

Trajectories in cognitive engagement, fatigue, and school achievement: The role of young adolescents' psychological need satisfaction

Stephen R. Earl^{a,*}, Ian M. Taylor^b, Carla Meijen^c, Louis Passfield^d

^a University of Lincoln, United Kingdom

^b Loughborough University, United Kingdom

^c St Mary's University, United Kingdom

^d University of Calgary, Canada

ARTICLE INFO

Keywords:

Psychological need satisfaction
Cognitive engagement
Cognitive fatigue
Academic attainment
Self-determination theory

ABSTRACT

The study investigates whether between-person differences in school-based psychological need satisfaction may explain trajectories in cognitive engagement, fatigue, and academic attainment over a school year. A sample of 361 young adolescents in the United Kingdom (mean age = 11.89 years; 55 % male, 45 % female) completed self-report measures of psychological need satisfaction, cognitive engagement, and cognitive fatigue on four occasions. Official school grades for English and Maths were collected. Hierarchical growth modelling revealed that pupils higher in psychological need satisfaction reported stable levels of cognitive engagement and lower fatigue. Pupils lower in psychological need satisfaction displayed declining levels of cognitive engagement and consistently higher fatigue. All pupils showed increases in school grades, yet higher psychological need satisfaction was related to greater gains. These trends existed when controlling for age, sex, ethnicity, and learning needs. The findings offer temporal insights into the role of school-based psychological needs in fostering cognitive engagement at school.

1. Introduction

A key objective for schools is to ensure that young adolescents achieve high academic grades within core subjects such as English and Mathematics (Department of Education, 2015). Against this backdrop, however, there are growing concerns regarding the downside associated with an exclusive focus on academic attainment. Namely, it may lead to an over-reliance on prescribed academic targets at the expense of engagement with learning (Mostafa, 2017). Pupils who become overly focused on school grades often display more deleterious experiences, such as psychological burnout, fatigue, and emotional ill-being (Paloş et al., 2019; Tuominen-Soini et al., 2012). Consequently, endeavours within teaching have shifted towards promoting characteristics of engagement, such as pupils' cognitive effort, willingness to explore topics, and intentions to transfer knowledge between different subjects (Frey et al., 2017; Schnitzler et al., 2021). Such efforts have coincided with greater attempts to nurture pupils' intrinsic motivation to help foster better learning mastery and engagement (Froiland & Worrell, 2016). Aligned with this aim, the present longitudinal study investigates whether the satisfaction of pupils' basic psychological needs may explain

trajectories in their cognitive engagement, cognitive fatigue, and academic attainment over a school year.

Engagement is defined broadly as a cognitive-affective state which is underpinned by a positive, fulfilling, and study-related state of mind (Upadaya & Salmela-Aro, 2013). High engagement at school has often been related with a multitude of personal and academic benefits (Li & Lerner, 2011; Widlund et al., 2021). More nuanced interpretations, however, signify engagement as a multidimensional construct, comprising of cognitive, affective, and behavioral components (Fredricks et al., 2004). Whilst the latter two relate to learners' enjoyment and persistence at school, respectively, it is cognitive engagement that is particularly synonymous with pupils' psychological approach to learning (Appleton et al., 2006). Specifically, cognitive engagement denotes a self-regulated learning approach whereby an individual will have an active intention to study and adopt different strategies to elaborate, organise, and memorise material (Appleton et al., 2008; Zimmerman & Schunk, 2011). That is, it reflects the extent to which one is thinking and attending to learning (Ben-Eliyahu et al., 2018). Pupils who are cognitively engaged will have a dedicated attitude towards learning, display committed investment to studying, be intrinsically

* Corresponding author at: School of Psychology, University of Lincoln, Brayford Pool, Lincoln, England LN6 7TS, United Kingdom.

E-mail address: SEarl@lincoln.ac.uk (S.R. Earl).

motivated, and develop flexibility in their use of knowledge (Blumenfeld, Kempler, & Krajcik, 2006; Fredricks & McColskey, 2012; Li & Lajoie, 2022). As such, cognitive engagement signifies pupils who are actively absorbed in the learning process.

Cognitive engagement has received particular interest within college-level education, being associated with positive correlates such as better academic adjustment (van Rooij et al., 2017), self-efficacy (Papinczak et al., 2008), help seeking behaviors (Leenknecht et al., 2019), and higher academic performance (Salamonson et al., 2013). Such relations are likely linked with self-regulated motivation and deeper processing of information (Platow et al., 2013). Similarly, cognitive engagement has been associated with higher academic attainment within adolescent schooling (Pietarinen et al., 2014), although longitudinal investigations of adolescents' cognitive engagement are somewhat scarce. Nonetheless, hallmarks of cognitive engagement such as self-regulated learning (Wang & Eccles, 2012) and intrinsic motivation (Gillet et al., 2012) have been found to decline during the early years of secondary school. Thus, gaining insights into potential antecedents and trajectories of adolescents' cognitive engagement may be of substantive value to educators by identifying ways to foster higher quality learning engagement.

A framework that provides particular insights into the development of personal agency and self-regulation is self-determination theory (SDT; Ryan & Deci, 2017). A core tenet of SDT is that the fulfilment of the innate psychological needs for autonomy, competence, and relatedness is fundamental for one's psychological integration and personal wellness (Vansteenkiste et al., 2018). More than just beneficial experiences, these three needs represent essential ingredients which underly optimal psychological development and functioning across all life domains (Chen et al., 2015). The need for autonomy reflects the feeling of volition and psychological freedom, whereby behaviour emanates from a sense of personal ownership and relevance (de Charms, 1968). Competence signifies the experience of feeling effective and capable of achieving desired goals (White, 1959), and relatedness denotes the need to feel connected and supported by others through close interpersonal relationships (Baumeister & Leary, 1995). It is through the satisfaction of these basic needs that individuals will be able to act authentically, explore intrinsic tendencies, master challenges, and fully absorb themselves in their environment (Ryan & Deci, 2016).

Within adolescent education, the notion of basic psychological needs has received considerable attention in relation to characteristics pertinent to personal and academic growth (Guay, 2022; Howard et al., 2021). Pupils' psychological need satisfaction has been positively associated with various developmental outcomes such as subjective well-being (e.g., Tian et al., 2014), enjoyment (Huhtiniemi et al., 2019), optimism (Carmona-Halty et al., 2019), and prosocial behaviour (Alivernini et al., 2021). From an academic perspective, psychological need fulfilment has also been linked with heightened autonomous school motivation (Bureau et al., 2021), greater help-seeking (Marchand & Skinner, 2007), and academic engagement (Buzzai et al., 2021). Such associations have been found consistent when accounting for different cultures and school subjects (Erturan-İlker et al., 2018), and typically result in higher academic attainment. This has been demonstrated in cross-sectional (Ahn et al., 2021), semester long (Jang et al., 2012), and multi-year studies (Wang et al., 2019b). In short, pupils high in psychological need satisfaction will be better able to self-regulate their own engagement and adjust to the social and academic demands of school (Charlot Colomès et al., 2021; Ratelle & Duchesne, 2014; Vandenberg et al., 2019).

Expanding upon the evidence above, it seems plausible that psychological need satisfaction may facilitate greater cognitive engagement. At a university level, positive relationships have been observed between student's psychological need satisfaction and deep learning (Orsini, Binnie, & Tricio, 2018), knowledge transfer (Wang et al., 2019a), complex thinking (Doménech-Betoret & Gómez-Artiga, 2014), and metacognitive strategies (Makarova, 2021). Comparable findings

have also been evident when students experience autonomous learning motivation (e.g., Núñez & León, 2016; Vansteenkiste et al., 2005). For example, university students experiencing autonomous motivation were found to report higher cognitive strategies such as rehearsal, organisation, monitoring, elaboration, and critical thinking, although critical thinking was the only strategy related with enhanced academic performance (Manganelli et al., 2019).

In relation to young adolescents, school-based psychological need satisfaction has been found to foster greater learning engagement, specifically in relation to cognitions (i.e., information processing, critical thinking) and agency (i.e., active participation in one's own learning; Cohen et al., 2020; Jang et al., 2016; Zhen et al., 2017). Specifically, psychological need satisfaction has been found to coincide with higher mastery orientations and often leads to greater efforts to conceptually understand information (Duchesne et al., 2017; also see Liem et al., 2008). Moreover, pupils reporting higher need satisfaction have been shown to display more effective cognitive strategies, such as better concentration, time management, and information processing, due to greater feelings of autonomous motivation and perceived competence (Ulstad et al., 2016). Building on this evidence, exploring the temporal relationship between young adolescents' psychological need satisfaction and cognitive engagement may help identify pupils who are at risk of cognitively detaching at school.

An additional barrier to cognitive engagement, and overall learning, is cognitive fatigue. Cognitive fatigue reflects a non-specific state of reduced vitality which is particularly prevalent in young adolescents at the start of secondary school as they deal with new educational and social demands (Ter Wolbeek et al., 2006). The experience of cognitive fatigue is detrimental to functions such as working memory, attentional focus, and the ability to regulate off-task thoughts (e.g., Mizuno et al., 2011; Nijhof et al., 2016). Furthermore, higher levels of cognitive fatigue are often associated with poorer learning and academic performance (Knight et al., 2018; Sievertsen et al., 2016). Whilst cognitive fatigue can arise from physical factors (e.g., sleep deprivation), it is also commonly associated with psychological struggle and poor motivational regulation (Hockey, 2011). Symptoms of mental fatigue stemming from maladaptive psychological experiences may be difficult to explicitly observe, and thus uncovering psychological determinants of these experiences may be helpful to educators.

The fulfilment of adolescents' psychological needs may help lessen their development of cognitive fatigue given it is concomitant with several energising outcomes, such as positive affect and vitality (Chen et al., 2015; Liu et al., 2017). Experimental findings have indicated that nurturing autonomous experiences in adolescents can help reduce cognitive load and enhance their retention of information (Schneider et al., 2018). Learners with low psychological need satisfaction, on the other hand, have been found to experience more deleterious cognitive consequences, such as burnout (Bartholomew et al., 2011), psychological distress (Gilbert et al., 2021), and feelings of pressure within the classroom (Wang et al., 2019c). These deenergising effects may manifest due to continual overregulation of negative thoughts, worries over failure, or desires to bolster self-worth (see Bartholomew et al., 2018). Furthermore, feelings of fatigue and diminished vitality may lead to passive classroom disengagement, reduced study efforts, and apathy towards learning (e.g., Earl et al., 2017; Mouratidis et al., 2011). Exploring differences in psychological need satisfaction at school may, therefore, help yield new understanding as to why certain pupils develop higher levels of cognitive fatigue compared to others.

