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Fostering excellence: Nurturing motivation and performance among high- and average-ability students through need-supportive teaching

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A R T I C L E I N F O

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A B S T R A C T

When students with high cognitive abilities disengage from school, this implies a severe loss of talent to students themselves and to society. Hence, it is important to understand how teachers can prevent disengagement and underachievement in high-ability students. Whereas a large body of research has demonstrated that need-supportive teaching (i.e., the provision of autonomy support, involvement, and structure) and differentiated instruction relate positively to students' academic development, it remains unclear whether such practices would be equally, more, or less beneficial for high-ability students. Drawing on data from a longitudinal four-wave study among early adolescents from Flanders ($N = 3586$), this study showed that need-supportive teaching in math classes was positively associated with intrinsic motivation, behavioral engagement, and math performance in high-ability students, both at the level of between-student differences and at the level of changes in students over time. Standardized estimates were typically between 0.05 and 0.20 at the between-person level, indicating small effect sizes, with more modest effect sizes at the within-person level. Importantly, these associations were found to be generally equivalent across high- and average-ability students. Comparing the provision of need-supportive teaching to either high- or average-ability students, high-ability students particularly reported more autonomy support from their math teachers than average-ability students, with small effect sizes (i.e., Cohen's d between 0.16 and 0.27). These findings underline the importance of need-supportive teaching to support the motivational and academic development of both high- and average-ability students.

1. Introduction

High-ability students, that is, students with above-average cognitive capacities in comparison with their age groups, often excel at school (Lubinski et al., 2014). However, not all students with high cognitive capacities actualize their potential (Lavrijsen et al., 2020; Snyder et al., 2019). A lack of motivation for school appears to be an important factor explaining underachievement in these high-ability students (McCoach & Siegle, 2003; Preckel et al., 2006; Ramos et al., 2022; Snyder & Linnenbrink-Garcia, 2013). To ensure

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that high-ability students fulfill their potential, it is thus of prime importance to foster their motivation for school.

The present study addressed the crucial role of teachers in supporting the motivational development of high-ability students. According to Self-Determination Theory (SDT), students thrive when their basic psychological needs for autonomy, relatedness, and competence are supported by their teachers (Ryan & Deci, 2017; Vansteenkiste et al., 2020). In the general student population, need-supportive teaching, as conveyed through the provision of autonomy support, involvement, and structure, has indeed regularly been associated with student motivation (Stroet et al., 2013). However, it is not yet clear whether these findings also apply to the specific case of high-ability students. Although recent research suggests that teachers often *believe* that structure would be less effective when interacting with high-ability students in comparison with typically developing students and that providing autonomy support would be more important for these students (Hornstra et al., 2020; Sypré et al., 2023), it remains unclear whether associations between need-supportive teaching and student motivation and achievement indeed differ between high- and average-ability students. This study thus investigated how student perceived need-supportive teaching affects the motivational and academic development of high-ability students and whether the strength of these associations varies as a function of the ability level of students.

1.1. Need-supportive teaching

SDT is a comprehensive theoretical framework describing human motivation as the result of the satisfaction of three basic psychological needs, including (a) autonomy, (b) relatedness, and (c) competence (Deci & Ryan, 2002; Ryan & Deci, 2020). First, the theory postulates that humans have a basic need for autonomy, which denotes the experience of a sense of volition, psychological freedom, and authenticity in one's actions, thoughts, and feelings. In the academic context, students may feel autonomous when they experience that their learning process matches their values and preferences and when they can engage in learning without feeling pressured (Niemiec & Ryan, 2009). Second, humans' need for relatedness denotes the need to develop warm and harmonious relationships characterized by mutual care and intimacy. At school, students will primarily form strong bonds with their peers, but their relationship with their teachers may also affect their feelings of belonging at school (Klassen et al., 2012). Third, people derive fulfilment from utilizing and extending their capabilities as such experiences satisfy their need for competence. In school, this need is satisfied when students experience a sense of mastery, when they can attain desired school outcomes, and when they can both refine and expand their skills (Vansteenkiste et al., 2024).

Beyond the articulation of these three basic needs, SDT proposes ways in which the social context, in particular teachers, can either support or thwart students' needs. In particular, students' basic needs may be promoted when teachers provide students with autonomy support, involvement, and structure. First, autonomy-supportive teaching offers students learning tasks they perceive to be relevant and meaningful and allows students to choose tasks that match their interests and preferences (Cheon et al., 2020; Reeve et al., 2004). Teachers may further enhance feelings of autonomy in their students when they use inviting (e.g., "I suggest" or "you may") or informational (e.g., "Let's take a look at how you have solved the task") language instead of controlling (e.g., "Now you should start doing this task") or evaluative (e.g., "You have to perform at least equally well as before") language (Mabbe et al., 2018). Similarly, teachers could accept students' resistance instead of suppressing it or inducing shame and guilt; that is, they could consider the students' perspectives without immediately judging or confronting it and help students to realize that their behavior is contrary to their goals while encouraging students to come up with alternative behaviors themselves (Reeve & Cheon, 2021; Soenens et al., 2015). Second, students have stronger feelings of belonging at school when they perceive their teachers to be involved (Osterman, 2000). For example, teachers may show their students their understanding, unconditional acceptance, and availability for support (Lietaert et al., 2015). Third, to promote students' competence, teachers should provide students with an appropriate amount of structure (Vansteenkiste et al., 2012). For example, teachers may provide clear and explicit instruction (e.g., clarity), monitor their students' progress and provide help when needed (e.g., guidance), and stimulate students to continuously expand their skills (e.g., encouragement; Aelterman et al., 2019; Patall et al., 2024).

Empirically, all three supportive teaching practices (i.e., autonomy support, involvement, and structure) have indeed been repeatedly associated with student motivation and engagement (see Stroet et al., 2013, for a review). Whereas most studies documenting these associations have adopted a cross-sectional design, recent studies have confirmed the benefits of need-supportive teaching using experimental (Waterschoot et al., 2019) and longitudinal study designs (Matos et al., 2018; Patall et al., 2018; Stroet et al., 2015).

1.2. Need-supportive teaching for high-ability students

The present study focused on the benefits of need-supportive teaching for students with high-cognitive ability. Overall, cognitive ability (or intelligence) has been conceptualized as "the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience" (Gottfredson, 1997, p. 13). Students scoring above a certain threshold on a cognitive ability test then are described as having high-cognitive ability; for example, Gagné (2004) proposed defining high-ability students as those scoring within the top 10% of their age group. One significant determinant of underachievement in high-ability students is reduced motivation for school (e.g., Ramos et al., 2022); thus, it is of prime importance to understand how teachers can support school motivation among these students.

In general, SDT postulates that autonomy, relatedness, and competence are universal requirements for thriving, suggesting that their satisfaction would be important for motivational development in every human (Deci & Ryan, 2002). Indeed, need satisfaction has been found to predict enhanced motivation and well-being regardless of characteristics such as cultural background (Nalipay et al., 2020), sex (Guérin et al., 2012), or age (Rodríguez-Meirinhos et al., 2020). Notwithstanding these universal aspirations, the strength of these associations may still depend on cultural and individual characteristics, which has been framed as the "universalism without uniformity" nature of SDT (Ryan et al., 2021; Soenens et al., 2015). Whereas one can expect that supporting basic psychological needs would also matter for high-ability students, it still might be that associations between need-supportive teaching and student motivation would differ in strength between high- and average-ability students.

First, theoretically, it has been argued that autonomy support would be of particularly high importance for high-ability students. Indeed, high-ability students often have strong self-regulatory skills, meaning that they employ effective strategies to initiate, direct, and monitor their learning process (Kettler, 2014; Risemberg & Zimmerman, 1992). Hence, providing these students with a high level of autonomy would enable them to fully experience the benefits of their advanced self-regulatory capacities and would thus particularly promote their motivation (Bouffard-Bouchard et al., 1993; Tortop, 2015). In addition, it has been suggested that a high level of autonomy would help high-ability students circumvent the threat of being underchallenged at school (Figg et al., 2012). In particular, qualitative research has suggested that when high-ability students are granted the opportunity to make their own choices (e.g., regarding the learning material, regarding their learning process), they would be less susceptible to boredom at school (Kanevsky & Keighley, 2003). Among high-ability students, autonomy satisfaction has indeed been associated with less negative affect, fewer withdrawal behaviors, and higher intrinsic motivation (Garn et al., 2012; Garn & Jolly, 2014; Miserandino, 1996), although these studies did not compare high-ability students to other students.

