal point was negligible, being situated at extremely low N-S values; i.e., $needs\ TAS_{r1} = supplies\ TAS_{r1} = -3.218$ (see Fig. 3B).

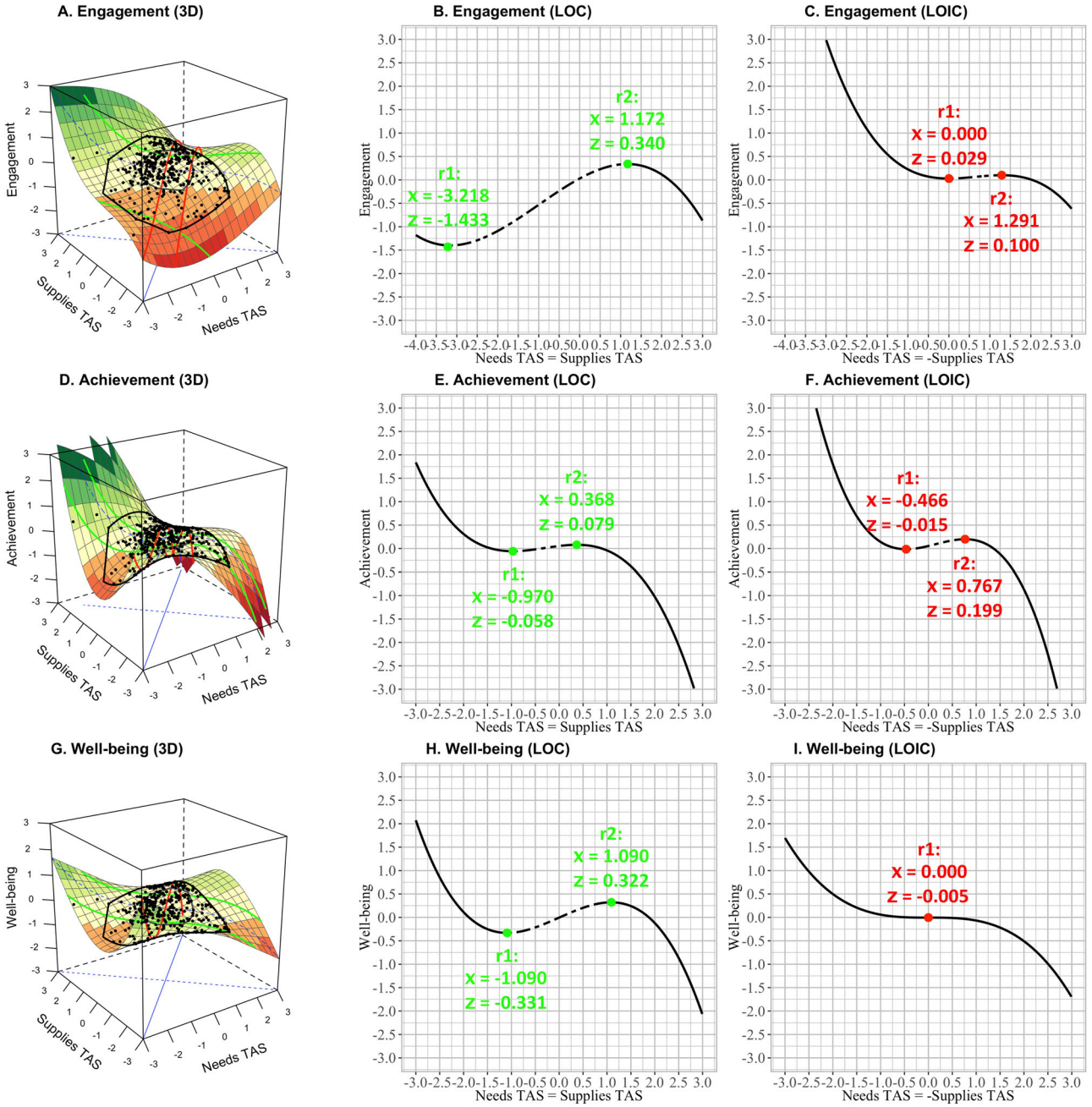

Fig. 3 Response Surfaces for Needs-Supplies Fit in Teacher Autonomy Support. Note. $N = 389$ secondary school students. TAS teacher autonomy support, LOC Line of congruence, LOIC Line of incongruence. For each outcome, the response surface is reported along the three dimensions (column **1**), along the LOC ($x = y$, N-S fit; column **2**), and along the LOIC ($x = -y$, N-S misfit; column **3**). Lines in green and red intersect reversal points ("r") on the LOC and LOIC, respectively. The fence around data points corresponds to the fourth quartile of the bivariate boxplot delimiting realistic observations for inference

dependent on N-S fit processes in parental support, being solely and positively related to levels of supplies which explained 3.5% of the variance in well-being (Table 3).