1.1. The present research

The aim of the present study was to examine whether differences in pupils' general psychological need satisfaction at school were associated with different rates of change in their cognitive engagement, cognitive fatigue, and school grades (i.e., English and Mathematics). Pupils in the initial years of secondary school were the particular focus (e.g., children

aged 11–14 years in the United Kingdom) as this represents a key period in which learning and academic engagement can be at risk of decline (Poorthuis et al., 2015; Riglin et al., 2013). Furthermore, young adolescents' learning, and academic development, are dynamic. Thus, exploring developmental patterns in these variables over time may offer richer insights into pupils' cognitive and academic adjustment. Equally, investigating positive changes in engagement and academic attainment is important for teachers to help them facilitate these processes in their pupils (Moilanen et al., 2010; Wang et al., 2015).

In the first instance, we sought to clarify the rates of change in cognitive engagement, cognitive fatigue, and academic attainment over an academic year. We then constructed multilevel models to explore whether interpersonal differences in pupils' psychological need satisfaction explained intrapersonal changes in their cognitive engagement, cognitive fatigue, and academic attainment (for comparable multilevel approaches see Birkeland et al., 2012; Taylor et al., 2010). In accord with previous studies (e.g., Tian et al., 2016), school-based psychological need satisfaction was measured at a general-school level, rather than classroom level, to assess how pupils' wider school experiences may relate to general change in their engagement and attainment. Inferring from the evidence described earlier, it was hypothesised that higher reports of psychological need satisfaction would explain linear increases in cognitive engagement and school grades, along with linear decreases in cognitive fatigue, over the school year.

2. Materials and methods

2.1. Participants

The study included 361 adolescents (199 male; 162 female) from a state-funded school in the United Kingdom (mean age = 11.89 years, $SD = 0.94$ years, range = 11–14 years). All pupils were in secondary school (6th Grade, $n = 164$; 7th Grade, $n = 122$; 8th Grade, $n = 75$), and recruited from 11 different classes which were differentiated on academic ability (mean size = 33 pupils). Approximately a third of the pupils were disclosed as having a form of special educational need ($n = 116$). Many of these educational needs were specific behavioral or learning requirements identified by the school ($n = 75$), whilst others were specialised diagnoses, such as dyslexia or dyspraxia ($n = 19$), Autistic Spectrum Disorder ($n = 9$), and physical impairments (i.e., visual or hearing; $n = 13$). Pupils were White ($n = 329$), Asian ($n = 14$), Black Caribbean/Black African ($n = 16$) or Arabic ($n = 2$), with 5 % of pupils registered as not having English as their native language.

2.2. Procedure

Ethical approval was obtained from the ethics committee at the principal researcher's university. Consent for pupils to take part in the study was provided by the school at an institutional level with parental opt-out forms provided to enable parents to indicate if they did not wish for their child to participate. From the initial recruitment, four parents opted for their child not to participate which resulted in the final sample of 361 pupils. Pupils were provided with verbal and written details of the study and provided written assent to confirm their willingness to participate. Pupils were instructed that they did not have to complete the questionnaire, or any specific questions, if they did not wish to. The questionnaire was administered by the principal researcher at the beginning of a general tutor session, rather than specific subject lesson, and collected on completion. This was to encourage pupils to respond in relation to their general school experiences, rather than a distinct class or specific teacher. The questionnaire took approximately 10 min to complete. Data collection was conducted at four separate timepoints across the school year. The first data collection was conducted in the third week of the academic year and the subsequent data collections were conducted at the end of each academic term (i.e., Fall, Spring, and Summer).

2.3. Measures

2.3.1. Basic psychological need satisfaction

Fifteen items were used to tap into pupils' general experience of autonomy, competence, and relatedness satisfaction at school. These items were preceded by the stem "When at school ..." and were responded to on a 7-point scale, ranging from 1 (*not at all true*) to 7 (*very true*). Autonomy was measured using five items (e.g., "I feel that I do school lessons because I want to", "I feel a certain freedom in choosing what I do"). These items were taken from previous research within adolescent education, whereby they demonstrated acceptable factorial structure and internal consistency ($\alpha = 0.81$; Standage et al., 2003). Confirmatory factor analysis in the present study revealed these items loaded appropriately together at each timepoint¹ (all loadings ≥ 0.62). Competence was assessed using the five item Perceived Competence subscale of the Intrinsic Motivation Inventory (McCauley et al., 1989), which was adapted to a broad school context (e.g., "I think I am pretty good at school activities"). These items previously demonstrated good internal consistency ($\alpha = 0.84$; McCauley et al., 1989), and demonstrated acceptable factor loadings across every time point in the present study (all loadings ≥ 0.48). Relatedness was measured using the five item Acceptance subscale of the Need for Relatedness Scale (Richer & Vallerand, 1998; e.g. "I feel listened to", "I feel supported"). These items demonstrated good internal consistency in the original work ($\alpha = 0.85$ – 0.94) and demonstrated acceptable factor loadings throughout the present study (all loadings ≥ 0.68). Collectively, the 15 items were collated to create an overall indicator of psychological need satisfaction which demonstrated high composite reliability throughout the study ($\rho_c \geq 0.88$, see Table 1).

2.3.2. Cognitive engagement

Pupils' cognitive engagement for learning was measured using six items from the deep approach scale of the Learning Process Questionnaire (LPQ-R-2F; Kember et al., 2004), and have been specifically used in secondary schools (Phan & Deo, 2007). These items tapped into pupils' interest taking (e.g., "I work hard at my studies because I find the material interesting") and cognitive commitment (e.g., "I like to do enough work on a topic so that I can form my own conclusions before I am satisfied"), as well as cognitive strategies to relate ideas (e.g., "I try to link what I have learned in one subject to what I learn in other subjects") and conceptually understand material ("I try to link new material, as I am reading it, to what I already know on that topic"). Pupils rated each item on a 5-point scale which ranged from 1 (*almost never*) to 5 (*almost always*). Confirmatory factor analysis revealed that these items loaded appropriately to a cognitive engagement construct at every timepoint (all loadings ranged between 0.53 and 0.78) and demonstrated high composite reliability across the study ($\rho_c \geq 0.78$, see Table 1).

2.3.3. Cognitive fatigue

Cognitive fatigue at school was measured using the Cognitive Fatigue subscale of the PedsQLTM Multidimensional Fatigue Scale (Varni & Limbers, 2008). Pupils read the stem "How tired are you generally at school" and then responded to six items (e.g., "It is hard for me to keep my attention on things", "I have trouble remembering what I was just thinking"). These items were rated on a 5-point scale which ranged from 1 (*never*) to 5 (*almost always*). Confirmatory factor analysis demonstrated appropriate factor loadings for each item throughout the study (ranging between 0.66 and 0.87), as well as high composite reliability at every timepoint ($\rho_c \geq 0.87$, see Table 1).

2.3.4. Academic attainment

Pupils' academic grades in the core subjects of English and

¹ Factor loadings of 0.40 or greater were considered acceptable based on criteria proposed by Stevens (2012).

Table 1
Descriptive statistics, composite reliability, and between-pupil variance (Intraclass Correlations Coefficients; ICC's).

| Variable | Range | Time 1 (n = 241) | | | Time 2 (n = 327) | | | Time 3 (n = 331) | | | Time 4 (n = 298) | | | ICC |
|----------------------|-------|------------------|------|----------|------------------|------|----------|------------------|------|----------|------------------|------|----------|------|
| | | M | SD | ρ_c | M | SD | ρ_c | M | SD | ρ_c | M | SD | ρ_c | |
| Psychological needs | 1–7 | 4.49 | 0.93 | 0.88 | 4.30 | 0.97 | 0.90 | 4.02 | 1.06 | 0.92 | 4.08 | 1.04 | 0.93 | 0.59 |
| Cognitive engagement | 1–5 | 3.31 | 0.61 | 0.78 | 3.16 | 0.69 | 0.84 | 3.08 | 0.75 | 0.86 | 3.12 | 0.73 | 0.86 | 0.57 |
| Cognitive fatigue | 1–5 | 2.90 | 0.89 | 0.87 | 2.89 | 0.90 | 0.91 | 2.83 | 0.89 | 0.90 | 2.87 | 0.87 | 0.91 | 0.55 |
| Academic attainment | 1–8 | 4.27 | 0.77 | – | 4.47 | 1.01 | – | 4.75 | 0.90 | – | 5.01 | 1.05 | – | 0.48 |

Note. Composite reliability could not be computed for academic attainment as this was calculated based on English and Mathematics grades from official school records.

Mathematics were obtained from official school records at every timepoint. Pupils completed initial assessments at the onset of the school year and at the end of each term based on their work throughout that term. These grades are reflective of pupils' academic performance across each distinct term, and not an incremental grade average for the entire school year at that point. Pupil attainment was based upon a numeric achievement level, ranging from a lower *Level 1* up to a higher *Level 8*. Inspection of attainment scores for English and Mathematics revealed they were moderately and positively correlated at every timepoint across the study (r values ranged between 0.48 and 0.59; $p < .001$). Thus, an overall attainment score was calculated at each timepoint by averaging these scores. The use of a composite score offered a better objective overview of pupils' general academic attainment as opposed to examining differences in subject-specific grades.

2.4. Data analysis

Multilevel modelling techniques were employed, using to MLwiN software (Version 3.05; Rasbash et al., 2020), to explore whether differences in psychological need satisfaction may explain changes in cognitive engagement, cognitive fatigue, and academic attainment. A three-tiered structure was accounted for in the models as the repeated measures at Level 1 (i.e., time varying) were nested within each pupil at Level 2 (i.e., time invariant) who were nested within separate classes at Level 3 (Curran & Bauer, 2011). To identify the proportional amount of variance accountable at each level of analysis, intraclass correlation coefficients (ICCs) were calculated from intercept-only models for all study variables (i.e., no predictor variables; Hox, 2010).

Unconditional growth models were first constructed to describe linear change over the school year in psychological need satisfaction, cognitive engagement, cognitive fatigue, and academic attainment. This was achieved by using a 'time' variable which was centred on the first time point (i.e., Time 1 equated to zero). Thus, the intercept of these growth models was interpreted as pupils' scores at the beginning of the study, with the slope coefficient signifying any linear change over the study. The slope coefficients were entered as fixed (i.e., the rate of change is consistent across pupils) and random effects (i.e., the rate of change may differ between pupils) and compared to obtain the better model fit.

Three conditional growth models were then constructed to test the extent that between-person differences in psychological need satisfaction explained trajectories in cognitive engagement, cognitive fatigue, and academic attainment. Building on the unconditional growth models, pupils' psychological need satisfaction scores at each time point were converted to standardised z -scores and averaged across time before being added to the models. This variable was grand mean centred so they were comparable against the overall sample mean (Enders & Tofghi, 2007). Thus, each model indicated whether pupil-differences in psychological need satisfaction at Level 2 were associated with intra-personal change in each outcome at the lower Level 1 (Raudenbush & Bryk, 2002). As the first timepoint was centred at zero, the main effects could be interpreted as the extent that pupil differences in psychological need satisfaction explained each outcome at the start of the study. In addition, a psychological need satisfaction \times time interaction term was

included in each model to determine whether psychological need satisfaction predicted the development of each outcome. The emergence of significant interactions was followed up by simple slope analyses based on values of ± 1 standard deviation in psychological need satisfaction (Preacher et al., 2006).