Second, teacher involvement has been related to high-ability students' motivation for school. For example, high-ability students have been reported to highly value teachers who care about their well-being, are nonjudgmental, grant students their respect, and know their students personally (Almukhambetova & Hernández-Torrano, 2020; Kanevsky & Keighley, 2003; Siegle et al., 2014). Furthermore, high-ability students have reported greater engagement when they experienced their relationship with the teacher to be supportive and warm (Steenberghs et al., 2023). Accordingly, models on high-ability achievement, such as the Achievement Orientation Model (Siegle & McCoach, 2005), underline the importance of teacher closeness and support for the academic development of high-ability students. However, it remains unclear whether teacher involvement would be particularly important for high-ability students as compared to average-ability students.

Finally, structure (i.e., offering clear instructions and providing appropriate guidance) has been argued to support the motivational and academic development of high-ability students (VanTassel-Baska & Stambaugh, 2005). Again, however, it remains to be seen whether structure would be more, less, or equally important to high-ability students' motivation as compared to other students. A particularly critical issue for high-ability students might be that to nurture their need for competence, students should have the opportunity to continuously expand their skills beyond their current capacities. However, high-ability students often report being underchallenged at school (Gallagher et al., 1997; Kanevsky & Keighley, 2003; Snyder & Linnenbrink-Garcia, 2013). Hence, differentiated instruction (i.e., appropriately adapting instruction to students' cognitive needs to ensure that all students can fully develop their capacities in school; Tomlinson, 2000, 2015) has been suggested to be of relevance for high-ability students (Bailey et al., 2012; Barbier et al., 2023).

Overall, these studies suggest that need-supportive teaching might be beneficial for high-ability students. However, few studies have empirically assessed whether a need-supportive teaching style would matter more or would matter less for high-ability students as compared to typically developing students. In a Dutch study, Bakx et al. (2019) asked 428 students from regular primary schools and 463 students from gifted educational programs to indicate which need-supportive practices characterized a good teacher to them. Consistent with the universality without uniformity principle (Soenens et al., 2015), gifted and non-gifted students indicated that a good teacher had to be autonomy supportive, involved, and structured. Students from gifted programs mentioned autonomy support somewhat less often, involvement equally often, and structure more often than students from regular classes, but these differences were not statistically significant. Students from gifted classes particularly valued teachers providing cognitively challenging instruction. Of note, findings from Bakx et al. (2019) should be interpreted with caution as all gifted respondents were recruited from special gifted programs, which may have affected their actual level of need satisfaction and the perceived importance of being provided need-supportive teaching. For example, gifted programs usually offer students more opportunities for independent work than regular classrooms (Kitsantas et al., 2017); when this would sufficiently satisfy students' need for autonomy, students in these programs might have been less inclined to mention autonomy support as an important teacher characteristic (Bakx et al., 2019). In a longitudinal Flemish study following 5172 students between Grades 5 and 7, measures of involvement (i.e., the quality of the teacher-student relationship) and structure (i.e., clarity of instruction) were found to be equally predictive of learning goal orientations between high- and average-ability students (Ramos et al., 2021). Autonomy support was not addressed in Ramos et al. (2021).

Finally, the most comprehensive attempt to compare effects of need-supportive teaching between high- and average-ability students was a Dutch study among 1975 Grade 3–6 students (Hornstra et al., 2020). In this study, teacher-reported provision of autonomy support, involvement, and structure were all found to be related to student motivation. Importantly, these associations were found to be similar in size between students nominated by the teacher as gifted and their classmates who were not nominated as such. However, notwithstanding the merits of Hornstra et al. (2020), its implications were restricted due to three limitations. First, the study was cross-sectional, precluding studying within-student changes over time, which would be highly informative from a developmental perspective (Curran & Bauer, 2011). Second, gifted students were identified by teacher nomination. However, such nominations tend to be biased towards more engaged and higher achieving students (Lavrijsen & Verschueren, 2020; Machts et al., 2016). Moreover, the control group included all students not nominated by their teacher as gifted; as a result, this control group might have been highly heterogenous, thereby masking differences between gifted and non-gifted students. For example, the control group possibly included students with high cognitive ability not recognized as such by their teachers, and students with very low ability, whose motivational needs may differ from other students (Estreder et al., 2023; Nurmi et al., 2013). Third, the study relied on single-item measures to capture need-supportive teaching practices. In particular, teacher provision of structure was measured as giving students "a lot of help and guidance during learning". Such a measure does not yet capture whether teachers also supported students in expanding their capacities, for example, by differentiating instruction to student skills (Bakx et al., 2019). Of note, research on within-class grouping, which is a particular form of differentiated instruction where teachers create homogeneous groups within classes to tailor instruction to the skill level of each group, has been reported to be particularly beneficial to students with high abilities (Steenbergen-Hu et al., 2016).

The present study thus expanded prior work by investigating links between need-supportive teaching and student outcomes in a longitudinal study by using a standardized cognitive ability test to distinguish between high- and average-ability students and by assessing, beyond autonomy support, involvement, and structure, the merits of differentiated instruction for high-ability students.

1.3. The provision of need-supportive teaching to high-ability students

Apart from addressing the potentially differential importance of need-supportive teaching between high- and average-students, this study also assessed student-perceived descriptive differences in the level of teacher *provision* of such practices. In particular, two recent studies have suggested that teachers may differ in their use of need-supportive teaching style in interaction with high-ability relative to average-ability students. First, in Hornstra et al. (2020) as discussed above, 80 Dutch primary school teachers rated their use of autonomy support, involvement, and structure towards individual students using single-item measures based on the Teacher as Social Context questionnaire (Belmont et al., 1988).[1] These ratings were then compared between students who had been nominated by their teacher as gifted and their non-nominated classmates. Teachers tended to provide students who were perceived as gifted with more autonomy, equal levels of involvement, and less structure than their classmates.

Similar findings were obtained by Sypré et al. (2023), who in a sample of 122 Flemish secondary school teachers described teachers' interactions with students who teachers believed to be either high- or average-ability using an adapted version of the Situations-in-School Questionnaire (Aelterman et al., 2019). Sypré et al. indicated that teachers were more autonomy-supportive and less structuring in relation with high-ability students; involvement was not addressed. Importantly, this study assessed teachers' *beliefs* about the differential effects of need-supportive practices between high- and average-ability students. In particular, teachers indicated that autonomy support would be more effective in dealing with high- relative to average-ability students. In addition, teachers held the belief that structure would be less effective when interacting with high-ability students. Presumably, teachers believe that because of their advanced capacities, high-ability students can make it "on their own", that is, without further teacher guidance (De Boer et al., 2013). Of note, as discussed above, these teacher beliefs seem to be somewhat at odds with empirical findings suggesting that for high-ability students, structure would be just as important as for other students (Hornstra et al., 2020; Ramos et al., 2021).

Beyond teacher reports of their provision of need-supportive teaching, the present study assessed how high- and average-ability students themselves experienced need-supportive teaching. These student perceptions of teacher behavior might differ somewhat from teacher beliefs and intentions. Recent research emphasizes that teachers need to calibrate their need-supportive approach to both student and situational characteristics (Vansteenkiste et al., 2019); for example, in highly unfamiliar learning situations, students may prefer their teacher to "lead the way" and to be clarifying rather than participative (Vansteenkiste et al., 2019). As students' perceptions of need-supportive teaching practices, rather than teachers' intentions, can be expected to affect students' motivational functioning (Stroet et al., 2013), the present study evaluated whether high-ability students experienced their teachers to be more, equally, or less autonomy supportive, involved, and structured than average-ability students.

1.4. Present study

This study investigated the benefits of need-supportive teaching for the motivational and academic functioning of high- and average-ability students in a large longitudinal community sample of Flemish early adolescents. Following the transition to secondary education, motivation for school often declines (Engels et al., 2017, 2021; Gottfried et al., 2001) and teachers have been identified as playing a critical role in supporting early adolescents' school engagement at this stage (Engels et al., 2021; Opdenakker & Minnaert, 2011). In addition, the present study specifically focused on mathematics, a subject in which there is considerable variability between students in engagement and achievement (Lazarides & Buchholz, 2019; Watt, 2000), with important implications for further academic outcomes (Lauermann et al., 2017).

The present study adopted a longitudinal design with four measurement occasions to investigate both differences between students and changes within students over time. In each measurement wave, students rated different dimensions (i.e., autonomy support, involvement, and structure) of need-supportive teaching by their math teacher, meaning that students evaluated the degree to which teachers adapted their instruction to students' cognitive needs (i.e., differentiated instruction). The study considered students' motivational functioning and their academic performance as important student outcomes. Regarding their motivational functioning, students' intrinsic motivation for mathematics and students' behavioral engagement during math classes was considered. To have a broad perspective on students' academic performance, both students' math grades and students' performance on a standardized math test were considered as indicators of achievement.