Interpretation of response surfaces

Engagement levels responded to a symmetric congruence effect (Fig. 4A): Students experiencing high (low) and equivalent amounts of needs and supplies in parental support reported higher (lower) levels of engagement in class, indicating a positive effect of N-S fit ($u_1 = 0.230$, $p < 0.001$; Fig. 4B). On the contrary, experiencing dissimilar amounts, either in the form of needs-facilitation (positive misfit) or needs-thwarting (negative misfit) was strictly related to lower engagement levels (single reversal situated at *needs* $PCS_{r1} = 0$; Fig. 4C). In other words, being provided with too much or

Table 4 Polynomial Parameters of Identified Needs-Supplies Fit Processes

Variable	Teacher Autonomy Support			Parental Competence Support			Peer Relatedness Support		
	ENG	ACH	WELL	ENG	ACH	WELL	ENG	ACH	WELL
Needs (b_1)	0.237***	0.183†	0.225***	0.115***	0.084***	0	0.144*	0	0.018
Supplies (b_2)	0.237***	−0.061†	0.225***	0.115***	−0.168***	0.193***	−0.072*	−0.007	0.439***
Needs^2 (b_3)	[A]0	−0.103***	0	−0.096***	0.000	0	0.000	0	−0.089**
Needs*Supplies (b_4)	−0.129*	−0.103***	0	0.193***	0.127*	0	0.117**	0	−0.089**
Supplies^2 (b_5)	0	0.103***	0	−0.096***	−0.063*	0	0.000	−0.186***	0.000
Needs^3 (b_6)	−0.014***	0	0	0	0	0	0.000	0	0.000
Needs^2*Supplies (b_7)	−0.041***	0	0	0	0	0	0.000	0	0.000
Needs*Supplies^2 (b_8)	−0.041***	−0.171**	−0.095***	0	0	0	0.000	0	−0.106*
Supplies^3 (b_9)	0.053*	0.057**	−0.032***	0	0	0	0.000	0	−0.035*
Explained var. R2 (adjusted)	11.8%	4.9%	4.8%	7.5%	3.1%	3.5%	2.0%	4.8%	12.0%

$N = 389$ secondary school students. *ENG* engagement in class, *ACH* academic achievement, *WELL* well-being. Parameters b_1 to b_9 describe the cubic polynomial effects of needs (x) and supplies (y) on SDT outcomes (z), for alternative needs-supplies fit processes (teacher autonomy support, parental competence support, peer relatedness support). All parameters are robust to the inclusion of covariates (i.e., age, gender, father and mother SES, grade point average, school level; see SM-E). Fit indices are reported in italic font in Table 3, whereas response surfaces are interpreted in Figs. 3 and 4

[A]Zero values are fixed by construction, as part of the identification strategy of the best-fitting polynomial

†p ≤ 0.10; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table 5 Relative Loss in Explained Variance of Supplies Only Models Relative to Needs-Supplies Fit Models

Variable	Teacher Autonomy Support			Parental Competence Support			Peer Relatedness Support		
	ENG	ACH	WELL	ENG	ACH	WELL	ENG	ACH	WELL
R2 Supplies Only	8.8%	0.0%	1.7%	2.6%	1.1%	3.5%	0.0%	0.9%	9.9%
R2 Needs-Supplies Fit	11.8%	4.9%	4.8%	7.5%	3.1%	—	2.0%	—	12.0%
Relative Loss of Supplies Only Model (vs. N-S Fit Model)	−34.1%	INF	−82.4%	−188.5%	−181.8%	Not applicable	INF	Not applicable	−21.2%