Parametric bootstrapping was performed for all conditional growth models based on resampling the residuals with 5 sets of 300 replicates (Rasbash et al., 2020). Bootstrapped estimates, standard errors, and 95 % confidence intervals were thus provided for all model coefficients. The proportional amount of variance explained at each level was also indicated using R_1^2 (within-person), R_2^2 (between-person), and R_3^2 (classroom) statistics (Hox, 2010). Previous literature has suggested that developmental changes in adolescents' school experiences (Fan, 2011; Rogers & Tannock, 2018), cognitive fatigue (Ter Wolbeek et al., 2006), and academic attainment (Erickson et al., 2015) may vary as a function of sex, age, learning difficulties, and ethnicity. Therefore, all models were subsequently re-examined to control for these demographic factors (see Table 3).

3. Results

3.1. Completion rate at each time point

From the overall 361 pupils, the percentage providing data at each timepoint were 68 % at Time 1, 91 % at Time 2, 92 % at Time 3, and 83 % at Time 4. In total, 87 % of the sample provided data for at least three data points. Multilevel modelling techniques can account for unequal datasets, thus, pupils with missing time points were not omitted from the analysis (Raudenbush & Bryk, 2002). In general, pupils' non-participation at a given timepoint was due to absence from school during data collection, rather than a refusal to participate in the study.

3.2. Descriptive statistics

Means and standard deviations for all measurement scales at each time point are presented in Table 1. Intercept-only models revealed that between 33 % and 40 % of the variance in psychological need satisfaction, cognitive engagement, and cognitive fatigue was attributable to within-person change, whereas only 21 % of the variance in academic attainment was at this level. Alternatively, between 48 % and 59 % of the variance in each study variable was attributable to between-person differences (see Table 1 for ICCs). Minimal variance (3 %) at the classroom level was found in both psychological need satisfaction and cognitive engagement, yet 12 % of the variance in cognitive fatigue and 31 % of the variance in academic attainment was attributable to classroom differences. Bivariate correlations between the study variables at each timepoint are displayed in Table 2 for informational purposes. Preliminary inspection at the onset of the study revealed no sex-related differences in psychological need satisfaction ($M_{Females} = 4.56$, $M_{Males} = 4.42$; $t[239] = 1.16$, $p = .25$), which was consistent at every subsequent timepoint. Moreover, age was found not to correlate with psychological need satisfaction at any point in the study.

Table 2
Bivariate correlations between all study variables at each time point.

| | Time 1 | | | Time 2 | | | Time 3 | | | Time 4 | | |
|-------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 1. Psychological needs | – | | | – | | | – | | | – | | |
| 2. Cognitive engagement | 0.42** | – | | 0.51** | – | | 0.55** | – | | 0.60** | – | |
| 3. Cognitive fatigue | –0.43** | –0.28** | – | –0.37** | –0.18** | – | –0.38** | –0.31** | – | –0.45** | –0.25** | – |
| 4. Academic attainment | 0.30** | 0.06 | –0.42** | 0.12* | 0.06 | –0.30** | 0.12* | 0.09 | –0.29** | 0.04 | 0.06 | –0.31** |

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

3.3. Trajectories of change in study variables

Results of the unconditional growth models revealed that pupils' psychological need satisfaction showed a generic decrease over the school year ($b = -0.15$; $p < .001$), albeit this pattern was heterogenous across the sample (i.e., significant random effects; $\sigma^2 = 0.03$; $p = .01$). Cognitive engagement also demonstrated a linear decline over the course of the study ($b = -0.05$; $p < .001$), however this was found to be uniform across the sample ($\sigma^2 = 0.01$, $p = .23$). In contrast, cognitive fatigue showed no linear change over the study ($b = -0.01$; $p = .69$) which was consistent across the sample ($\sigma^2 = 0.01$, $p = .09$). Finally, academic attainment displayed a linear increase over the school year ($b = 0.22$; $p < .001$), although this trend varied between pupils ($\sigma^2 = 0.01$; $p = .05$).

3.4. Psychological need satisfaction explaining trajectories in cognitive engagement, cognitive fatigue, and attainment

Standardised regression coefficients and standard errors from all conditional growth models are presented in Table 3. These models tested whether between-person variability in school-based psychological need satisfaction explained cognitive engagement, cognitive fatigue, and academic attainment over the school year. In regard to cognitive engagement, pupils with high psychological need satisfaction were found to report greater levels of cognitive engagement at the start of the study compared to those low in need satisfaction. These differences were moderate in effect size based on criteria proposed by Cohen (1988). Moreover, a statistically significant psychological needs \times time interaction was found. Simple slopes analysis revealed that pupils lower in psychological need satisfaction displayed a small decline in the

Table 3
Between-person differences in psychological need satisfaction explaining variability in cognitive engagement, cognitive fatigue, and academic attainment.

| Predictors | Initial models (no covariates) | | | Models (with covariates) | | |
|-----------------------------------|--------------------------------|-------------------------------|----------------------------|--------------------------|-----------------|----------------|
| | Cog. engagement | Cog. fatigue | Attainment | Cog. engagement | Cog. fatigue | Attainment |
| | b (SE) [95 % CI] | b (SE) [95 % CI] | b (SE) [95 % CI] | b (SE) | b (SE) | b (SE) |
| Fixed effects | | | | | | |
| Intercept | 3.24*** (0.03) [3.19/3.29] | 2.90*** (0.06) [2.80/3.00] | 4.49*** (0.09) [4.34/4.64] | 3.28*** (0.28) | 3.04*** (0.50) | 5.73*** (0.41) |
| Time | –0.05*** (0.01) [–0.08/–0.03] | –0.01 (0.01) [–0.03/0.02] | 0.22*** (0.01) [0.20/0.24] | –0.05*** (0.02) | –0.00 (0.01) | 0.25*** (0.01) |
| Sex | – | – | – | 0.03 (0.05) | 0.13 (0.08) | –0.25** (0.08) |
| Age | – | – | – | –0.01 (0.01) | –0.02 (0.11) | –0.09** (0.04) |
| Special educational need | – | – | – | 0.00 (0.01) | 0.16* (0.08) | –0.16 (0.08) |
| Ethnicity | – | – | – | –0.02 (0.09) | –0.06 (0.12) | –0.05 (0.18) |
| Between-person predictors | | | | | | |
| Psychological needs: mean | 0.31*** (0.04) [0.24/0.37] | –0.37*** (0.05) [–0.46/–0.30] | 0.06 (0.06) [–0.03/0.15] | 0.31*** (0.04) | –0.37*** (0.05) | 0.05 (0.05) |
| Psychological needs \times time | 0.06*** (0.02) [0.04/0.09] | –0.04* (0.02) [–0.07/–0.01] | 0.03* (0.01) [0.01/0.04] | 0.06*** (0.02) | –0.04* (0.02) | 0.03* (0.01) |
| Random effects | | | | | | |
| Level 3 error (classroom) | 0.00 (0.00) [0.00/0.00] | 0.07* (0.04) [0.01/0.13] | 0.29** (0.09) [0.14/0.42] | 0.00 (0.00) | 0.06* (0.03) | 0.25** (0.08) |
| Level 2 error (between-person) | 0.17*** (0.02) [0.14/0.20] | 0.33*** (0.03) [0.27/0.38] | 0.49*** (0.05) [0.42/0.57] | 0.17*** (0.02) | 0.33*** (0.03) | 0.47*** (0.04) |
| Level 1 error (within-person) | 0.20*** (0.01) [0.18/0.21] | 0.27*** (0.01) [0.24/0.29] | 0.14*** (0.01) [0.13/0.15] | 0.20*** (0.01) | 0.27*** (0.01) | 0.14*** (0.01) |
| R^2_3 (level 3 variance) | 0.00 | 0.33 | 0.09 | 0.00 | 0.48 | 0.20 |
| R^2_2 (level 2 variance) | 0.44 | 0.27 | 0.05 | 0.44 | 0.27 | 0.01 |
| R^2_1 (level 1 variance) | 0.02 | 0.01 | 0.35 | 0.02 | 0.01 | 0.35 |
| –2 * log likelihood | 1913.68 | 2361.20 | 1943.30 | 1902.14 | 2350.60 | 1928.64 |

Cog. = cognitive. 95 % CI = parametric bootstrapped confidence intervals after resampling the data five times using 300 replicates (for brevity, confidence intervals are not provided in the covariate models, although the coefficient estimates and standard errors for these models were obtained using the same bootstrapping procedures). Age was entered as a continuous variable, whereas binary dummy codes were used to differentiate sex (0 = female; 1 = male), special educational need (0 = none; 1 = educational need), and ethnicity (0 = White; 1 = Black, Asian, and minority ethnicity).

The proportional amount of variance that the current models explain in each dependent variable, when compared to the intercept only models, are shown at the classroom (R^2_3), between-person (R^2_2), and within-person (R^2_1) levels.

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

development of their cognitive engagement over the school year ($b = -0.12, p < .001$; see Fig. 1), whereas those higher in psychological need satisfaction displayed no deterioration in cognitive engagement ($b = 0.01, p = .71$). The inclusion of the predictor variables in this model accounted for 44 % of the proportional between-person variance in cognitive engagement, yet only 2 % of the within-person variance and 0 % of the classroom variance (see R^2 statistics in Table 3). The inclusion of covariates resulted in minor changes to the statistical parameters but no overall changes in the temporal trends and proportional variance (see Table 3 for a comparison of both sets of models).

Pupils higher in psychological need satisfaction were found to report lower levels of cognitive fatigue at the start of the study compared to those lower in psychological need satisfaction. These differences were moderate to large in effect size. A statistically significant psychological needs \times time interaction was also evident, however, simple slopes analysis indicated that reports of cognitive fatigue did not meaningfully vary over the study regardless of whether pupils were high ($b = -0.05, p = .16$) or low ($b = 0.04, p = .27$) in psychological need satisfaction (see Fig. 1). The inclusion of the predictor variables in this model accounted for 27 % of the proportional between-person level variance and 33 % of the classroom level variance in cognitive fatigue, but only 1 % of the within-person variance. The addition of the covariates accounted for a greater proportion of the classroom level variance in cognitive fatigue, however there were no changes to the results examining our hypotheses, including the interaction terms.