Associations between need-supportive teaching practices and student outcomes were then established (Fig. 1) and compared between the subgroup of high-ability students, who were identified as students scoring in the top 10% of their age group on a

[1] The single items included Autonomy support (i.e., "I give this student a lot of choices"), Structure (i.e., "I give this student a lot of help and guidance during learning"), and Involvement (i.e., "I have a good relationship with this student").

standardized cognitive ability test, and average-ability students, who were defined as students scoring in the middle 50% of the ability distribution (Gagné, 2004; Lavrijsen & Verschueren, 2023). All analyses controlled for students' gender, which has been repeatedly associated with engagement and achievement in mathematics, although the size and direction of these associations have been inconsistent between studies (e.g., Meece et al., 2006; Preckel et al., 2008; Rimm-Kaufman et al., 2015).

The following research goals and hypotheses were formulated. First, we investigated associations between each dimension of need-supportive teaching (i.e., autonomy support, involvement, structure, and differentiated instruction) and student outcomes (i.e., intrinsic motivation for mathematics, students' behavioral engagement during math classes, and students' math achievement) in the general population (i.e., full sample). Although such associations have been repeatedly documented in cross-sectional studies (Stroet et al., 2013), this study investigated these associations longitudinally, distinguishing between the between-student (i.e., whether students who perceived their teachers to be need-supportive were, on average, more motivated and engaged) and the within-student level (i.e., whether students were particularly motivated and engaged at times they perceived their teacher to be particularly need-supportive). Consistent with previous research, we expected positive associations between each dimension of need-supportive teaching and student outcomes at both levels (Pekrun & Marsh, 2022).

Second, associations between need-supportive teaching and student outcomes were compared between high- and average-ability students. Based on SDT's universal perspective, we expected need-supportive teaching to be important for both high-ability and typically developing students. Whereas Hornstra et al. (2020) did not find these associations to differ between these groups, there are some theoretical considerations (Kettler, 2014) that suggest that autonomy support would be highly important for high-ability students. Hence, we expected that associations between autonomy support and student outcomes would be somewhat more pronounced among high-ability students as compared to average-ability students. For the relationships between teacher involvement or teacher structure and student outcomes, there were no sound theoretical reasons to expect differences between high- and average-ability students; thus, consistent with Hornstra et al. (2020), we did not hypothesize any differences in these relationships between both groups. Finally, for students with high cognitive ability, a good fit between student skills and instructional challenge have been proposed to be most critical (Barbier et al., 2023; Steenbergen-Hu et al., 2016). Hence, we expected that differentiated instruction would matter somewhat more for high-ability students relative to average-ability students.

Finally, student-perceived levels of teacher provision of autonomy support, involvement, structure, and differentiated instruction were compared between high- and average-ability students. Previous research suggests that teachers tend to provide more autonomy support, less structure, and equal levels of involvement to gifted compared to non-gifted students (Hornstra et al., 2020; Sypré et al., 2023), although this may not necessarily translate into student perceptions (Bakx et al., 2019). In addition, within gifted education, differentiating instruction to student capacities has regularly been promoted to meet the cognitive needs of students with outstanding abilities (Barbier et al., 2023). Hence, we expected student perceptions of differentiated instruction to be higher among high-ability students than among average-ability students. In these comparisons, we distinguished between differences at the class level (i.e., whether teachers provide more need-supportive practices or less need-supportive practices in classes with many high-ability students) and at the individual level (i.e., whether teachers, within a single class, provide high-ability students with more need-supportive practices or less need-supportive practices as compared to their average-ability classmates).

2. Method

2.1. Participants

This study was conducted among a sample of 3586 students (50.3% males; $M_{\text{age}} = 12.4$ years at first measurement occasion [i.e., Wave 1]) from 166 classes within 27 schools during the first 2 years of secondary school within the context of the large-scale TALENT study in Flanders (Belgium). The TALENT study, which took place from Fall 2017 to Spring 2019, was an interuniversity project that was designed to investigate psychosocial, motivational, and academic development among high-ability students. Among participating schools, all students in the A-stream were invited to participate.[2] After completing a cognitive ability test at the start of Grade 7, students were asked to fill out questionnaires in the fall and spring of Grade 7 and the fall and spring of Grade 8. In addition, math tests were administered during Wave 1, Wave 2, and Wave 4. The study was approved by the Ethical Committee of KU Leuven. Prior to conducting the study, we obtained informed consent from students and their parents.

2.2. Measures

For all measures, composite scores were calculated as the arithmetic mean scores across all items.

2.2.1. Need-supportive teaching: autonomy support, involvement, and structure

Students rated need-supportive teaching by their math teacher with a short version of the Teacher as Social Context Questionnaire (TASCQ; Belmont et al., 1988). The TASCQ is one of the most prominent measures of students' perceptions of need-supportive teaching (e.g., Baeten et al., 2013; Haerens et al., 2013; Sierens et al., 2009). Because participants in the larger project from which the current

[2] In Flanders, students who successfully complete primary education (typically about 85%–90% of the population) start secondary education in a program with a largely shared curriculum and a strong emphasis on basic education (A-stream). Students who do not successfully complete primary education and students with severe learning disabilities are referred to vocational preparatory or special education programs.

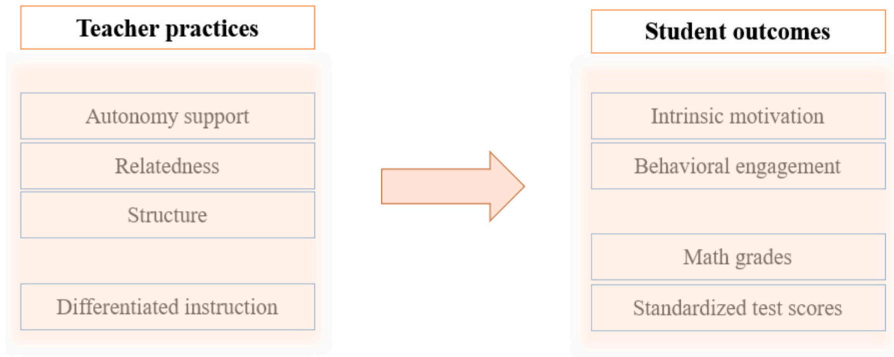

Fig. 1. Conceptual Model of the Associations between Need-Supportive Teaching Practices and Students' Motivational and Academic Outcomes.

data were drawn completed an extended battery of questionnaires, the measures had to be as concise as possible. Therefore, measures were shortened by selecting items that loaded highest in factor analyses (e.g., Gogol et al., 2014) on previously collected independent samples, which also validated the translation of the scale to Dutch (Sierens et al., 2009). All items were scored by students on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*very much*). Autonomy support was measured with four items (e.g., "My math teacher lets me choose how I deal with my schoolwork"). Across four waves, internal consistency ($\alpha_{W1} = 0.55$; $\alpha_{W2} = 0.57$; $\alpha_{W3} = 0.61$; $\alpha_{W4} = 0.59$) was marginally acceptable (Taber, 2018). Involvement was measured with four items (e.g., "My math teacher really cares about me"). Across the four waves, internal consistency was good ($\alpha_{W1} = 0.79$; $\alpha_{W2} = 0.83$; $\alpha_{W3} = 0.79$; $\alpha_{W4} = 0.82$). Finally, structure was measured with four items (e.g., "My math teacher checks if I'm ready before moving on"); one item that reduced the internal consistency of the scale was removed so that adequate internal consistency could be reached ($\alpha_{W1} = 0.66$; $\alpha_{W2} = 0.70$; $\alpha_{W3} = 0.71$; $\alpha_{W4} = 0.74$).

2.2.2. *Need-supportive teaching: differentiated instruction*

Student perceptions of differentiated instruction were measured with six items. Four items were derived from the scale documented by Bos et al. (2005) that assesses the degree to which teachers customize tasks to student capacities (e.g., "My math teacher gives students with different capacities different tasks"). To increase the reliability of the scale, two items were added (i.e., "My math teacher manages to instruct students with different capacities differently" and "My math teacher manages to let students with different capacities help each other"). Construct validity of the extended and translated instrument has been documented in previous research that has used the scale to describe how teachers respond to differences in ability between students (Lavrijsen, Dockx, et al., 2022). All items were responded to by students on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*very much*). The internal consistency was acceptable ($\alpha_{W1} = 0.68$; $\alpha_{W2} = 0.69$; $\alpha_{W3} = 0.70$; $\alpha_{W4} = 0.74$).

2.2.3. *Intrinsic motivation for mathematics*

Students' intrinsic motivation for mathematics was measured with the two intrinsic value items from the well-established expectancy-value framework by Eccles and Wigfield (1995; e.g., "I like working on math assignments and I like doing math"). The validity of these items, which were translated to Dutch as part of a previous research project (Denies et al., 2017), to capture intrinsic value has been repeatedly documented (e.g., Gaspard et al., 2020; Lauermann et al., 2017; Lazarides et al., 2020). The items were rated on a 5-point Likert-scale ranging from 1 (*not at all*) to 5 (*very much*) and showed good reliability ($\alpha_{W1} = 0.82$; $\alpha_{W2} = 0.82$; $\alpha_{W3} = 0.80$; $\alpha_{W4} = 0.82$).