INF infinity. Percentages under 0.001 are rounded to 0. Missing values correspond to models for which no needs-supplies fit process is observed

too little parental support at home (relative to ideal levels of support) was associated with poorer student engagement, a process close to H2. The N-S fit process for achievement showed a similar pattern but with modifications induced by curvature and nonproportionality in the response surface aligning with H2 and H10. Thus, the positive effect of N-S fit was evident, but only upon reaching levels of parental support approximately 0.5 SD above the mean (reversal situated at $needs\ PCS_{r1} = supplies\ PCS_{r1} = 0.660$; Fig. 4E). Moreover, the line of the congruence effect was nonproportional, being moved towards negative misfit where students reported more needs than supplies. More precisely, the nonproportionality indicated that the optimal amount of parental support for achievement was reached for students who received somehow less parental support than what they deemed necessary, but this deficit in parental support became detrimental to achievement if it was too large, for approximately a 2/3 SD of misfit (i.e., at $needs\ PCS_{r1} = -supplies\ PCS_{r1} > 0.660$; Fig. 3F).

Needs-Supplies Fit Processes With Peers

Model identification

N-S fit processes relative to peer relatedness support were only evident in relation to well-being, in the form of linear-quadratic-cubic effects explaining 12.0% of the variance in well-being (FM27; Table 3). For this model, the inclusion of needs effects contributed to increase the explained variance by 21%, relative to a model only including the effects of supplies (Table 5). For other outcomes, the N-S fit process with peers was trivial in effect size (R2 = 2.0% for engagement), or did not depend on variations in needs, being only determined by variations in supplies (R2 = 4.8% for achievement). For these reasons, we only interpret the N-S fit process in relation to well-being (interpretations for other processes are reported in SM).