In relation to academic attainment, pupil differences in psychological need satisfaction had no association with academic attainment at the start of the study. Nonetheless, a statistically significant psychological needs \times time interaction was found, albeit this was small in magnitude (Cohen, 1988). Inspection of the simple slopes indicated that, whilst all pupils increased in school grades over the school year, pupils higher in psychological need satisfaction demonstrated greater attainment increases ($b = 0.25, p < .001$) compared to pupils lower in psychological need satisfaction ($b = 0.20, p < .001$; see Fig. 2 for graphical depiction). The inclusion of the predictor variables in this model were found to explain 35 % of the within-person variance in academic attainment, 9 % of the classroom level variance, and 5 % of the between-person variance. The attainment trajectories associated with psychological need satisfaction remained consistent when accounting for the covariates, although they accounted for a greater proportion of classroom variance and less of the between-person variance.

Finally, previous studies have demonstrated positive temporal relationships between self-efficacy beliefs and both cognitive engagement and attainment (e.g., Caprara et al., 2008). Given the conceptual overlap

between the psychological need of competence and self-efficacy, we ran three supplementary models to check whether a composite of autonomy and relatedness satisfaction continued to explain each dependent variable when competence satisfaction was excluded. Indeed, the direction and strength of the need \times time interaction remained consistent for cognitive engagement ($b = 0.06, p < .001$) and cognitive fatigue ($b = -0.04, p = .02$), although this interaction no longer reached statistical significance in relation to attainment ($b = 0.02, p = .09$).

4. Discussion

The present study provides a longitudinal examination of how individual differences in psychological need satisfaction explain trajectories in young adolescents' cognitive engagement, cognitive fatigue, and academic attainment. Pupils experiencing greater psychological need satisfaction at school demonstrated higher and consistent levels of cognitive engagement over the school year, whereas pupils lower in psychological need satisfaction showed declines in their cognitive engagement over the same period. Pupils with heightened psychological need satisfaction also reported lower levels of cognitive fatigue compared to those lacking psychological need satisfaction, and these differences remained constant over the school year. Furthermore, although increases in school grades were evident for all pupils, the experience of higher psychological need satisfaction was associated with greater increases in attainment across the year. Building on theoretical propositions within SDT (Deci & Ryan, 2016), these findings offer temporal insights into the adaptive role that psychological need satisfaction may play in maintaining young adolescents' learning engagement at school.

Extending existing knowledge (Cohen et al., 2020; Jang et al., 2016), young adolescents higher in psychological need satisfaction not only reported greater cognitive engagement at school but were found to maintain it throughout the year. As with previous studies (e.g., Wang & Eccles, 2012), a generic decline in cognitive engagement was found across the current sample, yet this was not evident for pupils reporting high psychological need satisfaction. Pupils who experience fulfilment of their psychological needs will feel they can be successful at school, are able to express themselves freely, and that they are supported by others in a non-judgmental way. Previous studies have indicated that such feelings may prompt enhanced levels of autonomous engagement (Bureau et al., 2021; Zhen et al., 2017), agency towards learning (Cohen et al., 2020), and mastery strivings towards tasks (Duchesne et al., 2017). The present findings suggest that pupils whose psychological needs are satisfied appear to be more dedicated towards their learning

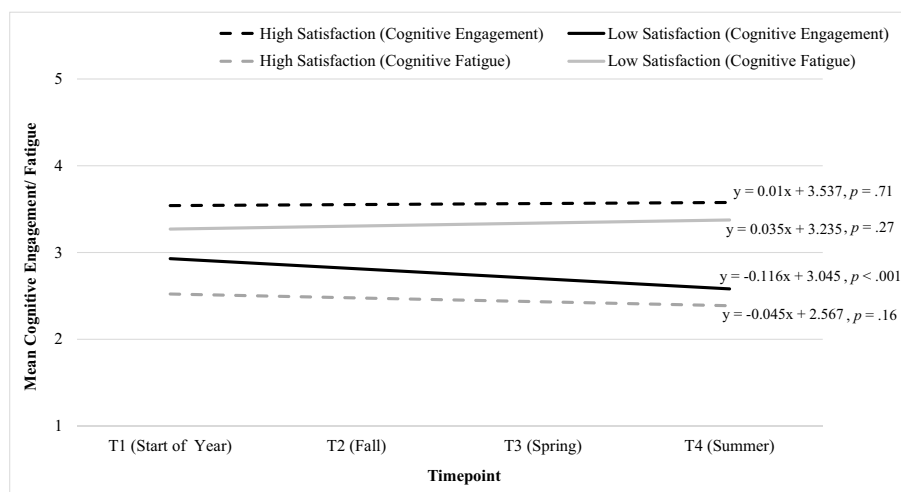


Fig. 1. Trajectories in cognitive engagement and cognitive fatigue associated with differences in pupils' psychological need satisfaction over the school year. Relevant equations for each slope are depicted within the figure along with the level of statistical significance.

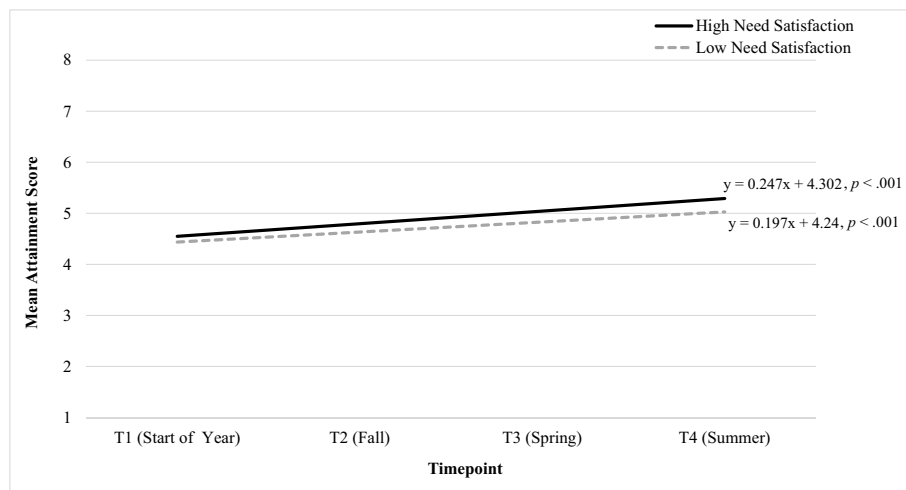


Fig. 2. Trajectories in academic attainment associated with differences in pupils' psychological need satisfaction. Relevant slopes equations are shown for pupils high and low in psychological need satisfaction (both slopes statistically differed from zero; $p < .001$).

and have a prolonged deep engagement with the information they learn at school.

On the other hand, pupils lacking psychological need satisfaction at school displayed lower levels of cognitive engagement which declined over the school year. This pattern is somewhat worrying as it suggests these pupils may gradually disengage from the learning process over time. Deficits in psychological need satisfaction often manifest in self-handicapping learning strategies, such as cognitive detachment from tasks (e.g., Jang et al., 2016), passive withdrawal to hide feelings of incompetency (e.g., Earl et al., 2017), and general disconnection from learning (e.g., Collie et al., 2019). These processes may inhibit a deep engagement with learning as pupils may simply try to avoid failure or become preoccupied by negative thoughts which hamper their ability to think critically and elaborate on information. Pupils who lack psychological need satisfaction at school may therefore become increasingly withdrawn from learning and require more targeted learning support from teachers (e.g., Filippello et al., 2019; Mahmoudi et al., 2018).

It is notable that cognitive engagement, unexpectedly, did not correlate with academic attainment at any timepoint across the present study. Likewise, cognitive engagement demonstrated a generic decline over the school year whilst academic grades showed a linear increase. This would imply that cognitive engagement at school may not translate into high achievement. Previous evidence with university students found that whilst autonomous motivation was positively related with various cognitive learning strategies (e.g., rehearsal, organisation, monitoring, elaboration), it was only critical thinking that had any association with academic attainment (Manganelli et al., 2019). Further research may be needed to explore how distinct cognitive strategies may relate to school performance. Alternatively, it may be that traditional assessment methods tend to evaluate abilities more attributable to the memorisation of information, as opposed to pupils' ability to elaborate or transfer knowledge across subjects (e.g., Nieminen et al., 2021). The present measure of attainment encompassed the subjects of English and Mathematics which often rely on the memorisation of spelling, grammar, or arithmetic calculations. Future studies could assess whether the present trends vary when using assessments that rely on the memorisation of information compared to tests regarding the application of concepts to real-world problems.

Additionally, pupils higher in psychological need satisfaction displayed lower levels of cognitive fatigue throughout the school year compared to their counterparts. The experience of cognitive fatigue during secondary school is often detrimental to learning, engagement, and performance (Mizuno et al., 2011; Sievertsen et al., 2016). This seemed to be the case in our study as cognitive fatigue was negatively

correlated with both cognitive engagement and academic attainment at every timepoint. Pupils with higher fulfilment of their psychological needs will have a heightened sense of autonomy, psychological freedom, and capability at school. Consequently, these pupils may be less likely to overthink how they act or perform (Schneider et al., 2018), and thus able to maintain higher levels of psychological energy throughout the school year (see Chen et al., 2015; Liu et al., 2017). On the contrary, lower psychological need satisfaction is concordant with symptoms of cognitive fatigue and psychological burnout (e.g., Bartholomew et al., 2011). This fatigue may derive from a continual monitoring of maladaptive thoughts linked to feelings of distress (Gilbert et al., 2021), perceived pressure (Wang et al., 2019c), or a need to prove oneself to others (Bartholomew et al., 2018). As a result, these experiences may make it more challenging for pupils to cognitively engage with school-based activities (e.g., Jang et al., 2016; Mouratidis et al., 2011).

In regard to academic attainment, although differences in psychological need satisfaction had no relation to school grades at the onset of the study, pupils higher in need satisfaction demonstrated greater attainment increases over the year. Inferring from extant evidence, these increases could potentially stem from academically advantageous consequences of greater behavioral engagement (Buzzai et al., 2021; Wang et al., 2019b), help seeking (Marchand & Skinner, 2007), and autonomous motivation (Ahn et al., 2021). Nevertheless, it is noticeable that a greater proportion of the variance in attainment was accounted for at the within-person and classroom level, as opposed to the between-person level. Indeed, uniform gains in school grades were observed for all pupils regardless of their experience of psychological need satisfaction (see Barkoukis et al., 2014 for comparable trajectories). These generic attainment gains may simply be attributable to the inevitable time-based learning effects of school tuition. Moreover, it is plausible that changes in academic attainment may be partially explained by differences between classrooms. For instance, increases in school grades may be the result of differences in teacher grading practices, such as using more stringent marking criteria at the start of the school year (Hochweber et al., 2014). Alternatively, pupils who achieve higher grades may potentially receive greater levels of academic support and more challenging learning tasks within the classroom (McKown et al., 2010). These pupils may therefore be predisposed to experience higher fulfilment of their psychological needs, as well as higher school grades (Morgan & Fuchs, 2007). On the contrary, pupils attaining lower school grades may be underestimated and not provided with the same supportive opportunities, which may thwart their psychological needs (Urhahne et al., 2011).