2.2.4. *Behavioral engagement in math classes*

Students' behavioral engagement was measured with a shortened version of Skinner et al.'s (2008) questionnaire by using five items assessing students' effort, attention, and persistence in math classes (e.g., "I try hard to do well in math classes"). The items were rated on a 5-point Likert-scale ranging from 1 (*not at all*) to 5 (*very much*). The questionnaire, which was translated to Dutch as part of a previous research project on Flemish adolescents (Engels et al., 2017), has been widely used; construct validity (e.g., Engels et al., 2017, 2021; Steenberghs et al., 2023) and factor-analytical behavior (Immekus & Ingle, 2019) have been repeatedly documented. Internal consistency was high ($\alpha_{W1} = 0.83$; $\alpha_{W2} = 0.85$; $\alpha_{W3} = 0.83$; $\alpha_{W4} = 0.85$).

2.2.5. *Math grades*

Schools provided student math grades for the first and second terms of each academic year. Students are graded with a score between 0 and 100. As Flemish schools have full autonomy over their grading policy, grades were standardized within schools to account for differences in the meaning of grades between schools.

2.2.6. *Standardized mathematics test*

Items were adopted from the LiSO-test (Loopbanen in het Secundair Onderwijs), a standardized mathematics test lasting 2 h that has demonstrated good reliability and validity (Dockx et al., 2017). Each test included 36 items; on average, students obtained a score equal to 18.57 out of 36 (Wave 1), 19.55 out of 36 (Wave 2) and 20.10 out of 36 (Wave 3). Item response theory (IRT) analyses confirmed that the test measured one underlying math competency and that the test had good marginal reliabilities (Wave 1 = 0.89; Wave 2 = 0.86; Wave 4 = 0.86). Based on the IRT analyses, raw test scores were converted into math achievement scores using Weighted Likelihood Estimation (Warm, 1989).

2.2.7. High- and average-cognitive ability

General intelligence was measured at the beginning of the study (October 2017). Each student completed a cognitive test (Cognitieve Vaardigheidstest volgens CHC-model [CoVaT-CHC]; Magez et al., 2015) measuring both fluid and crystallized intelligence. The CoVaT-CHC builds on other validated cognitive tests within the CHC-model of intelligence (Horn & Cattell, 1966) and has demonstrated both content (Tierens, 2015) and criterion validity (Magez & Bos, 2015). The IQ for each student was calculated based on a comparison of test results with a representative norming sample, resulting in a score with population $M = 100$ and $SD = 15$. High-ability students were identified as scoring in the top 10% of the norming sample (i.e., IQ $\geq$ 120); these students were compared to average-ability students scoring in the middle 50% of the intelligence distribution (i.e., IQ between 90 and 110).[3]

2.2.8. Gender

Gender was coded with males as the reference category (0).

2.2.9. Time

Time was coded as 0 for Wave 1, 1 for Wave 2, 2 for Wave 3, and 3 for Wave 4. In addition, a squared term was added to control for non-linear change.

2.3. Missing data

Throughout the course of any longitudinal study, some students leave the study whereas other students may enter the study. In the present study, this was particularly due to students changing schools (i.e., either leaving a participating school or entering a participating school during the study). In the Flemish education system, changing schools often happens at the end of the school year. As data were collected during classes, some students missed one or more data collection periods because they were absent (e.g., due to illness). At the start of the present study, 3409 students consented to participate.

The sample for Wave 1 (i.e., fall of Grade 7) included 3040 students, with 369 students (i.e., 10.8% of the original sample) being absent at the time of the data collection. The sample for Wave 2 (i.e., spring of Grade 7) included 3090 students, with 319 students (i.e., 9.4% of the original sample) being absent at the time of this data collection. At the start of Grade 8, there was both an influx of 168 new students from other schools in the study sample and 538 students who left a participating school, which reduced the sample by 370 students. Of the 3039 students that were then in the sample, 2840 students participated in Wave 3 (i.e., an absence rate of 6.5%) and 2738 students in Wave 4 (i.e., an absence rate of 9.9%). Importantly, differences in motivational measures between the group of students who stayed in the study and the group of students who left the study between waves were very small (e.g., the average value for intrinsic motivation for mathematics was $d = 0.04$ higher in the first group). To ensure maximal use of the sample, Restricted Maximum Likelihood estimation was used, meaning that parameters were estimated by maximizing a likelihood function indicating the probability to observe the available data. With this method, observations with missing values did not have to be discarded and all available information was used to estimate the model.

2.4. Analysis plan

For all statistical analyses, the software package SAS was used (SAS Institute Inc., 2023). To assess associations between need-supportive teaching and student outcomes, multilevel analyses were performed predicting intrinsic motivation, behavioral engagement, math grades, and standardized math test achievement based on student-perceived levels of need-supportive teaching. To differentiate between-student and within-student effects in the longitudinal data, both the students' mean level across the four waves and the student score in each assessment, centered around this mean, were included as predictors (Wang & Maxwell, 2015). Hence, the outcome in a specific wave was modeled to result from both a time-invariant student-level predictor at Level 2 (e.g., how much the student felt the teacher to be generally autonomy-supportive) and from a student-mean centered time-variant predictor at Level 1 (e.g., how much the student felt the teacher to be autonomy-supportive at the time of the assessment compared to the average level of student-perceived autonomy support across all four waves). The resulting estimates thus can be thought to represent "trait" and "state" measures of the teaching variables. Nesting of students in classes was considered by including the class level as a random component.[4] To allow for heterogeneous variances between waves, the multilevel models were estimated using an unstructured residual covariance

[3] Whereas several classifications of intelligence test scores have been proposed, the 90–110 interval typically has been described as the "average ability" group (e.g., Kaufman et al., 2015). Alternative classifications, in particular, defining the average ability group as the students within 1 *SD* of the population mean (i.e., the 85–115 interval) yielded similar results (available from the first author).

[4] Whereas classes were also nested within schools, only a smaller part of the variance was located at the school level. To not overburden the multilevel models, we did not take the school level into account in further analyses.

structure.

Empty models showed that for intrinsic motivation, 5% of the variance was located at the class level (i.e., variability between classes), 41% at the between-student level (i.e., variability between students), and 53% at the within-student level (i.e., variability between waves within a single student). For behavioral engagement, 6% of the variance was located at the class level, 41% at the between-student level, and 53% at the within-student level. For math grades, 10% of the variance was located at the class level, 66% at the between-student level, and 24% at the within-student level. Finally, for achievement on the standardized math test, 37% of the variance was located at the class level, 37% at the between-student level, and 28% at the within-student level.[5]

To answer the research questions, three series of models were estimated. First, to establish general relationships between teaching practices and student outcomes, multilevel models were estimated in the full sample. Second, to focus on the specific associations for high-ability students, similar models were estimated in the subsample of high-ability students only (i.e., IQ $\geq$ 120). Third, to compare high-ability (IQ $\geq$ 120) and average-ability students (IQ = 90–110), an interaction model was estimated contrasting associations between both groups. In all analyses, predictors and outcomes were grand-mean standardized to allow straightforward interpretation of estimates and interaction effects (Enders & Tofighi, 2007). As such, the resulting coefficients can then be interpreted as effect sizes, that is, estimates $\beta < 0.20$ reflect a weak effect, $0.20 < \beta < 0.50$ a moderate effect, and $\beta > 0.50$ a strong effect (Cohen, 1988). To acknowledge that multiple hypotheses were tested, *p*-values in all tables are only emphasized in bold when they were below a Bonferroni-corrected threshold of $0.05/16 = 0.0031$.[6] Furthermore, for each of these models, the share of explained variance was compared to a model not including teaching predictors (i.e., only including gender and a time-trend) to indicate the share of explained variance that can be attributed to the contribution of the teaching variables (Selya et al., 2012). Furthermore, for each model, Akaike Information Criterion (AIC) was calculated as an indication of model fit and compared to that of the model only including gender and time, with a reduction in AIC corresponding to an improvement in model fit.

Finally, for each wave, average student-reported levels of autonomy support, involvement, structure, and differentiated instruction were compared between high- and average-ability students correcting for student gender and for the nesting of students into classes (PROC SURVEYREG). To distinguish between differences at the class level (i.e., whether teachers provide more or less need-supportive practices in classes with many high-ability students) and at the individual level (i.e., whether teachers provide high-ability students with more or less need-supportive practices as compared to their average-ability classmates), two additional models were estimated, one in which class-average values of teaching practices were regressed on student ability status (indicating differences at the class level) and one in which individual reports of teaching practices were regressed on ability status, controlling for the class average levels (indicating differences between students within a single class).

3. Results

3.1. Descriptive statistics

Table 1 reports the descriptive statistics, including means and standard deviations of all variables over all waves, and the correlations between the variables at Wave 1. The results show that, except for a small negative correlation between differentiated instruction and standardized test scores, all teaching practices had positive bivariate correlations to the student outcomes, with mostly moderate associations in the case of intrinsic motivation and behavioral engagement and weaker associations in the case of math achievement.