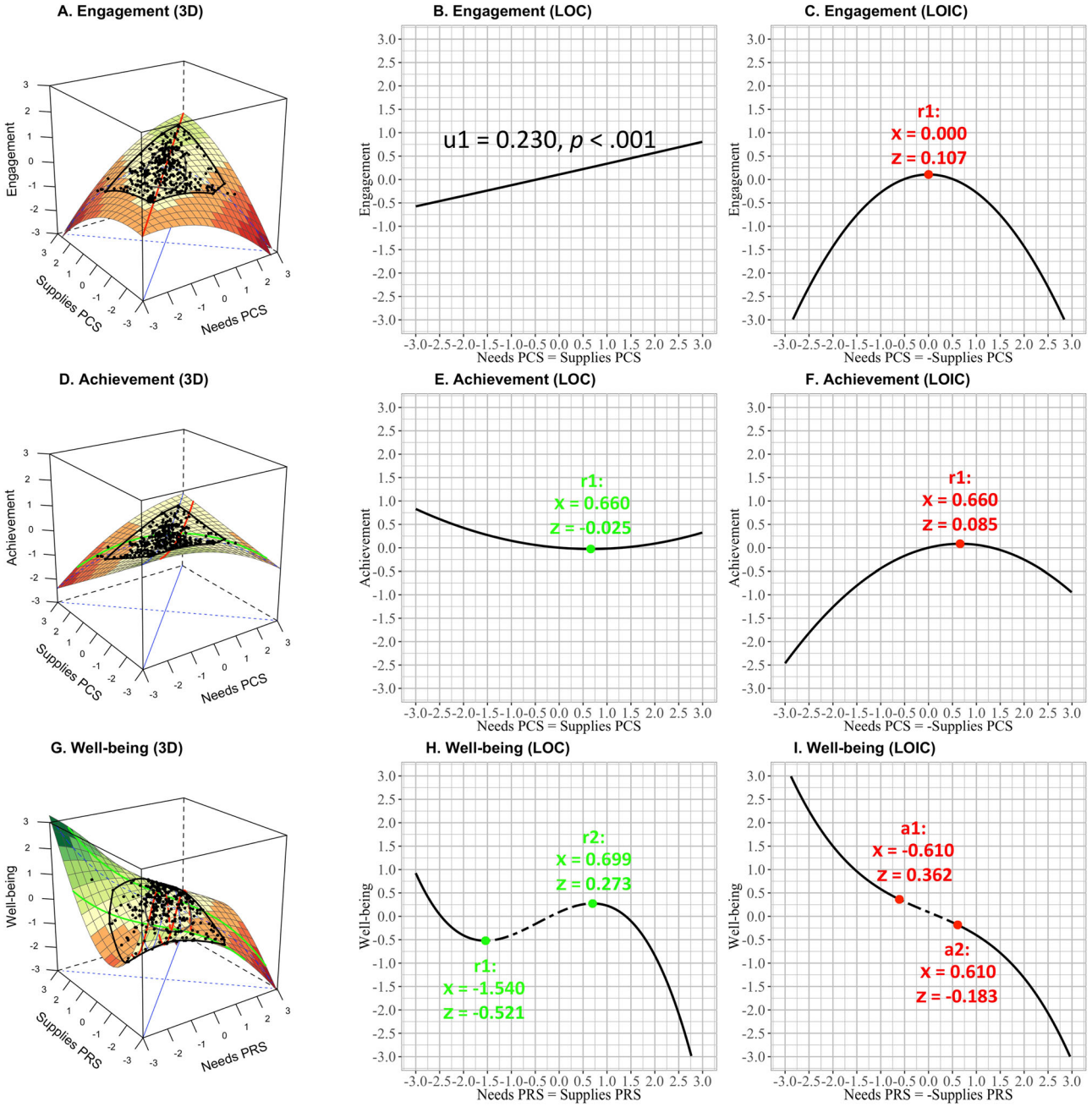

Fig. 4 Response Surfaces for Needs-Supplies Fit in Parental Competence Support (Engagement, Achievement) and Peer Relatedness Support (Well-Being). Note. $N = 389$ secondary school students. PCS parental competence support, PRS peer relatedness support, LOC Line of congruence, LOIC Line of incongruence. For each outcome, the response surface is reported along the three dimensions (column **1**), along the LOC (column **2**), and along the LOIC (column **3**). The metaparameter $u_1 = b_1 + b_2$ defines the slopes of the LOC. Lines in green and red intersect reversal ("r") or acceleration points ("a") on the LOC and LOIC, respectively. Other needs-supplies processes either negligible (i.e., $R2 \leq 2\%$) or not dependent on needs levels are reported in the Supplemental Material B

Interpretation of response surface

The response surface of well-being showed needs-supplies fit and misfit processes mostly compatible with expectations from H11 and H12. For most of the range of values, N-S fit in peer relatedness support had a positive effect on well-being, with high (low) levels of equivalent needs and supplies being associated with increased (decreased) well-being levels (Fig. 4H). However, this positive effect of fit reversed in valence at very low levels of needs and supplies (i.e., *needs* $PRS_{r1} = supplies\ PRS_{r1} < -1.540SD$): For these

students, low amounts of peer relatedness sufficed to sustain well-being. Conversely, the positive effect of fit became detrimental for students experiencing moderately high levels of needs and supplies (i.e., $needs\ PRS_{r2} = \ supplies\ PRS_{r2} > 0.699SD$), indicating that well-being started decreasing when socialization with peers was perceived as very important (high needs) and very much provided for (high supplies). The non-proportionality of these nonlinearities (i.e., at very low vs. moderately high congruent values) made the process similar to H12, although reversals occurred instead of accelerations. For N-S misfit processes, the whole range of values indicated that experiencing relative excess in supplies in peer relatedness support (needs-facilitation) was associated with increased well-being, whereas the reverse was true for the relative deficit in supplies (needs-thwarting; Fig. 4I). These effects appeared to accelerate and become large for relative excess (i.e., $needs\ PRS_{r1} = -supplies\ PRS_{r1} < -0.610,\ \Delta(S-N) = 0.610 * 2 = 1.220SD$) or relative deficit in supplies (i.e., $needs\ PRS_{r2} = \ -supplies\ PRS_{r2} > 0.610,\ \ \Delta(S-N) = -0.610 * 2 = -1.220SD$). Due to an absence of quadratic effects, the cubic process was proportional, bearing close correspondence to H11.

Discussion

Extant research in SDT has demonstrated that experiencing positive social relationships within the family and at school is beneficial to youth development and that this is due to the satisfaction of students' basic needs for autonomy, competence, and relatedness. Extending SDT's framework, the present study introduced the notion that the appropriate amount of support to foster youth development depends on each student's psychological functioning and, in particular, on their unique levels of support needs. Through innovative measures of supplies and needs in social support across three social agents (i.e., teachers, parents, peers), this study revealed that student differences in the level of needs significantly influence how supplies in social support relate to key outcomes such as classroom engagement, academic achievement, and subjective well-being. This discovery holds significant implications for guiding educators in providing strategic levels of support, but also for fundamental propositions relating to the theory of basic psychological needs in SDT and the modeling of person-environment fit processes at school.