4.1. Conceptual and practical implications

The current findings offer insights into the benefits of school-based psychological need satisfaction for young adolescents' cognitive engagement, cognitive fatigue, and general achievement. The fulfilment of pupils' psychological needs is an intrapsychic experience that is dependent on the subjective meaning they place upon the school context (Deci et al., 1996). Some pupils may perceive school as an appealing environment in which they actively seek out learning opportunities and deeply engage with learning material across multiple subjects. For other pupils, however, aspects of the school environment may be perceived as coercive, isolating, and overly judgemental (e.g., Shukla et al., 2016; Warburton et al., 2020). Pupils in this latter case appear to be at risk of gradually disengaging with learning over time and experiencing persistent cognitive fatigue at school. The main motive for these pupils may be to simply avoid failure rather than maximise their learning. It may be worthwhile for educators to devise ways to enhance pupils' own awareness of their psychological experiences and learning, so they avoid becoming solely concerned with academic performance (e.g., Earl et al., 2021). Encouraging pupils to draw comparisons between different topics they find interesting, so they develop a sense of agency towards their learning, may be valuable rather than solely emphasising assessment-based outcomes.

From a practical perspective, methods to nurture learning motivation and engagement have grown within educational domains (e.g., Frey et al., 2017). Initiatives have often included developing new pedagogies or incorporating new computer technologies to broaden learning (e.g., Dolmans et al., 2016; Tao, 2021). In combination with these practices, creating school ambiances that foster young adolescents' psychological need satisfaction may be valuable in helping facilitate their learning engagement. Principally, psychological need satisfaction derives from school-based interactions that are autonomy supportive (Reeve & Cheon, 2021). Autonomy support involves offering patience rather than pressure towards learning, emphasising the relevance of taught material, and allowing pupils to make meaningful decisions over their learning (Aelterman et al., 2019; Cheon et al., 2018). Such provisions centre on taking a pupil-focused perspective which cultivates a sense of relatedness by acknowledging pupils' feelings, thoughts, and opinions (Opdenakker, 2021). Moreover, autonomy support should be accompanied with informational and structured direction so that pupils feel they know how to improve and can identify ways to succeed in their academic work (Hospel & Galand, 2016). This guidance will enable pupils to feel they can be effective in their academic pursuits and encourage them to direct their engagement towards their learning without fear of being criticised (Cheon et al., 2020; Guay et al., 2017).

4.2. Limitations and directions for future research

The present research focuses on the early years of secondary school as they signify an important developmental phase of adolescence (Wigfield et al., 2006), as well as a pivotal time in children's schooling (e.g., Goldstein et al., 2015). Nevertheless, it is acknowledged that the present sample only included one school institution and tracked pupils across a single year. Further research would be required to replicate the current study across multiple school years and academic institutions. Moreover, it would be worthwhile to assess whether the decline in cognitive engagement for pupils low in psychological need satisfaction is exacerbated over several years. A possible explanation for the present findings may be that the pupils higher in psychological need satisfaction were more self-aware and better understood the cognitive engagement items. Cognitive engagement typically encompasses abstract thinking, metacognition, and conceptual understanding which develop with age during adolescence (Schneider, 2008). Future multiyear examinations may facilitate a wider age-range in the sample population to explore whether changes in cognitive engagement become more apparent as pupils enter later stages of adolescence, and whether the associations

between cognitive engagement and psychological need satisfaction are more prominent for older rather than younger adolescents.

The present findings were found to remain consistent when accounting for the potential confounding effects of sex, age, educational need, and ethnicity. Recent studies, however, have indicated that socio-economic status (SES) may be an antecedent for adolescents' psychological experiences at school (Alivernini et al., 2019, 2020). Data on pupils SES was not available in the present study, yet its inclusion in future work may offer greater insights into pupils at risk of lower psychological need satisfaction and higher cognitive fatigue at school.

A further consideration is that the psychological needs in the present study were assessed using separate scales. Advances in the measurement of psychological needs have resulted in holistic scales that offer stronger reliability across cultures and minimise high intercorrelations between the needs (e.g., Chen et al., 2015). Such scales may offer a more comprehensive evaluation of school-based psychological needs in future work. Additionally, such measures make the theoretical distinction between the satisfaction of one's psychological needs and the more overt frustration of their needs (see Cheon et al., 2019). A growing number of studies have found psychological need frustration to be uniquely associated with more deleterious outcomes, such as school disengagement (Jang et al., 2016), pressurised school motivation (Warburton et al., 2020), and behavioral defiance (Haerens et al., 2015). It seems feasible that pupils reporting greater frustration of their psychological needs may demonstrate greater declines in cognitive engagement, as well as enhanced cognitive fatigue, compared to those reporting higher satisfaction of their needs. Clarifying any temporal discrepancies between experiences of psychological need satisfaction and frustration may shed further light on pupils' adaptive and maladaptive learning experiences at school.

Finally, a particular strength of the current work is that official school grades were used to evaluate academic attainment, as opposed to relying on pupil or teacher reported achievement (e.g., Kuncel et al., 2005). Nonetheless, the present measure of academic attainment related to the specific subjects of English and Mathematics, whereas psychological need satisfaction was assessed at a generic school level. It would be insightful to evaluate whether the relationships found between psychological need satisfaction and academic attainment remained consistent if both constructs were assessed in relation to specific school subjects (see Erturan-İlker et al., 2018). In addition, the antecedents of academic attainment are diverse and may extend to a multitude of external factors not covered in this study, including the difficulty level of academic content, parental support, and pupils' interest in specific subjects (e.g., Kerpelman et al., 2008; Zhen et al., 2018; Zwick & Himelfarb, 2011). Accounting for these additional variables in future work may offer more nuanced insights into trajectories in academic attainment.

5. Conclusions

Over the past decade, calls for educational policies to emphasise learning engagement and pupil well-being, rather than attainment outcomes, have gained precedence (Bonell et al., 2014). The present work helps advance knowledge by unearthing longitudinal insights into how differences in school-based psychological need satisfaction may predict trajectories in cognitive engagement, cognitive fatigue, and school grades. Pupils experiencing lesser psychological need satisfaction at school demonstrated lower and declining cognitive engagement, which coincided with high and consistent levels of cognitive fatigue. Conversely, pupils higher in psychological need satisfaction displayed heightened cognitive engagement and lower cognitive fatigue which did not vary throughout the school year. The experience of psychological need satisfaction was also found to predict greater increases in school grades, albeit all pupils showed attainment improvements. Collectively, these findings highlight the potential cognitive benefits that psychological need satisfaction may have for young adolescents at school. This

knowledge may be informative for educators in considering how school practices may best support pupils' psychological needs to help sustain their academic engagement and development.

Declaration of competing interest

None. All authors have no conflicts of interests (financially or personally) that have influenced this research.