3.2. Associations between need-supportive teaching and student outcomes

Table 2 reports the results from a multilevel model predicting intrinsic motivation, behavioral engagement, and math achievement in the general population. Autonomy support, involvement, and structure were all uniquely associated with intrinsic motivation and with behavioral engagement. Among these teaching practices, involvement was the most robust predictor of intrinsic motivation and behavioral engagement, although autonomy support and structure were meaningfully associated with both outcomes. Although these associations were mostly modest in size, they were observed both at the between-student and at the within-student level. By contrast, differentiated instruction appeared to have only very small associations with either intrinsic motivation and behavioral engagement, with estimates failing to reach significance at either the between-student (in the case of intrinsic motivation) or the within-student level (in the case of behavioral engagement). Together, need-supportive teaching practices explained 20% (intrinsic motivation) and 23% (behavioral engagement) of the total variance in motivational outcomes. Math achievement, both when operationalized as

[5] The relatively larger share of math achievement variance located at the class level, in comparison to the motivational outcomes, can be interpreted in the context of the Flemish school system, which to a certain degree sorts students in Grades 7 and 8 into different classes according to ability.

[6] Correcting for Type I error is particularly important when one predicts multiple outcomes (i.e., many different tests for a single construct); *p*-values are commonly adjusted by dividing them by the number of hypotheses tested (i.e., Bonferroni-correction). However, scholars have also argued that routinely adjusting *p*-values can jeopardize statistical power (e.g., Gelman & Hill, 2006). This is particularly true when substantially different constructs are assessed as outcomes. In the present study, we had two related outcomes in either the motivational or achievement domain, with four predictors being tested at two levels (between- and within-students). Hence, conservatively, statistical significance of outcomes can be evaluated by contrasting *p*-values to a threshold equal to 0.05 divided by 2*4*2.

Table 1
Descriptive Statistics and Correlations at Wave 1.

	Measure	Wave 1		Wave 2		Wave 3		Wave 4		Correlations								
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	Autonomy support	3.77	0.78	3.73	0.80	3.76	0.82	3.70	0.82									
(2)	Involvement	3.42	0.90	3.32	0.96	3.23	0.93	3.31	0.97	0.52*								
(3)	Structure	3.46	0.94	3.39	0.97	3.41	1.00	3.39	1.01	0.47*	0.65*							
(4)	Differentiated instruction	2.58	0.80	2.66	0.84	2.61	0.84	2.75	0.88	0.03	0.34*	0.40*						
(5)	Intrinsic motivation	3.54	1.12	3.32	1.13	3.28	1.12	3.28	1.14	0.35*	0.42*	0.40*	0.20*					
(6)	Behavioral engagement	4.14	0.70	3.95	0.79	3.98	0.77	3.81	0.84	0.41*	0.40*	0.37*	0.09*	0.48*				
(7)	Math grades	72.03	13.21	67.60	15.21	66.59	14.78	64.57	16.14	0.21*	0.14*	0.06*	0.01	0.23*	0.22*			
(8)	Standardized test score	0.00	1.06	0.42	1.10	.	.	0.91	1.15	0.18*	0.02	0.06*	−0.12*	0.17*	0.10*	0.60*		
(9)	High ability (0 = average ability, 1 = high ability)	11.2%	.	.	.	.	.	.	.	0.06*	−0.03	−0.02	−0.04	0.05*	0.00	0.36*	0.53*	
(10)	Female gender (0 = male, 1 = female)	49.7%	.	.	.	.	.	.	.	0.10*	0.00	−0.03	−0.13*	−0.04	0.13*	0.04*	−0.05	−0.10*

* $p < .05$.

Table 2
Multilevel Model Predicting Intrinsic Motivation for Math, Behavioral Engagement in Math Classes, Math Grades and Performance on a Standardized Math Test as a Function of Student-Reported Teaching Practices.

	Intrinsic motivation			Behavioral Engagement			Math grades			Standardized test score		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p
Intercept	0.19	0.02	**< 0.001**	0.12	0.02	**< 0.001**	0.30	0.03	**< 0.001**	−0.36	0.04	**< 0.001**
Gender (0 = male)	−0.11	0.02	**< 0.001**	0.17	0.02	**< 0.001**	0.02	0.03	0.532	−0.12	0.02	**< 0.001**
Time	−0.19	0.02	**< 0.001**	−0.16	0.02	**< 0.001**	−0.37	0.02	**< 0.001**	0.43	0.02	**< 0.001**
Time (squared)	0.04	0.01	**< 0.001**	0.00	0.01	0.908	0.05	0.00	**< 0.001**	−0.06	0.01	**< 0.001**
Between students												
Autonomy support	0.12	0.02	**< 0.001**	0.20	0.01	**< 0.001**	0.22	0.02	**< 0.001**	0.17	0.02	**< 0.001**
Involvement	0.20	0.02	**< 0.001**	0.22	0.02	**< 0.001**	0.00	0.02	0.883	−0.03	0.02	0.100
Structure	0.14	0.02	**< 0.001**	0.11	0.02	**< 0.001**	0.03	0.02	0.153	0.03	0.02	0.059
Differentiated inst.	0.02	0.01	0.099	−0.05	0.01	**< 0.001**	0.00	0.02	0.845	0.00	0.01	0.995
Within students												
Autonomy support	0.07	0.01	**< 0.001**	0.10	0.01	**< 0.001**	0.02	0.01	**< 0.001**	0.03	0.01	**< 0.001**
Involvement	0.16	0.01	**< 0.001**	0.14	0.01	**< 0.001**	0.02	0.01	**0.001**	0.02	0.01	0.032
Structure	0.09	0.01	**< 0.001**	0.10	0.01	**< 0.001**	0.02	0.01	**< 0.001**	0.00	0.01	0.830
Differentiated inst.	0.03	0.01	**< 0.001**	0.00	0.01	0.738	−0.01	0.01	0.309	0.00	0.01	0.639
n	3586			3586			3586			3246		
N (Grade 7)	166			166			166			166		
N (Grade 8)	158			158			158			158		
AIC	28,129			27,690			21,449			16,615		
Reduction in AIC	2263			2990			1705			1262		
Reduction in AIC (%)	7%			10%			7%			7%		
Variance components												
Class level	0.02			0.03			0.07			0.27		
Student level	0.30			0.26			0.66			0.36		
Residual	0.47			0.46			0.21			0.18		
Variance explained by teaching practices												
Class level	49%			30%			0%			9%		
Student level	27%			38%			8%			6%		
Residual	11%			11%			2%			2%		
Total	20%			23%			6%			6%		

Note. *p*-values in bold are significant after Bonferroni-correction (i.e., $p < .0031$). AIC and variance components compared to a model only including gender and time.

student grades and scores on a standardized test, was significantly associated with autonomy support at both the between-student and within-student levels. Whereas math grades were incrementally significantly predicted by involvement and structure at the within-student level, these associations were small (i.e. with both standardized estimates equal to 0.02). Standardized math tests scores were not predicted by any of the other need-supportive practices beyond autonomy support except for a very small association with involvement at the within-student level. Altogether, need-supportive teaching explained 6% of the variance in math grades and standardized test performance.

Table 3 reports the results from the same multilevel model estimated on the subgroup of high-ability students only. Among high-ability students, autonomy support, involvement, and structure uniquely predicted intrinsic motivation and behavioral engagement at both the between-student and within-student levels. Math achievement was only meaningfully predicted by autonomy support (at the between-student level). Standardized estimates obtained in this subsample were roughly comparable with these for the general population, although statistical significance was not always reached in this subgroup, in particular when applying the Bonferroni correction, likely due to the smaller size of this subsample.

Finally, to more formally statistically test whether the associations between need-supportive teaching and student outcomes were similar for high- and average-ability students, a multilevel model including the interactions between each of the teaching practices and ability status was conducted, contrasting a high-ability (i.e., IQ ≥ 120) to an average-ability subgroup (i.e., IQ = 90–110). Table 4 reports the results from this analysis. None of the interaction terms reached significance, indicating that the benefits of need-supportive teaching were equivalent between high- and average-ability students.

3.3. Differences in provision

Table 5 and Table 6 compare student reports of math teachers' provision of autonomy support, involvement, structure, and differentiated instruction between high- and average-ability students accounting for both student gender and the nesting of students into classes. Whereas Table 5 compares average levels of need-supportive practices between average- and high-ability students, Table 6 distinguishes between differences at the individual level (i.e., whether teachers, within a single class, provide high-ability students with more need support or less need support relative to their classmates) and on the class level (i.e., whether teachers provide more need support or less need support to classes with many high-ability students).