Summary of Findings

The first contribution of this study was to provide evidence that individual variations in the needs for social support (e.g., in teacher autonomy support) modify how the amount of supplies in such support relates to important youth outcomes (RQ1). This was demonstrated across all kinds of social support examined (i.e., teacher autonomy support, parental competence support, peer relatedness support) by the fact that the prediction of outcomes increased substantially after including the effects of needs in the predictive model (by 122% on average, or 182% on median; see Table 5), and by the fact that the response surfaces showed clear nonlinearities that underscored the importance of considering the combined levels of needs and supplies (see next paragraph), as opposed to single level of supplies—as is usually assumed in SDT research. The finding that levels of needs matter for understanding needs-supportive contexts aligns with preliminary evidence showing that needs-supplies fit in teacher autonomy support also influences students' feelings of autonomy and competence (Núñez-Regueiro, Juhel, et al., 2024), and extends this evidence to new youth outcomes and new social ecologies (i.e., relationships with parents, peers). Exceptions to this finding were nevertheless observed for 3 out of 9 models of needs-supplies fit processes, for which only the main or quadratic effect of supplies was observed (i.e., N-S fit in parental or peer support for well-being and achievement, respectively), or for which the explanatory power of needs-supplies fit processes was trivial (i.e., N-S fit in peer support for achievement). More research is needed to explore whether needs-supplies fit processes are specific to certain combinations of youth outcomes and kinds of social support (as the present findings suggest), or whether larger samples are needed to uncover these specific—and perhaps more "noisy"— needs-supplies fit processes.

A second major finding of this study concerned the way needs and supplies combined to predict youth engagement in class, academic achievement, and subjective well-being (RQ2). As expected from H9 through H12, the majority of processes investigated showed that when adolescents experienced high needs and high supplies (positive fit), or a relative excess in supplies (positive misfit), they also experienced more positive youth outcomes (for 10 out of 12 needs-supplies fit and misfit processes identified). Conversely, experiencing low levels of needs and supplies (negative fit), or relative deficits in supplies (negative misfit), was associated with more negative youth outcomes (for 11 out of 12 processes). Nonetheless, some exceptions to these general trends were also found depending on the range of needs-supplies values or on the specific process considered. For example, for all processes relative to teacher autonomy support and one process relative to peer relatedness support (i.e., well-being), the positive effect of needs-supplies fit reversed in valence at very high levels of needs and supplies. This could indicate that an excessive degree of needs might be detrimental to adjustment, even if the adolescent is provided with "fitting" high amounts of supplies. An opposite reversal effect was observed for

students reporting very low amounts of needs and supplies, who experienced higher-than-expected adjustment levels. Future research might investigate further why such profiles of students deviate from general trends in needs-supplies fit processes, which have also been observed in relation to needs satisfaction processes (Núñez-Regueiro, Juhel, et al., 2024). Another exception to general trends concerned processes relative to parental competence support, for which positive needs-supplies misfit (excess supplies relative to needs) appeared to have detrimental effects on engagement and achievement. This finding may reflect the fact that, during adolescence, youth tend to experience declines in their receptiveness to parental socialization processes (including monitoring of learning activities), notably to spend more time exploring relationships with peers (Smetana et al., 2015). The findings that positive misfit in parental support is negatively related to school engagement and achievement could indicate that adolescents appreciate receiving the right amount of parental support to meet their needs with school activities (positive needs-supplies fit), but that any surplus might be experienced as invasive and as contradicting their search for autonomy and individuation.