References

- Aelterman, N., Vansteenkiste, M., Haerens, L., Soenens, B., Fontaine, J. R., & Reeve, J. (2019). Toward an integrative and fine-grained insight in motivating and demotivating teaching styles: The merits of a circumplex approach. *Journal of Educational Psychology, 111*(3), 497–521. <https://doi.org/10.1037/edu0000293>
- Ahn, I., Chiu, M. M., & Patrick, H. (2021). Connecting teacher and student motivation: Student-perceived teacher need-supportive practices and student need satisfaction. *Contemporary Educational Psychology, 64*, Article 101950. <https://doi.org/10.1016/j.cedpsych.2021.101950>
- Alivernini, F., Bianchi, D., Cavicchiolo, E., Manganelli, S., Cozzolino, M., Lucidi, F., & Park, N. (2021). Positive youth development among youth living in poverty: The role of psychological needs satisfaction. *Youth & Society, 1–23*. <https://doi.org/10.1177/0044118X211035956>
- Alivernini, F., Cavicchiolo, E., Girelli, L., Lucidi, F., Biasi, V., Leone, L., Manganelli, S., ... (2019). Relationships between sociocultural factors (gender, immigrant and socioeconomic background), peer relatedness and positive affect in adolescents. *Journal of Adolescence, 76*, 99–108. <https://doi.org/10.1016/j.adolescence.2019.08.011>
- Alivernini, F., Cavicchiolo, E., Manganelli, S., Chirico, A., & Lucidi, F. (2020). Students' psychological well-being and its multilevel relationship with immigrant background, gender, socioeconomic status, achievement, and class size. *School Effectiveness and School Improvement, 31*(2), 172–191. <https://doi.org/10.1080/09243453.2019.1642214>
- Appleton, J. J., Christenson, S. L., Kim, D., & Reschly, A. L. (2006). Measuring cognitive and psychological engagement: Validation of the student engagement instrument. *Journal of School Psychology, 44*(5), 427–445. <https://doi.org/10.1016/j.jsp.2006.04.002>
- Appleton, J. J., Christenson, S. L., & Furlong, M. J. (2008). Student engagement with school: Critical conceptual and methodological issues of the construct. *Psychology in the Schools, 45*(5), 369–386. <https://doi.org/10.1002/pits.20303>
- Barkoukis, V., Taylor, I., Chanal, J., & Ntoumanis, N. (2014). The relation between student motivation and student grades in physical education: A 3-year investigation. *Scandinavian Journal of Medicine & Science in Sports, 24*(5), 406–414. <https://doi.org/10.1111/sms.12174>
- Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., Bosch, J. A., & Thøgersen-Ntoumani, C. (2011). Self-determination theory and diminished functioning: The role of interpersonal control and psychological need thwarting. *Personality and Social Psychology Bulletin, 37*, 1459–1503. <https://doi.org/10.1177/0146167211413125>
- Bartholomew, K. J., Ntoumanis, N., Mouratidis, A., Katartzis, E., Thøgersen-Ntoumani, C., & Vlachopoulos, S. (2018). Beware of your teaching style: A school-year long investigation of controlling teaching and student motivational experiences. *Learning and Instruction, 53*, 50–63. <https://doi.org/10.1016/j.learninstruc.2017.07.006>
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*, 497–529. <https://doi.org/10.1037/0033-2909.117.3.497>
- Ben-Eliyahu, A., Moore, D., Dorph, R., & Schunn, C. D. (2018). Investigating the multidimensionality of engagement: Affective, behavioral, and cognitive engagement across science activities and contexts. *Contemporary Educational Psychology, 53*, 87–105. <https://doi.org/10.1016/j.cedpsych.2018.01.002>
- Birkeland, M. S., Melkevik, O., Holsen, I., & Wold, B. (2012). Trajectories of global self-esteem development during adolescence. *Journal of Adolescence, 35*(1), 43–54. <https://doi.org/10.1016/j.adolescence.2011.06.006>
- Blumenfeld, P. C., Kempfer, T. M., & Krajcik, J. S. (2006). Motivation and cognitive engagement in learning environments. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 475–488). New York, NY: Cambridge University Press.
- Bonell, C., Humphrey, N., Fletcher, A., Moore, L., Anderson, R., & Campbell, R. (2014). Why schools should promote students' health and wellbeing. *BMJ (Clinical Research Ed.), 348*, Article g3078. <https://doi.org/10.1136/bmj.g3078>
- Bureau, J. S., Howard, J. L., Chong, J. X., & Guay, F. (2021). Pathways to student motivation: A meta-analysis of antecedents of autonomous and controlled motivations. *Review of Educational Research, 92*(1), 46–72. <https://doi.org/10.3102/00346543211042426>
- Buzzai, C., Sorrenti, L., Costa, S., Toffle, M. E., & Filippello, P. (2021). The relationship between school-basic psychological need satisfaction and frustration, academic engagement and academic achievement. *School Psychology International, 42*(5), 497–519. <https://doi.org/10.1177/01430343211017170>
- Caprara, G. V., Fida, R., Vecchione, M., Del Bove, G., Vecchio, G. M., Barbaranelli, C., & Bandura, A. (2008). Longitudinal analysis of the role of perceived self-efficacy for self-regulated learning in academic continuance and achievement. *Journal of Educational Psychology, 100*(3), 525–534. <https://doi.org/10.1037/0022-0663.100.3.525>
- Carmona-Halty, M., Schaufeli, W. B., Llorens, S., & Salanova, M. (2019). Satisfaction of basic psychological needs leads to better academic performance via increased psychological capital: A three-wave longitudinal study among high school students. *Frontiers in Psychology, 10*, 2113. <https://doi.org/10.3389/fpsyg.2019.02113>
- Charlot Colomès, A. A., Duchesne, S., & Boisclair Châteauevert, G. (2021). Autonomy support and school adjustment: The mediating role of basic psychological needs. *International Journal of School & Educational Psychology, 9*, S182–S200. <https://doi.org/10.1080/21683603.2021.1877226>
- Chen, B., Vansteenkiste, M., Beyers, W., Boone, L., Deci, E. L., der Kaap-Deeder, V., Verstuyf, J., ... (2015). Basic psychological need satisfaction, need frustration, and need strength across four cultures. *Motivation and Emotion, 39*(2), 216–236. <https://doi.org/10.1007/s11031-014-9450-1>
- Cheon, S. H., Reeve, J., Lee, Y., & Lee, J. W. (2018). Why autonomy-supportive interventions work: Explaining the professional development of teachers' motivating style. *Teaching and Teacher Education, 69*, 43–51. <https://doi.org/10.1016/j.tate.2017.09.022>
- Cheon, S. H., Reeve, J., Lee, Y., Ntoumanis, N., Gillet, N., Kim, B. R., & Song, Y. G. (2019). Expanding autonomy psychological need states from two (satisfaction, frustration) to three (dissatisfaction): A classroom-based intervention study. *Journal of Educational Psychology, 111*(4), 685–702. <https://doi.org/10.1037/edu0000306>
- Cheon, S. H., Reeve, J., & Vansteenkiste, M. (2020). When teachers learn how to provide classroom structure in an autonomy-supportive way: Benefits to teachers and their students. *Teaching and Teacher Education, 90*, Article 103004. <https://doi.org/10.1016/j.tate.2019.103004>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.
- Cohen, R., Moed, A., Shoshani, A., Roth, G., & Kanat-Maymon, Y. (2020). Teachers' conditional regard and students' need satisfaction and agentic engagement: A multilevel motivation mediation model. *Journal of Youth and Adolescence, 49*(4), 790–803. <https://doi.org/10.1007/s10964-019-01114-y>
- Collie, R. J., Granziera, H., & Martin, A. J. (2019). Teachers' motivational approach: Links with students' basic psychological need frustration, maladaptive engagement, and academic outcomes. *Teaching and Teacher Education, 86*, Article 102872. <https://doi.org/10.1016/j.tate.2019.07.002>
- Curran, P. J., & Bauer, D. J. (2011). The disaggregation of within-person and between-person effects in longitudinal models of change. *Annual Review of Psychology, 62*, 583–619. <https://doi.org/10.1146/annurev.psych.093008.100356>
- de Charms, R. (1968). *Personal causation: The internal affective determinants of behavior*. New York, NY: Academic.
- Deci, E. L., & Ryan, R. M. (2016). Optimizing students' motivation in the era of testing and pressure: A self-determination theory perspective. In W. C. Liu, J. C. K. Wang, & R. M. Ryan (Eds.), *Building autonomous learners* (pp. 9–29). Singapore: Springer.
- Deci, E. L., Ryan, R. M., & Williams, G. C. (1996). Need satisfaction and the self-regulation of learning. *Learning and Individual Differences, 8*(3), 165–183. [https://doi.org/10.1016/S1041-6080\(96\)90013-8](https://doi.org/10.1016/S1041-6080(96)90013-8)
- Department of Education; United Kingdom. (June, 2015). New reforms to raise standards and improve behaviour. Retrieved from <https://www.gov.uk/government/news/new-reforms-to-raise-standards-and-improve-behaviour>. (Accessed 15 December 2021).
- Dolmans, D. H., Loyens, S. M., Marcq, H., & Gijbels, D. (2016). Deep and surface learning in problem-based learning: A review of the literature. *Advances in Health Sciences Education, 21*(5), 1087–1112. <https://doi.org/10.1007/s10459-015-9645-6>
- Doménech-Betoret, F., & Gómez-Artiga, A. (2014). The relationship among students' and teachers' thinking styles, psychological needs and motivation. *Learning and Individual Differences, 29*, 89–97. <https://doi.org/10.1016/j.lindif.2013.10.002>
- Duchesne, S., Ratelle, C. F., & Fong, B. (2017). Psychological need satisfaction and achievement goals: Exploring indirect effects of academic and social adaptation following the transition to secondary school. *The Journal of Early Adolescence, 37*(9), 1280–1308. <https://doi.org/10.1177/0272431616659561>
- Earl, S. R., Taylor, I. M., Meijen, C., & Passfield, L. (2017). Autonomy and competence frustration in young adolescent classrooms: Different associations with active and passive disengagement. *Learning and Instruction, 49*, 32–40. <https://doi.org/10.1016/j.learninstruc.2016.12.001>
- Earl, S. R., Meijen, C., Taylor, I. M., & Passfield, L. (2021). Developing young adolescents' psychological need satisfaction: A feasibility study of a pupil-focused intervention in secondary schools. *Educational Studies, 47*(5), 591–608. <https://doi.org/10.1080/03055698.2020.1719386>
- Enders, C. K., & Tofghi, D. (2007). Centering predictor variables in cross-sectional multilevel models: A new look at an old issue. *Psychological Methods, 12*(2), 121. <https://doi.org/10.1037/1082-989X.12.2.121>
- Erickson, A. S. G., Noonan, P. M., Zheng, C., & Brussow, J. A. (2015). The relationship between self-determination and academic achievement for adolescents with intellectual disabilities. *Research in Developmental Disabilities, 36*, 45–54. <https://doi.org/10.1016/j.ridd.2014.09.008>
- Erturan-İlker, G., Quested, E., Appleton, P., & Duda, J. L. (2018). A cross-cultural study testing the universality of basic psychological needs theory across different academic subjects. *Psychology in the Schools, 55*(4), 350–365. <https://doi.org/10.1002/pits.22113>
- Fan, W. (2011). Social influences, school motivation and gender differences: An application of the expectancy-value theory. *Educational Psychology, 31*(2), 157–175. <https://doi.org/10.1080/01443410.2010.536525>
- Filippello, P., Buzzai, C., Costa, S., & Sorrenti, L. (2019). School refusal and absenteeism: Perception of teacher behaviors, psychological basic needs, and academic achievement. *Frontiers in Psychology, 10*, 1471. <https://doi.org/10.3389/fpsyg.2019.01471>

- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74, 59–109. <https://doi.org/10.3102/00346543074001059>
- Fredricks, J. A., & McColskey, W. (2012). The measurement of student engagement: A comparative analysis of various methods and student self-report instruments. In *Handbook of research on student engagement* (pp. 763–782). Boston, MA: Springer.
- Frey, N., Fisher, D., & Hattie, J. (2017). Surface, deep, and transfer? Considering the role of content literacy instructional strategies. *Journal of Adolescent & Adult Literacy*, 60(5), 567–575. <https://doi.org/10.1002/jaal.576>
- Froiland, J. M., & Worrell, F. C. (2016). Intrinsic motivation, learning goals, engagement, and achievement in a diverse high school. *Psychology in the Schools*, 53(3), 321–336. <https://doi.org/10.1002/pits.21901>
- Gilbert, W., Bureau, J. S., Poellhuber, B., & Guay, F. (2021). Predicting college students' psychological distress through basic psychological need-relevant practices by teachers, peers, and the academic program. *Motivation and Emotion*, 45(4), 436–455. <https://doi.org/10.1007/s11031-021-09892-4>
- Gillet, N., Vallerand, R. J., & Lafrenière, M. A. K. (2012). Intrinsic and extrinsic school motivation as a function of age: The mediating role of autonomy support. *Social Psychology of Education*, 15(1), 77–95. <https://doi.org/10.1007/s11218-011-9170-2>
- Goldstein, S. E., Boxer, P., & Rudolph, E. (2015). Middle school transition stress: Links with academic performance, motivation, and school experiences. *Contemporary School Psychology*, 19(1), 21–29. <https://doi.org/10.1111/apps.12227>
- Guay, F. (2022). Applying self-determination theory to education: Regulations types, psychological needs, and autonomy supporting behaviors. *Canadian Journal of School Psychology*, 37(1), 75–92. <https://doi.org/10.1177/08295735211055355>
- Guay, F., Roy, A., & Valois, P. (2017). Teacher structure as a predictor of students' perceived competence and autonomous motivation: The moderating role of differentiated instruction. *British Journal of Educational Psychology*, 87(2), 224–240. <https://doi.org/10.1111/bjep.12146>
- Haerens, L., Aelterman, N., Vansteenkiste, M., Soenens, B., & Van Petegem, S. (2015). Do perceived autonomy-supportive and controlling teaching relate to physical education students' motivational experiences through unique pathways? Distinguishing between the bright and dark side of motivation. *Psychology of Sport and Exercise*, 16, 26–36. <https://doi.org/10.1016/j.psychsport.2014.08.013>
- Hochweber, J., Hosenfeld, I., & Klieme, E. (2014). Classroom composition, classroom management, and the relationship between student attributes and grades. *Journal of Educational Psychology*, 106(1), 289–300. <https://doi.org/10.1037/a0033829>
- Hockey, G. R. J. (2011). A motivational control theory of cognitive fatigue. In P. L. Ackerman (Ed.), *Cognitive fatigue: Multidisciplinary perspectives on current research and future applications* (pp. 167–187). American Psychological Association. <https://doi.org/10.1037/12343-008>
- Hospel, V., & Galand, B. (2016). Are both classroom autonomy support and structure equally important for students' engagement? A multilevel analysis. *Learning and Instruction*, 41, 1–10. <https://doi.org/10.1016/j.learninstruc.2015.09.001>
- Howard, J. L., Bureau, J., Guay, F., Chong, J. X., & Ryan, R. M. (2021). Student motivation and associated outcomes: A meta-analysis from self-determination theory. *Perspectives on Psychological Science*, 16(6), 1300–1323. <https://doi.org/10.1177/1745691620966789>
- Hox, J. J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). Hove, UK: Routledge.
- Huhtiniemi, M., Sääkslahti, A., Watt, A., & Jaakkola, T. (2019). Associations among basic psychological needs, motivation and enjoyment within Finnish physical education students. *Journal of Sports Science & Medicine*, 18(2), 239–247. <https://www.jssm.org/volume18/iss2/cap/jssm-18-239.pdf>
- Jang, H., Kim, E. J., & Reeve, J. (2012). Longitudinal test of self-determination theory's motivation mediation model in a naturally occurring classroom context. *Journal of Educational Psychology*, 104(4), 1175. <https://doi.org/10.1037/a0028089>
- Jang, H., Kim, E. J., & Reeve, J. (2016). Why students become more engaged or more disengaged during the semester: A self-determination theory dual-process model. *Learning and Instruction*, 43, 27–38. <https://doi.org/10.1016/j.learninstruc.2016.01.002>
- Kember, D., Biggs, J., & Leung, D. Y. (2004). Examining the multidimensionality of approaches to learning through the development of a revised version of the learning process questionnaire. *British Journal of Educational Psychology*, 74(2), 261–279. <https://doi.org/10.1348/000709904773839879>
- Kerpelman, J. L., Eryigit, S., & Stephens, C. J. (2008). African american adolescents' future education orientation: Associations with self-efficacy, ethnic identity, and perceived parental support. *Journal of Youth and Adolescence*, 37(8), 997–1008. <https://doi.org/10.1007/s10964-007-9201-7>
- Knight, S. J., Politis, J., Garnham, C., Scheinberg, A., & Tollit, M. A. (2018). School functioning in adolescents with chronic fatigue syndrome. *Frontiers in Pediatrics*, 302. <https://doi.org/10.3389/fped.2018.00302>
- Kuncel, N. R., Credé, M., & Thomas, L. L. (2005). The validity of self-reported grade point averages, class ranks, and test scores: A meta-analysis and review of the literature. *Review of Educational Research*, 75(1), 63–82. <https://doi.org/10.3102/00346543075001063>
- Leenknecht, M., Hompus, P., & van der Schaaf, M. (2019). Feedback seeking behaviour in higher education: The association with students' goal orientation and deep learning approach. *Assessment & Evaluation in Higher Education*, 44(7), 1069–1078. <https://doi.org/10.1080/02602938.2019.1571161>
- Li, S., & Lajoie, S. P. (2022). Cognitive engagement in self-regulated learning: An integrative model. *European Journal of Psychology of Education*, 37(3), 833–852. <https://doi.org/10.1007/s10212-021-00565-x>
- Li, Y., & Lerner, R. M. (2011). Trajectories of school engagement during adolescence: Implications for grades, depression, delinquency, and substance use. *Developmental Psychology*, 47(1), 233–247. <https://doi.org/10.1037/a0021307>
- Liem, A. D., Lau, S., & Nie, Y. (2008). The role of self-efficacy, task value, and achievement goals in predicting learning strategies, task disengagement, peer relationship, and achievement outcome. *Contemporary Educational Psychology*, 33(4), 486–512. <https://doi.org/10.1016/j.cedpsych.2007.08.001>
- Liu, J., Bartholomew, K., & Chung, P. K. (2017). Perceptions of teachers' interpersonal styles and well-being and ill-being in secondary school physical education students: The role of need satisfaction and need frustration. *School Mental Health*, 9(4), 360–371. <https://doi.org/10.1007/s12310-017-9223-6>
- Mahmoudi, H., Brown, M. R., Amani Saribagloo, J., & Dadashzadeh, S. (2018). The role of school culture and basic psychological needs on Iranian adolescents' academic alienation: A multi-level examination. *Youth & Society*, 50(1), 116–136. <https://doi.org/10.1177/0044118X15593668>
- Makarova, D. N. (2021). Metacognitive regulation, basic psychological needs and subjective vitality of first year university students. *Вестник Санкт-Петербургского университета. Психология*, 11(1), 63–71. <https://doi.org/10.21638/spbu16.2021.104>
- Manganelli, S., Cavicchiolo, E., Mallia, L., Biasi, V., Lucidi, F., & Alivermini, F. (2019). The interplay between self-determined motivation, self-regulated cognitive strategies, and prior achievement in predicting academic performance. *Educational Psychology*, 39(4), 470–488. <https://doi.org/10.1080/01443410.2019.1572104>
- Marchand, G., & Skinner, E. A. (2007). Motivational dynamics of children's academic help-seeking and concealment. *Journal of Educational Psychology*, 99(1), 65. <https://doi.org/10.1037/0022-0663.99.1.65>
- McCauley, E., Duncan, T., & Tammen, V. V. (1989). Psychometric properties of the intrinsic motivation inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, 60, 48–58. <https://doi.org/10.1080/02701367.1989.10607413>
- McKown, C., Gregory, A., & Weinstein, R. S. (2010). Expectations, stereotypes, and self-fulfilling prophecies in classroom and school life. In *Handbook of research on schools, schooling, and human development* (pp. 256–274). Routledge.
- Mizuno, K., Tanaka, M., Fukuda, S., Imai-Matsumura, K., & Watanabe, Y. (2011). Relationship between cognitive functions and prevalence of fatigue in elementary and junior high school students. *Brain and Development*, 33(6), 470–479. <https://doi.org/10.1016/j.braindev.2010.08.012>
- Moilanen, K. L., Shaw, D. S., & Maxwell, K. L. (2010). Developmental cascades: Externalizing, internalizing, and academic competence from middle childhood to early adolescence. *Development and Psychopathology*, 22(3), 635–653. <https://doi.org/10.1017/S0954579410000337>
- Morgan, P. L., & Fuchs, D. (2007). Is there a bidirectional relationship between children's reading skills and reading motivation? *Exceptional Children*, 73(2), 165–183. <https://doi.org/10.1177/001440290707300203>
- Mostafa, T. (2017). In , 79. *Is too much testing bad for student performance and well-being?* (pp. 1–6). OECD Publishing. <https://doi.org/10.1787/22260919>
- Mouratidis, A. A., Vansteenkiste, M., Sideridis, G., & Lens, W. (2011). Vitality and interest-enjoyment as a function of class-to-class variation in need-supportive teaching and pupils' autonomous motivation. *Journal of Educational Psychology*, 103(2), 353–366. <https://doi.org/10.1037/a0022773>
- Nieminen, J. H., Asikainen, H., & Rämö, J. (2021). Promoting deep approach to learning and self-efficacy by changing the purpose of self-assessment: A comparison of summative and formative models. *Studies in Higher Education*, 46(7), 1296–1311. <https://doi.org/10.1080/03075079.2019.1688282>
- Nijhof, L. N., Nijhof, S. L., Bleijenberg, G., Stellato, R. K., Kimpen, J. L., Pol, H. E. H., & van de Putte, E. M. (2016). The impact of chronic fatigue syndrome on cognitive functioning in adolescents. *European Journal of Pediatrics*, 175(2), 245–252. <https://doi.org/10.1007/s00431-015-2626-1>
- Núñez, J. L., & León, J. (2016). The mediating effect of intrinsic motivation to learn on the relationship between Student's autonomy support and vitality and deep learning. *The Spanish Journal of Psychology*, 19, E42. <https://doi.org/10.1017/sjp.2016.43>
- Opendakker, M.-C. (2021). Need-supportive and need-thwarting teacher behavior: Their importance to boys' and girls' academic engagement and procrastination behavior. *Frontiers in Psychology*, 12, Article 628064. <https://doi.org/10.3389/fpsyg.2021.628064>
- Orsini, C. A., Binnie, V. I., & Tricio, J. A. (2018). Motivational profiles and their relationships with basic psychological needs, academic performance, study strategies, self-esteem, and vitality in dental students in Chile. *Journal of Educational Evaluation for Health Professions*, 15:11. <https://doi.org/10.3352/jeehp.2018.15.11>
- Paloš, R., Maricuțoiu, L. P., & Costea, I. (2019). Relations between academic performance, student engagement and student burnout: A cross-lagged analysis of a two-wave study. *Studies in Educational Evaluation*, 60, 199–204. <https://doi.org/10.1016/j.stueduc.2019.01.005>
- Papinczak, T., Young, L., Groves, M., & Haynes, M. (2008). Effects of a metacognitive intervention on students' approaches to learning and self-efficacy in a first year medical course. *Advances in Health Sciences Education*, 13(2), 213–232. <https://doi.org/10.1007/s10459-006-9036-0>
- Phan, H. P., & Deo, B. (2007). The revised learning process questionnaire: A validation of a Western model of students' study approaches to the South Pacific context using confirmatory factor analysis. *British Journal of Educational Psychology*, 77(3), 719–739. <https://doi.org/10.1348/000709906X158339>
- Pietarinen, J., Soini, T., & Pyhältö, K. (2014). Students' emotional and cognitive engagement as the determinants of well-being and achievement in school. *International Journal of Educational Research*, 67, 40–51. <https://doi.org/10.1016/j.ijer.2014.05.001>
- Platow, M. J., Mavor, K. I., & Grace, D. M. (2013). On the role of discipline-related self-concept in deep and surface approaches to learning among university students. *Instructional Science*, 41(2), 271–285. <https://doi.org/10.1007/s11251-012-9227-4>