Overall, the most robust difference between high-ability and average-ability students was in their perception of autonomy support. Over all four waves, high-ability students reported receiving significantly more autonomy support than average-ability students, with

Table 3
Multilevel Model Predicting Intrinsic Motivation for Math, Behavioral Engagement in Math Classes, Math Grades, and Performance on a Standardized Math Test as a Function of Student-Reported Teaching Practices in the Subsample of Students with High-Cognitive Ability.

	Intrinsic motivation			Behavioral Engagement			Math grades			Standardized test score		
	β	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*
Intercept	0.27	0.06	**< 0.001**	0.14	0.05	0.006	0.94	0.05	**< 0.001**	0.59	0.05	**< 0.001**
Gender (0 = male)	0.04	0.07	0.595	0.15	0.06	0.019	0.10	0.07	0.156	−0.09	0.06	0.143
Time	−0.26	0.05	**< 0.001**	−0.19	0.05	**0.001**	−0.25	0.03	**< 0.001**	0.49	0.04	**< 0.001**
Time (squared)	0.06	0.02	**< 0.001**	0.01	0.02	0.755	0.03	0.01	0.013	−0.08	0.01	**< 0.001**
Between students												
Autonomy support	0.10	0.05	0.046	0.20	0.04	**< 0.001**	0.08	0.05	0.089	0.16	0.04	**< 0.001**
Involvement	0.21	0.06	**< 0.001**	0.16	0.05	**< 0.001**	0.05	0.05	0.357	−0.03	0.05	0.596
Structure	0.15	0.06	0.007	0.10	0.05	0.041	0.07	0.05	0.186	0.06	0.05	0.245
Differentiated inst.	0.02	0.04	0.561	0.00	0.04	0.961	−0.01	0.04	0.722	−0.07	0.04	0.064
Within students												
Autonomy support	0.09	0.02	**< 0.001**	0.10	0.02	**< 0.001**	0.01	0.01	0.573	0.02	0.02	0.384
Involvement	0.13	0.02	**< 0.001**	0.12	0.02	**< 0.001**	0.01	0.02	0.395	0.02	0.02	0.356
Structure	0.04	0.02	0.087	0.11	0.02	**< 0.001**	0.01	0.02	0.549	0.01	0.02	0.558
Differentiated inst.	0.03	0.02	0.105	0.03	0.02	0.183	−0.01	0.01	0.491	−0.01	0.02	0.588
n	401			401			401			389		
N (Grade 7)	114			114			114			114		
N (Grade 8)	109			109			109			109		
AIC	3497			3416			2216			1931		
Reduction in AIC	227			312			97			101		
Reduction in AIC (%)	6%			8%			4%			5%		
Variance components												
Class level	0.02			0.01			0.04			0.04		
Student level	0.35			0.25			0.36			0.29		
Residual	0.42			0.43			0.15			0.16		
Variance explained by teaching practices												
Class level	31%			39%			−8%			−6%		
Student level	26%			30%			6%			9%		
Residual	9%			11%			1%			3%		
Total	18%			20%			3%			6%		

Note. *p*-values in bold are significant after Bonferroni-correction (i.e., $p < .0031$). AIC and variance components compared to a model only including gender and time. HA (high ability) defined as IQ $\geq$ 120.

weak to moderate effect sizes (Cohen's *d* between 0.16 and 0.27). This difference was located both at the class and at the individual levels; that is, teachers were perceived to provide more autonomy support to classes with a higher percentage of high-ability students, and, within a single class, high-ability students perceived the teacher to provide more autonomy support compared to their classmates. High- and average-ability students reported roughly equal levels of involvement by their math teacher (with only a slightly lower value for involvement in classes with more high-ability students in the first wave). For structure, average differences between average- and high-ability students were mostly not statistically significant. In the final measurement wave, high-ability students reported their teachers as providing higher levels of structure. Distinguishing between the individual and class levels made clear that this difference was observed only at the class level, indicating that teachers tended to provide more structure to classes with many high-ability students but did not provide more structure to high relative to average-ability students within a single class. Similarly, high-ability students reported that their teachers engaged somewhat less often in differentiated instruction relative to average-ability students, but this difference was also only observed at the class level, indicating that teachers tended to differentiate less in classes with more high-ability students (Lavrijsen, Dockx, et al., 2022).

4. Discussion

When high-ability students lose their engagement for school, this can jeopardize their academic development (Gallagher et al., 1997; Ramos et al., 2022; Snyder et al., 2013). Hence, for educators, it is of prime importance to understand how the motivation and achievement of high-ability students can be promoted. This study built on SDT (Ryan & Deci, 2017) to investigate how math teachers can support the basic psychological needs of high-ability students. In particular, in a large longitudinal community sample of Flemish early adolescents, the present study assessed how need-supportive teaching practices (i.e., autonomy support, involvement, structure, and differentiated instruction; Stroet et al., 2013) relate to the motivational and academic functioning of high-ability students.

4.1. Benefits of need-supportive teaching

First, this study investigated the associations between need-supportive teaching and students' motivational and academic outcomes. Both average-ability and high-ability students reported to be more intrinsically motivated and behaviorally engaged when their teachers (a) provided them choice, solid rationales for learning tasks, and activities that match interests (i.e., autonomy support); (b) showed them ample care and understanding (i.e., involvement); and (c) were clear and helpful in their guidance and instruction (i.e.,

Table 4
Multilevel Model Predicting Intrinsic Motivation for Math, Behavioral Engagement in Math Classes, Math Grades, and Performance on a Standardized Math Test as a Function of Student-Reported Teaching Practices, Contrasting Students with High and Average Ability.

	Intrinsic motivation			Behavioral Engagement			Math grades			Standardized test score		
	β	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*
Intercept	0.15	0.03	**< 0.001**	0.12	0.03	**< 0.001**	0.15	0.03	**< 0.001**	−0.47	0.04	**< 0.001**
Gender (0 = male)	−0.07	0.03	0.018	0.18	0.03	**< 0.001**	0.14	0.04	**< 0.001**	−0.02	0.03	0.349
Time	−0.17	0.03	**< 0.001**	−0.16	0.03	**< 0.001**	−0.37	0.02	**< 0.001**	0.43	0.02	**< 0.001**
Time (squared)	0.03	0.01	**< 0.001**	0.00	0.01	0.872	0.06	0.01	**< 0.001**	−0.06	0.01	**< 0.001**
Between students												
Autonomy support	0.13	0.02	**< 0.001**	0.20	0.02	**< 0.001**	0.15	0.03	**< 0.001**	0.09	0.02	**< 0.001**
Structure	0.13	0.03	**< 0.001**	0.13	0.03	**< 0.001**	0.03	0.03	0.336	0.05	0.02	0.021
Involvement	0.17	0.03	**< 0.001**	0.19	0.02	**< 0.001**	0.03	0.03	0.249	0.00	0.02	0.826
Differentiated inst.	0.04	0.02	0.036	−0.04	0.02	0.046	−0.01	0.02	0.708	−0.06	0.02	**< 0.001**
Within students												
Autonomy support	0.07	0.01	**< 0.001**	0.09	0.01	**< 0.001**	0.02	0.01	0.010	0.03	0.01	**0.001**
Involvement	0.15	0.01	**< 0.001**	0.14	0.01	**< 0.001**	0.02	0.01	0.019	0.01	0.01	0.153
Structure	0.09	0.01	**< 0.001**	0.09	0.01	**< 0.001**	0.03	0.01	**< 0.001**	−0.01	0.01	0.349
Differentiated inst.	0.04	0.01	**0.002**	−0.01	0.01	0.252	−0.01	0.01	0.521	−0.01	0.01	0.344
High ability	0.14	0.04	**0.001**	−0.03	0.04	0.498	0.85	0.05	**< 0.001**	0.90	0.03	**< 0.001**
Interactions with high ability (HA)												
Between students												
HA x Aut. support	−0.02	0.05	0.659	−0.01	0.05	0.817	−0.07	0.06	0.268	0.05	0.04	0.276
HA x Structure	0.00	0.06	0.984	−0.04	0.06	0.514	0.04	0.07	0.532	−0.01	0.05	0.910
HA x Involvement	0.05	0.06	0.413	−0.03	0.06	0.630	0.01	0.07	0.852	−0.03	0.05	0.616
HA x Diff. inst.	−0.02	0.04	0.606	0.04	0.04	0.355	−0.02	0.05	0.711	0.06	0.04	0.091
Within students												
HA x Aut. support	0.03	0.03	0.334	0.01	0.03	0.572	−0.01	0.02	0.622	−0.02	0.02	0.412
HA x Involvement	−0.01	0.03	0.619	−0.02	0.03	0.516	−0.01	0.02	0.524	0.00	0.02	0.971
HA x Structure	−0.05	0.03	0.055	0.01	0.03	0.836	−0.02	0.02	0.291	0.02	0.02	0.319
HA x Diff. inst.	0.00	0.02	0.999	0.04	0.02	0.101	−0.01	0.02	0.744	0.01	0.02	0.687
n	2083			2083			2083			2016		
N (Grade 7)	166			166			166			166		
N (Grade 8)	158			158			158			158		
AIC	17,310			16,964			12,762			9468		
Reduction in AIC	1315			1752			1235			1329		
Reduction in AIC (%)	7%			9%			9%			12%		
Variance components												
Class level	0.02			0.03			0.07			0.13		
Student level	0.30			0.26			0.51			0.24		
Residual	0.45			0.44			0.20			0.17		
Variance explained by teaching practices												
Class level	48%			35%			−8%			35%		
Student level	26%			36%			22%			33%		
Residual	11%			11%			3%			2%		
Total	19%			23%			16%			26%		