A third noteworthy contribution was the finding that needs-supplies fit processes with teachers was a strong determinant of both youth engagement in class (12% explained variance) and their subjective well-being (5%), Conversely, processes involving peers and parents mostly determined youth well-being (12%) and engagement (7%), respectively, but were less evident for other outcomes (2–3%). Overall, this pattern of findings aligns with research indicating that teacher and parental support (but not peer support) are essential to adolescents' engaging with learning activities (Furrer & Skinner, 2003; Wang & Eccles, 2012), and that both peer and teacher support are necessary to experience positive mental health at school (i.e., interdependencies of basic needs satisfaction in peer and teacher relatedness; Núñez-Regueiro & Wang, 2024). The fact that teacher autonomy support plays such a crucial role in youth learning and development was underlined before (Ryan & Deci, 2020; Slemp et al., 2024), but becomes even more explicit in the present investigation by the identification of previously unknown mechanisms associated with teacher needs-supportive (positive needs-supplies fit) and needs-facilitating behavior (positive needs-supplies misfit).

Limitations and Future Directions

The present findings innovated by the use of new measurements (i.e., needs-supplies scales) and modeling methods (i.e., cubic RSA) to identify needs-supportive contexts and their effects on youth outcomes. As with any innovation, further research is necessary to validate the robustness of these findings on needs-supplies fit processes to other national contexts (e.g., in a multisite study), other age groups (e.g., among elementary school or college students), or alternative needs-supplies scales. For instance, although our study focused on 3 dimensions of social ecologies (i.e., teacher autonomy support, parental competence support, peer relatedness support), there are at least 9 potential dimensions (3 sources of social support*3 basic psychological needs). The focus on these 3 dimensions was based on two reasons. First, including all 9 dimensions would have resulted in an overly long questionnaire, thereby increasing the risk of poor quality data due to respondents' fatigue (satisficing behavior, lack of attention, missing data; Galesic & Bosnjak, 2009). Second, preliminary research has shown that the needs for autonomy, competence, and relatedness were most influenced in terms of explained variance, respectively, by the teachers, the family context, and the group of peers (Fraina et al., 2020). Therefore, the three dimensions retained in the present study were coherent with the most notable linkages between the type of need and the type of social support. Nonetheless, exploring alternative dimensions of social ecologies could unveil new insights into needs-supplies fit processes (e.g., needs-supplies scales in teacher relatedness support or teacher competence support), and provide a more complete exploration of needs satisfaction processes in SDT.

Another limitation concerns the cross-sectional design of the study, which limited the analysis to interindividual variations in needs-supplies fit processes and youth outcomes, without informing on intraindividual processes of change. Future studies might consider using longitudinal designs to uncover longitudinal relations between needs, supplies, and youth outcomes. In doing so, multiple waves of data (i.e., at least 3 waves of data) would be necessary to formally disaggregate inter- and intraindividual processes of change using "detrending" techniques, such as random-intercept cross-lagged panel models or growth curve models (Hamaker et al., 2015; Núñez-Regueiro et al., 2019, 2021). One limitation of these techniques is their lack of integration with cubic RSA. As such, nonlinearities in needs-supplies fit processes as those uncovered in this research are currently unavailable for longitudinal settings. A compromising solution would be using two-wave data designs (e.g., needs-supplies fit predictors on T1, youth outcomes on T2), but such designs are vulnerable to statistical artifacts due to the conflation of inter- and intraindividual processes of change (Hamaker et al., 2015; Núñez-Regueiro et al., 2021; Núñez-Regueiro, Fayol, et al., 2024). Methodological developments are still needed to enable synergies between RSA and detrending techniques in analyses of needs-supplies fit among youth.

Finally, the data for the study was self-reported by adolescents. Self-reported data can be problematic to the extent that respondents lack accuracy about their own perceptions, being influenced by their desire to be consistent or to look fair

in the eyes of external evaluators (Paulhus & Vazire, 2007). Although studies have shown that reports from students and from educators (parents, teachers) usually correlate highly in relation to diverse processes such as youth stress (Wagner et al., 1988) or behavioral engagement with school activities (Wang et al., 2016), it is possible that the results could have differed using alternative measurement methods. Complementary research assessing the convergent validity of the present study with alternative measures of needs-supplies fit processes (e.g., parental or teacher reports) and youth outcomes would be valuable in this regard.