- Poorthuis, A. M., Juvonen, J., Thomaes, S., Denissen, J. J., Orobio de Castro, B., & Van Aken, M. A. (2015). Do grades shape students' school engagement? The psychological consequences of report card grades at the beginning of secondary school. *Journal of Educational Psychology, 107*(3), 842–854. <https://doi.org/10.1037/edu0000002>
- Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics, 31*(4), 437–448. <https://doi.org/10.3102/10769986031004437>
- Rasbash, J., Steele, F., Browne, W. J., & Goldstein, H. (2020). *A user's guide to MLwiN, v3.05*. Centre for Multilevel Modelling, University of Bristol.
- Ratelle, C. F., & Duchesne, S. (2014). Trajectories of psychological need satisfaction from early to late adolescence as a predictor of adjustment in school. *Contemporary Educational Psychology, 39*(4), 388–400. <https://doi.org/10.1016/j.cedpsych.2014.09.003>
- Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (Vol. 1). Sage.
- Reeve, J., & Cheon, S. H. (2021). Autonomy-supportive teaching: Its malleability, benefits, and potential to improve educational practice. *Educational Psychologist, 56* (1), 54–77. <https://doi.org/10.1080/00461520.2020.1862657>
- Richer, S. F., & Vallerand, R. J. (1998). Construction et validation de l'échelle du sentiment d'appartenance sociale (Construction and validation of the perceived relatedness scale). *Revue Européenne de Psychologie Appliquée, 48*, 129–137.
- Riglin, L., Frederickson, N., Shelton, K. H., & Rice, F. (2013). A longitudinal study of psychological functioning and academic attainment at the transition to secondary school. *Journal of Adolescence, 36*(3), 507–517. <https://doi.org/10.1016/j.adolescence.2013.03.002>
- Rogers, M., & Tannock, R. (2018). Are classrooms meeting the basic psychological needs of children with ADHD symptoms? A self-determination theory perspective. *Journal of Attention Disorders, 22*(14), 1354–1360. <https://doi.org/10.1177/1087054713508926>
- Ryan, R. M., & Deci, E. L. (2016). Facilitating and hindering motivation, learning, and well-being in schools. In K. R. Wenzel, & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 96–119). Routledge/Taylor & Francis Group.
- Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. New York: Guilford Publishing.
- Salamonson, Y., Weaver, R., Chang, S., Koch, J., Bhathal, R., Khoo, C., & Wilson, I. (2013). Learning approaches as predictors of academic performance in first year health and science students. *Nurse Education Today, 33*(7), 729–733. <https://doi.org/10.1016/j.nedt.2013.01.013>
- Schneider, W. (2008). The development of metacognitive knowledge in children and adolescents: Major trends and implications for education. *Mind, Brain, and Education, 2*(3), 114–121. <https://doi.org/10.1111/j.1751-228X.2008.00041.x>
- Schneider, S., Nebel, S., Beege, M., & Rey, G. D. (2018). The autonomy-enhancing effects of choice on cognitive load, motivation and learning with digital media. *Learning and Instruction, 58*, 161–172. <https://doi.org/10.1016/j.learninstruc.2018.06.006>
- Schnitzler, K., Holzberger, D., & Seidel, T. (2021). All better than being disengaged: Student engagement patterns and their relations to academic self-concept and achievement. *European Journal of Psychology of Education, 36*(3), 627–652. <https://doi.org/10.1007/s10212-020-00500-6>
- Shukla, K., Konold, T., & Cornell, D. (2016). Profiles of student perceptions of school climate: Relations with risk behaviors and academic outcomes. *American Journal of Community Psychology, 57*(3–4), 291–307. <https://doi.org/10.1002/ajcp.12044>
- Sievertsen, H. H., Gino, F., & Piovesan, M. (2016). Cognitive fatigue influences students' performance on standardized tests. *Proceedings of the National Academy of Sciences, 113*(10), 2621–2624. <https://doi.org/10.1073/pnas.1516947113>
- Standage, M., Duda, J. L., & Ntoumanis, N. (2003). A model of contextual motivation in physical education: Using constructs from self-determination and achievement goal theories to predict physical activity intentions. *Journal of Educational Psychology, 95* (1), 97–110. <https://doi.org/10.1037/0022-0663.95.1.97>
- Stevens, J. P. (2012). *Applied multivariate statistics for the social sciences*. Routledge.
- Tao, X. (2021, April). Ways to promote students' deep learning in English teaching based on computer technology. *Journal of Physics: Conference Series, 1881*(2), 022042. <https://doi.org/10.1088/1742-6596/1881/2/022042>. IOP Publishing.
- Taylor, I. M., Ntoumanis, N., Standage, M., & Spray, C. M. (2010). Motivational predictors of physical education students' effort, exercise intentions, and leisure-time physical activity: A multilevel linear growth analysis. *Journal of Sport and Exercise Psychology, 32*(1), 99–120. <https://doi.org/10.1123/jsep.32.1.99>
- Ter Wolbeek, M., Van Doornen, L. J., Kavalaars, A., & Heijnen, C. J. (2006). Severe fatigue in adolescents: A common phenomenon? *Pediatrics, 117*(6), e1078–e1086. <https://doi.org/10.1542/peds.2005-2575>
- Tian, L., Chen, H., & Huebner, E. S. (2014). The longitudinal relationships between basic psychological needs satisfaction at school and school-related subjective well-being in adolescents. *Social Indicators Research, 119*(1), 353–372. <https://doi.org/10.1007/s11205-013-0495-4>
- Tian, L., Tian, Q., & Huebner, E. S. (2016). School-related social support and adolescents' school-related subjective well-being: The mediating role of basic psychological needs satisfaction at school. *Social Indicators Research, 128*(1), 105–129. <https://doi.org/10.1007/s11205-015-1021-7>
- Tuominen-Soini, H., Salmela-Aro, K., & Niemivirta, M. (2012). Achievement goal orientations and academic well-being across the transition to upper secondary education. *Learning and Individual Differences, 22*(3), 290–305. <https://doi.org/10.1016/j.lindif.2012.01.002>
- Ulstad, S. O., Halvari, H., Sørebo, Ø., & Deci, E. L. (2016). Motivation, learning strategies, and performance in physical education at secondary school. *Advances in Physical Education, 6*(1), 27–41. <https://doi.org/10.4236/ape.2016.61004>
- Upadaya, K., & Salmela-Aro, K. (2013). Development of school engagement in association with academic success and well-being in varying social contexts: A review of empirical research. *European Psychologist, 18*(2), 136–147. <https://doi.org/10.1027/1016-9040/a000143>
- Urhahne, D., Chao, S. H., Florineth, M. L., Luttenberger, S., & Paechter, M. (2011). Academic self-concept, learning motivation, and test anxiety of the underestimated student. *British Journal of Educational Psychology, 81*(1), 161–177. <https://doi.org/10.1348/000709910X504500>
- van Rooij, E. C., Jansen, E. P., & van de Grift, W. J. (2017). Secondary school students' engagement profiles and their relationship with academic adjustment and achievement in university. *Learning and Individual Differences, 54*, 9–19. <https://doi.org/10.1016/j.lindif.2017.01.004>
- Vandenkerckhove, B., Soenens, B., Van der Kaap-Deeder, J., Brenning, K., Luyten, P., & Vansteenkiste, M. (2019). The role of weekly need-based experiences and self-criticism in predicting weekly academic (mal) adjustment. *Learning and Individual Differences, 69*, 69–83. <https://doi.org/10.1016/j.lindif.2018.11.009>
- Vansteenkiste, M., Aelterman, N., De Muynck, G. J., Haerens, L., Patall, E., & Reeve, J. (2018). Fostering personal meaning and self-relevance: A self-determination theory perspective on internalization. *The Journal of Experimental Education, 86*(1), 30–49. <https://doi.org/10.1080/00220973.2017.1381067>
- Vansteenkiste, M., Zhou, M., Lens, W., & Soenens, B. (2005). Experiences of autonomy and control among Chinese learners: Vitalizing or immobilizing? *Journal of Educational Psychology, 97*, 468–483. <https://doi.org/10.1037/0022-0663.97.3.468>
- Varni, J. W., & Limbers, C. A. (2008). The PedsQL™ multidimensional fatigue scale in young adults: Feasibility, reliability and validity in a university student population. *Quality of Life Research, 17*(1), 105–114. <https://doi.org/10.1007/s11136-007-9282-5>
- Wang, M. T., Chow, A., Hofkens, T., & Salmela-Aro, K. (2015). The trajectories of student emotional engagement and school burnout with academic and psychological development: Findings from Finnish adolescents. *Learning and Instruction, 36*, 57–65. <https://doi.org/10.1016/j.learninstruc.2014.11.004>
- Wang, M. T., & Eccles, J. S. (2012). Adolescent behavioral, emotional, and cognitive engagement trajectories in school and their differential relations to educational success. *Journal of Research on Adolescence, 22*(1), 31–39. <https://doi.org/10.1111/j.1532-7795.2011.00753.x>
- Wang, C., Hsu, H. C. K., Bonem, E. M., Moss, J. D., Yu, S., Nelson, D. B., & Levesque-Bristol, C. (2019a). Need satisfaction and need dissatisfaction: A comparative study of online and face-to-face learning contexts. *Computers in Human Behavior, 95*, 114–125. <https://doi.org/10.1016/j.chb.2019.01.034>
- Wang, Y., Tian, L., & Huebner, E. S. (2019b). Basic psychological needs satisfaction at school, behavioral school engagement, and academic achievement: Longitudinal reciprocal relations among elementary school students. *Contemporary Educational Psychology, 56*, 130–139. <https://doi.org/10.1016/j.cedpsych.2019.01.003>
- Wang, C. J., Liu, W. C., Kee, Y. H., & Chian, L. K. (2019c). Competence, autonomy, and relatedness in the classroom: Understanding students' motivational processes using the self-determination theory. *Heliyon, 5*(7), Article e01983. <https://doi.org/10.1016/j.heliyon.2019.e01983>
- Warburton, V. E., Wang, J. C., Bartholomew, K. J., Tuff, R. L., & Bishop, K. (2020). Need satisfaction and need frustration as distinct and potentially co-occurring constructs: Need profiles examined in physical education and sport. *Motivation and Emotion, 44* (1), 54–66. <https://doi.org/10.1007/s11031-019-09798-2>
- White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review, 66*, 297–333. <https://doi.org/10.1037/h0040934>
- Widlund, A., Tuominen, H., & Korhonen, J. (2021). Development of school engagement and burnout across lower and upper secondary education: Trajectory profiles and educational outcomes. *Contemporary Educational Psychology, 66*, Article 101997. <https://doi.org/10.1016/j.cedpsych.2021.101997>
- Wigfield, A., Byrnes, J. P., & Eccles, J. S. (2006). Development during early and middle adolescence. In P. H. Winne (Ed.), *5. Handbook of educational psychology* (pp. 87–113).
- Zimmerman, B. J., & Schunk, D. H. (2011). *Handbook of self-regulation of learning and performance*. Routledge/Taylor & Francis Group.
- Zhen, R., Liu, R. D., Ding, Y., Wang, J., Liu, Y., & Xu, L. (2017). The mediating roles of academic self-efficacy and academic emotions in the relation between basic psychological needs satisfaction and learning engagement among Chinese adolescent students. *Learning and Individual Differences, 54*, 210–216. <https://doi.org/10.1016/j.lindif.2017.01.017>
- Zhen, R., Liu, R. D., Ding, Y., Liu, Y., Wang, J., & Xu, L. (2018). The moderating role of intrinsic value in the relation between psychological needs support and academic engagement in mathematics among Chinese adolescent students. *International Journal of Psychology, 53*(4), 313–320. <https://doi.org/10.1002/ijop.12374>
- Zwick, R., & Himelfarb, I. (2011). The effect of high school socioeconomic status on the predictive validity of SAT scores and high school grade-point average. *Journal of Educational Measurement, 48*(2), 101–121. <https://doi.org/10.1111/j.1745-3984.2011.00136.x>