Note. p-values in bold are significant after Bonferroni-correction (i.e., $p < .0031$). AIC and variance components compared to a model only including gender and time. HA (high ability) defined as IQ $\geq$ 120; average ability defined as IQ between 90 and 110.

structure). Although these three teaching practices were strongly intercorrelated, each dimension contributed uniquely to students' motivational functioning; altogether, these practices explained about a quarter of the variance in high-ability students' motivational outcomes. Specific to autonomy support, some have argued that offering high-ability students ample choice in selecting tasks that match their interests and preferences might help them to stay engaged with school, particularly when they risk being underchallenged (Garn & Jolly, 2014; Tortop, 2015). Giving these students the opportunity to choose cognitively more challenging tasks might prevent them from being bored (Figg et al., 2012). Although in the general population several interventions have been developed to enhance teachers' provision of autonomy-support to students (e.g., Aelterman et al., 2014; Cheon et al., 2018, 2020), future research could consider whether these interventions would work just as well with high-ability students.

Second, the key role of teacher involvement for high-ability students' motivational development resonates with findings by Bakx et al. (2019), who found that high-ability students cited mutual understanding to be the prime characteristic of a good teacher, and with seminal models on high-ability underachievement, such as the Achievement Orientation Model (Siegle & McCoach, 2005), that have claimed teacher emotional support to be a crucial feature of a supporting learning environment for high-ability students (Ramos et al., 2021; Steenberghs et al., 2023). Again, previous research has identified several ways in which affective teacher-student relationships can be fostered (Pianta et al., 2002); findings from the present study strongly suggest integrating such insights into training programs for teachers working with high-ability students.

Third, the present study emphasized that high-ability students thrive when teachers provide a high level of structure (i.e., when teachers support students' competence by being clear and appropriately guiding in their instruction; VanTassel-Baska & Stambaugh, 2005). Training teachers in providing structured instruction to high-ability students, while being at the same time cognitively

Table 5
Average Student-Perceived Levels of Math Teachers' Provision of Autonomy Support, Involvement, Structure, and Differentiated Instruction Compared between Average- and High-Ability Students.

	Wave 1				Wave 2				Wave 3				Wave 4			
	$M_{average}$	M_{high}	*d*	*p*	$M_{average}$	M_{high}	*d*	*p*	$M_{average}$	M_{high}	*d*	*p*	$M_{average}$	M_{high}	*d*	*p*
Autonomy support	**3.76**	**3.94**	**0.23**	**0.001**	**3.72**	**3.85**	**0.16**	**0.007**	**3.71**	**3.94**	**0.27**	**<0.001**	**3.66**	**3.89**	**0.27**	**<0.001**
Involvement	3.43	3.35	−0.09	0.230	3.34	3.28	−0.06	0.307	3.23	3.25	0.02	0.785	3.32	3.41	0.10	0.089
Structure	3.47	3.37	−0.11	0.102	3.43	3.37	−0.06	0.400	3.41	3.47	0.06	0.290	**3.37**	**3.60**	**0.22**	**<0.001**
Differentiated instruction	**2.59**	**2.46**	**−0.17**	**0.016**	2.65	2.54	−0.13	0.053	2.59	2.57	−0.03	0.690	2.77	2.70	−0.08	0.233

Note. Significant differences in bold. Controlling for student gender and clustering in classes.

Table 6
Average Student-Perceived Levels of Math Teachers' Provision of Autonomy Support, Involvement, Structure, and Differentiated Instruction Compared between Average- and High-Ability Students Distinguishing between the Individual and Class Level.

	Wave 1				Wave 2				Wave 3				Wave 4			
	M_{average}	M_{high}	*d*	*p*	M_{average}	M_{high}	*d*	*p*	M_{average}	M_{high}	*d*	*p*	M_{average}	M_{high}	*d*	*p*
Individual level																
Autonomy support	**3.73**	**3.84**	**0.15**	**0.006**	**3.74**	**3.82**	**0.10**	**0.013**	**3.71**	**3.79**	**0.11**	**0.028**	**3.72**	**3.81**	**0.12**	**0.026**
Involvement	3.32	3.32	0.00	0.988	3.33	3.34	0.01	0.810	3.32	3.33	0.01	0.895	3.33	3.37	0.04	0.445
Structure	3.40	3.37	−0.04	0.401	3.45	3.41	−0.04	0.531	3.40	3.45	0.05	0.242	3.41	3.51	0.10	0.056
Differentiated instruction	2.65	2.65	0.00	0.938	2.64	2.63	−0.01	0.887	2.62	2.69	0.08	0.097	2.67	2.65	−0.03	0.621
Class level																
Autonomy support	**3.74**	**3.82**	**0.09**	**0.018**	3.71	3.75	0.06	0.148	**3.72**	**3.85**	**0.16**	**<0.001**	**3.66**	**3.81**	**0.17**	**<0.001**
Involvement	**3.44**	**3.35**	**−0.10**	**0.046**	3.33	3.26	−0.08	0.082	3.22	3.23	0.01	0.767	3.32	3.39	0.07	0.057
Structure	3.49	3.42	−0.08	0.082	3.40	3.36	−0.04	0.410	3.40	3.42	0.02	0.598	**3.39**	**3.52**	**0.14**	**0.003**
Differentiated instruction	**2.62**	**2.48**	**−0.18**	**<0.001**	**2.68**	**2.57**	**−0.13**	**0.001**	**2.62**	**2.52**	**−0.12**	**0.002**	2.78	2.72	−0.06	0.124

Note. Significant differences in bold. Controlling for student gender and clustering in classes.

ambitious and pacy enough to prevent boredom among these students, might be particularly important, in particular because teachers often tend to focus their energy on helping low achieving, struggling students (Deunk et al., 2018). Whereas effect sizes were quite modest for each of these practices, it is important to emphasize that associations were generally observed at both the level of between-student differences and at the level of within-student changes over time. For example, this means that students from involved teachers reported on average not only a higher intrinsic motivation for mathematics (i.e., between-student level), but also that students tended to report enjoying mathematics more at times they perceived their teacher to be particularly involved. Observing associations both at the between- and the within-student levels underscore the robustness of the benefits of need-supportive teaching for high- and average-ability students and extends findings from previous cross-sectional studies (Hornstra et al., 2020).

Finally, this study considered whether differentiating instruction to student capacities would promote motivation in high- and average-ability students (Barbier et al., 2023). Bivariately, differentiated instruction was indeed positively related to student intrinsic motivation and behavioral engagement. However, these associations ceased to be significant after other teacher practices were controlled for. Arguably, differentiated instruction shares some conceptual overlap with the dimension of structure (e.g., accounting for student progress before advancing to new material); indeed, both practices were moderately interrelated. This might have reduced the probability to find unique association between differentiated instruction and student outcomes after accounting for structuring practices.

Whereas student motivation and engagement were consistently predicted by different teaching practices, student math achievement was meaningfully predicted mostly by autonomy support and less so by the other need-supportive practices. Accordingly, need-supportive teaching explained less variance in student achievement than in student motivation. Arguably, achievement is somewhat less malleable by teachers than is student motivation as achievement depends more strongly on student characteristics such as cognitive ability (Kriegbaum et al., 2018; Lavrijsen, Vansteenkiste, et al., 2022; Roth et al., 2015), leaving less room for teaching practices to predict students' academic performance. Indeed, Roorda et al.'s (2017) relatively recent meta-analysis reported achievement to generally be less dependent on teaching quality than students' engagement. Still, in the present study, need-supportive teaching (in particular, autonomy support) contributed not only to student motivation and engagement, but also to students' academic outcomes.

4.2. *Teaching high-ability students: same or different?*

In addition, this study tested whether associations between need-supportive teaching and student outcomes were equivalent between high- and average-ability students. Overall, our major finding was that need-supportive teaching held similar benefits for high-ability students and average-ability peers. Theoretically, it has been argued that autonomy support would be of prime importance for high-ability students, even more than for average-ability students (Garn & Jolly, 2014; Kettler, 2014; Sypré et al., 2023). Although the present study found autonomy support to be vital to the motivational and academic outcomes of high-ability students, its importance was found to be equally important among other students. Of note, the average level of autonomy support provided to high-ability students was considerably higher than among average-ability students. Hence, high-ability students seemed to fare well with such a high level of autonomy, perhaps because they often possess good self-regulatory capacities that allow them to handle the allowed choice and freedom adequately (Kettler, 2014; Tortop, 2015).