Implications for Educational Practice

This study informs on the mechanisms by which socialization processes in both school and home environments can be effective in supporting youth development. It reveals that the effectiveness varies depending on the source of social support and, importantly, on the youth considered as well. Although caution is warranted in taking the present results to practice (see Limitations), a number of implications can be drawn. For teachers, supplies in autonomy support should preferably exceed the levels of needs required of the students: Needs facilitation was indeed always associated with positive academic and well-being outcomes, whereas simply "fitting" amounts (positive fit) was not always optimal at high levels of needs. However, in school contexts where teachers face multiple demands, the provision of support should be done strategically. This implies informing teachers on student needs for autonomy support, to better tailor their interventions in class. For example, some intervention programs (e.g., Check and Connect) provide students with a mentor to help them monitor their progress and difficulties at school (Janosz et al., 2019). A similar approach could be implemented to assess individual differences in student needs by a mentor, who could then inform teachers about their students' needs.

On the contrary, for parents, excessive supplies in competence support appear to be detrimental to student engagement and learning, and hence it is not recommended based on the present findings. Instead, fitting amounts of supplies—or even a slight deficit in supplies—may contribute positively to engagement in class and achievement for students with strong needs for such support. The fact that excessive supplies of competence support was negatively related to engagement or achievement is certainly counterintuitive, although it aligns with research underscoring the complexity of youth-parent relationships during adolescence as both a source of conflict and outgrowth (Núñez-Regueiro & Núñez-Regueiro, 2021; Smetana et al., 2015). It is possible that this counterintuitive finding reflects a reverse causality, whereby excessive support is actually an effect (rather than a cause) of decreased levels of engagement or achievement. Future research could clarify this point by using longitudinal designs and appropriate techniques to identify causal ordering between needs-supplies fit processes with parental support (Núñez-Regueiro et al., 2021).

Concerning peers, being popular and receiving peer-relatedness support in excess may support subjective well-being, but may undermine levels of engagement in class. As argued before (Furrer & Marchand, 2022; Núñez-Regueiro & Wang, 2024), situations of excess peer relatedness may undermine engagement levels by concentrating socialization processes at the expense of other social agents (e.g., teachers, parents). This viewpoint also suggests that subjective well-being cannot be taken as a unique indicator of optimal development, as this would hide situations of academic dysfunction. Educators in the school or community contexts are therefore encouraged to analyze youth outcomes in combination, rather than in isolation. Moreover, it is recommended that educators rely on SDT's needs-supplies fit processes as an explanatory framework for interpreting socialization processes at school, given that monitoring needs and supplies across multiple social agents (i.e., teachers, parents, peers) may help offset imbalances in the sources of social support. Systemic interventions across diverse social ecologies have been shown to improve academic and developmental outcomes (e.g., Henggeler, 2011; Janosz et al., 2019).

Implications for Self-Determination Theory

The present research shows that needs-supplies fit processes matter for understanding the psychological functioning of students in relation to important youth outcomes (engagement in class, academic achievement, subjective well-being). Specifically, situations of needs-satisfaction (positive fit or misfit) and needs-frustration (negative fit or misfit) are best characterized as a function of the interplay between needs and supplies (as proposed in this study; Fig. 1B), as opposed to being only related to the level of supplies (as currently assumed in SDT; Fig. 1A). The present findings demonstrate indeed that such needs-satisfaction and needs-frustration processes are positively and negatively related to psychological functioning, as assumed by SDT's basic needs theory (Proposition 1a). Moreover, because the patterns observed for needs-supplies fit and misfit relative to teacher autonomy support strongly matched those observed with processes of needs satisfaction (for details, see Núñez-Regueiro, Juhel, et al., 2024), it could be argued that needs satisfaction mediates the processes between needs-supplies fit in teacher autonomy support and youth outcomes, as also assumed by SDT. In light of these new findings and their coherence with SDT's conceptualization of basic psychological needs and needs-supportive contexts, we propose a complement to the aforementioned tenants of SDT to highlight the fact that variations in needs satisfaction or frustration are dependent not only on the levels of supplies, but also on the