In addition, teachers often believe that providing structure is less needed when teaching high-ability students (Sypré et al., 2023), maintaining that students with advanced cognitive capacities can "make it on their own" and thus do not need guidance from teachers (De Boer et al., 2013). Yet, the findings from the present study strongly refute such claims as high-ability students benefited just as much from teachers offering clear instruction and guidance as any other student. Hence, it is important to communicate to teachers that for students with advanced intellectual capacities, supporting competence development through structured teaching is key to their healthy motivational development. Finally, involvement and differentiated instruction were found to be roughly equally important for high-ability students relative to their average-ability peers.

Finding need support to be equally important for high- and average-ability students is aligned with the universality assumptions of SDT (Ryan & Deci, 2017). The most comprehensive empirical study to date also did not find evidence for diverging associations between both groups (Hornstra et al., 2020). The present study extends findings from Hornstra et al.'s (2020) previous cross-sectional study by using a longitudinal design and demonstrating that associations between need-supportive teaching and student outcomes does not depend on ability status, neither at the level of between-student differences nor at the level of change within students over time. In addition, whereas Hornstra et al. (2020) used teacher nomination to identify high-ability students, the present study relied on a standardized cognitive ability test to distinguish between high- and average-ability students. With its more methodologically rigorous approach, the present study underscored that autonomy support, involvement, and structure matter for high-ability students and that need-supportive teaching is just as important for these students as they are for their average-ability peers.

4.3. *Provision of need-supportive teaching to high-ability students*

Finally, the present study compared the degree to which math teachers provided need-supportive teaching practices to high-ability and average-ability students. Previous research has suggested that teachers provide more autonomy, equal levels of involvement, and less structure to high-ability students relative to their average-ability peers (Hornstra et al., 2020; Sypré et al., 2023). Also, in the present study, high-ability students reported that their teachers supported their autonomy to a larger degree than that reported by average-ability students. That teachers are more inclined to provide more autonomy to high-ability students might be due to the generally stronger self-regulatory skills of such students; indeed, when teachers perceive that their high-ability students are able to effectively govern their own learning process (Kettler, 2014; Tortop, 2015), they might be more willing to grant these students a high level of autonomy.

Furthermore, teachers were perceived to be equally involved when teaching high- and average-ability students. The fact that high-ability students found their teachers to be generally involved is positive news as such students seem to highly value teachers who show them care and understanding (Bakx et al., 2019). Teachers were also perceived to provide a comparable degree of structure to both high- and average-ability students; although in the final measurement wave teachers were somewhat more structured in classes with many high-ability students, there were no differences in the perceived provision of structure between high- and average-ability students within a single class.

Previous research has suggested that teachers often believe that a high degree of structure would be less important for high-ability students (Sypré et al., 2023). However, the present study relied on student reports of teacher practices that may have diverged from how teachers intended to instruct students (Stroet et al., 2013). Finally, although appropriately targeting instruction to student capacities has often been proposed as key to sustaining the motivation of students with high cognitive abilities (Barbier et al., 2023), the present study yielded no indications that teachers would engage more often in differentiated instruction when instructing high-ability students. In fact, teachers were found to provide somewhat less differentiated instruction to classes with many high-ability students. This finding could be related to the broader educational context of this study. In Flanders, classes with high-average ability have been found to be more homogeneous in terms of student ability than classes with low-average ability (e.g., inverse correlation equal to −0.32 between class mean and class standard deviation in math achievement; Lavrijsen, Dockx, et al., 2022), which might be due to the fact that the placement of students in low (but not high) ability tracks is often related to non-ability factors, such as behavioral problems or social disadvantage (Van Praag et al., 2013). In more homogeneous classes, teachers might find it less necessary to differentiate their instruction between students (Pozas et al., 2019), which might explain why, at the class level, teachers' use of differentiated instruction was inversely related to student ability.

4.4. Implications

These findings may encourage teachers to further develop their need-supportive teaching skills and to invest in all dimensions of need support, including structure, to average- and high-ability students. One possibility is that teachers follow a teacher training in this regard (Cheon et al., 2020). Despite the shown critical importance of a need-supportive teaching style for both average- and high-ability students, it is critical that teachers learn to tailor or calibrate their need-supportive style to the students and learning tasks at hand (Vansteenkiste et al., 2019). Although students may benefit from structure at times, they may fare better with elevated autonomy support during other times, with this variation in the application of need-supportive strategies possibly varying between average- and high-ability students.

School psychologists may assist teachers in creating a classroom environment that promotes motivation and achievement in students (Daniels & Dueck, 2022). For example, school psychologists may build a collaborative relationship with teachers to discuss and share ideas on how to make classes optimally motivating and supportive to all students, they can offer teachers professional development opportunities to further advance need-supportive teaching practices, and they can recognize teachers' efforts in creating a motivating classroom environment from a shared commitment to student success.

Also at the student level, school psychologists can assist in restoring motivation in students when it has eroded; for instance, school psychologists can assist in identifying the obstacles that hinder motivation among average- and high-ability students (Shaunessy-Dedrick & Lazarou, 2020). In addition, school psychologists could support students' capabilities for *need crafting*, which indicates the degree to which students are aware of their personal sources of psychological need satisfaction (e.g., knowing which activities one is good at and that may satisfy the need for competence) and the extent to which students are prepared to act upon accordingly (e.g., trying to regularly take part in such activities). Indeed, studies have shown that adolescents who are better aware of the activities that are conducive to their basic needs and who pro-actively take action to get their needs fulfilled reported higher need satisfaction and enhanced well-being (Laporte et al., 2021).

4.5. Strengths and limitations

The present study had considerable strengths, such as the longitudinal design, the distinction between the between-student and within-student level, the large sample, and the use of a standardized cognitive ability test to identify high- and average-ability students. However, several limitations must be acknowledged. First, the study drew on student reports of need-supportive teaching practices, implying that students evaluated both the predictors and the two motivational outcomes, which possibly raised the risk of common-method bias. Of note, however, the third outcome (i.e., math achievement) provided an external, standardized assessment of student's academic development. Moreover, how students experience teaching practices arguably may be more decisive for their adjustment than external report of these practices. Indeed, as documented by Stroet et al.'s (2013) review, student perceptions of teaching behavior generally have a larger impact on student engagement than external accounts of these practices. Still, future research could further enhance understanding of the motivational effects of need-supportive teaching by also including teacher-reports or external observations of need-supportive teaching (Reeve et al., 2004). Second, the internal consistency of the autonomy support measure, which was a shortened version of the corresponding measure of the TASCQ (Belmont et al., 1988), was only marginally acceptable. This was particularly due to the scale consisting of two positively and two negatively worded items. To ensure that this did not threaten robustness of the results, an additional model was estimated in which autonomy support was operationalized with the two positive items only. Results, which are available from the first author, proved to be consistent across operationalizations. Third, student motivation is a strongly contextual phenomenon that depends on many characteristics, such as the educational context or student age. This study was carried out in a sample of early adolescents after the transition to secondary school in Flanders, which is a period characterized by a general decline in students' school engagement (Scherrer & Preckel, 2019). Whether need-supportive teaching is equally important for the motivational development of high-ability students in other developmental periods or other educational systems will have to be addressed by future research. Similarly, future research could further focus on the heterogeneity between students in the associations between teacher practices and student motivation and achievement, for example by including random slopes and explaining the between-student variability in these slopes by student characteristics. Finally, whereas this study focused on mathematics, associations between teacher behavior and student outcomes in other subject domains could be further disentangled.

5. Conclusion

Ensuring that high-ability students stay motivated for their schoolwork is important both for their academic development and for society (Snyder & Linnenbrink-Garcia, 2013). Based on SDT (Deci & Ryan, 2002), this study investigated the benefits of need-supportive teaching for the motivational and academic functioning of high-ability students in a large longitudinal sample of Flemish early adolescents. We found that high- and average-ability students' perceptions of autonomy support, involvement, and structure by their math teachers uniquely predicted their intrinsic motivation for math, behavioral engagement in math classes, and to a lesser extent, math performance. Teachers' use of differentiated instruction did not meaningfully predict student outcomes beyond these other teacher practices. These associations were observed both at the level of between-student differences and at the level of changes in students over time. Importantly, associations between need-supportive teaching and student outcomes were generally similar between high- and average-ability students. Finally, high-ability students reported their math teachers to be more autonomy supportive than average-ability students, whereas there were no consistent differences in the provision of the other need-supportive dimensions between high- and average-ability students.

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Declaration of competing interest

The authors declare no conflict of interest.

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