Table 6 Saturated Cubic Polynomial Models

Variable	Teacher Autonomy Support			Parental Competence Support			Peer Relatedness Support		
	ENG	ACH	WELL	ENG	ACH	WELL	ENG	ACH	WELL
Needs (b_1)	0.210*	0.247*	0.254**	−0.016	0.020	0.054	0.201*	0.094	−0.030
Supplies (b_2)	0.241*	−0.117	0.237†	0.083	−0.302*	0.329***	−0.132	−0.144	0.569***
Needs^2 (b_3)	−0.013	−0.151*	−0.056	−0.110†	−0.006	−0.048	−0.105	−0.082	−0.038
Needs*Supplies (b_4)	−0.124†	−0.097	−0.007	0.192**	0.097	0.035	0.156	0.000	−0.079
Supplies^2 (b_5)	0.012	0.093†	0.031	−0.052	−0.085	0.032	0.004	−0.146†	−0.021
Needs^3 (b_6)	−0.020	−0.034	−0.020	0.033	−0.029	0.014	−0.041	−0.040	0.026
Needs^2*Supplies (b_7)	−0.047	0.035	0.013	0.045	0.059	0.003	0.066	0.067	−0.027
Needs*Supplies^2 (b_8)	−0.010	−0.164***	−0.095*	0.023	0.081	−0.007	−0.038	−0.032	−0.091
Supplies^3 (b_9)	0.058	0.056	−0.041	−0.022	0.013	−0.085†	0.012	0.032	−0.083

Saturated cubic models do not specify any constraints on model parameters (freely estimated parameters), making the process unidentified and also overlooking significant effects. Saturated quadratic polynomials (not shown) are even more limited by their assumption of null third-order polynomials (i.e., b_6 to b_9 are fixed to zero). On the contrary, best-fitting quadratic or cubic polynomial families (with parametric constraints) test for specific processes and reveal meaningful significant effects (see Table 4)

†$p < 0.10$. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$

levels of individual needs that determine which amount of supplies is optimal for youth development, as follows:

> *"BPNT Proposition Ib* ***(complemented):*** *Psychological need satisfactions and frustrations vary within persons over time, contexts, and social interactions. Any factor or event that produces variations in need satisfaction or need frustration will also produce variations in wellness, and this principle extends from highly aggregated levels of analysis down to moment-to-moment or situation-to-situation variations in functioning.* ***The amount of variation produced will depend on the level of individual needs, modifying how the individual is affected by supplies provided across contexts****."*

Complementary research is needed to test further the validity of this theoretical complement and to shed light on the determinants of individual differences in needs for social support among youth. In this research agenda, we underscore the importance of adopting a comparative framework for response surface analysis in which predefined families of polynomials are tested. As shown elsewhere (Núñez-Regueiro, Juhel, et al., 2024; Núñez-Regueiro & Juhel, 2024b) and in this study (see Table 6), saturated (undefined) polynomial models overlook the existence of needs-supplies fit processes and their non-linearities, even when these are evidenced in the empirical data once an appropriate polynomial family is identified (see Table 4). Future studies are urged to adopt a similar comparative framework to replicate or identify new N-S fit processes in youth development (Núñez-Regueiro & Juhel, 2022, 2024b).

Conclusion

Research has shown that experiencing positive socialization processes is key to youth adaptation and well-being, as this contributes to satisfying their basic psychological needs for autonomy, competence, and relatedness. Conversely, adolescents receiving smaller amounts of needs-supportive behavior appeared more exposed to negative outcomes. The present study showed that these relations are actually more complex than previously thought and that they depend on the level of needs unique to each adolescent: While some youth require elevated levels of support to feel happy, engage in school activities, and succeed, others may be satisfied by much lower levels of support. In addition, experiencing excessive levels of competence support, particularly from parents, may have detrimental effects on youth adaptation, whereas excessive levels of autonomy support from teachers appear optimal. In summary, acknowledging individual differences in needs for support, as well as identifying specific needs-supplies fit relating to each kind of relationship (peers, parents, teachers) can provide valuable information for educators working with youth. Further research is needed to consolidate these findings and characterize needs-supportive contexts more completely.

Data Availability

The data and scripts used during the current study are available in the Open Science Framework repository, at https://osf.io/fdt9u.

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Authors' Contributions FNR conceived the study, conducted the data collection and analyses, coordinated the project, and drafted the manuscript; ESM participated in the literature review, to the interpretation of the data, and helped to draft the manuscript; JJ participated in the design of the study and to the data analyses, and helped to draft the manuscript. All authors read and approved the final manuscript.

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Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Ethical Approval The study was performed in accordance with the ethical standards of the journal. The study protocol was exempted from ethics committee approval because it was conducted as part of the training in teacher education (i.e., research practice).

Informed Consent Informed consent was obtained from all participants of the study. Data confidentiality was preserved through anonymous data collection.

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