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The trajectory of student agentic engagement in mathematics: The role of individual variables

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ABSTRACT

This study investigates the longitudinal trajectory of agentic engagement in mathematics over a school year and the influence on it of individual factors, namely student gender and personality traits. Data were collected from more than 400 sixth graders in Northern Italy, by use of the Agentic Engagement Scale and the Big Five Questionnaire for Children. Latent growth curve modeling revealed a significant decline in agentic engagement over time. Initial levels of agentic engagement did not differ between male and female students; however, female students exhibited a steeper decline over time. Personality traits, specifically openness and extraversion, were positively associated with higher initial levels of agentic engagement but did not influence its trajectory. These findings are discussed by highlighting that, while individual characteristics such as gender and personality play a role, the development of agentic engagement cannot be fully understood without considering also the influence of the learning environment.

Educational relevance statement: This study tested the trajectory of agentic engagement in mathematics over a school year in 6th grade, a novel direction of inquiry in the field, while also testing the role of individual variables such as gender and personality traits. The results highlight a concerning declining trend in agentic engagement, which was steeper for female students with respect to their male counterparts, with no significant effect of personality traits. Thus, these findings bring the attention, by exclusion rather than confirmation, on the importance of the learning environment, suggesting urgent reflections on the contemporary topic of students' active participation in learning.

1. Introduction

The fostering of student agency – which, within a psychosocial theoretical framework (Bae et al., 2025), is conceptualized as learners' ability to actively and proactively engage in educational processes and exert influence over their own school experiences (Reeve & Jang, 2022; Zambrano et al., 2022) – has emerged as a key priority in school contexts (Reeve & Jang, 2022), particularly in the domains of science and mathematics (Leijen et al., 2024). Collective insights from academic research (Cook-Sather, 2020; Reeve & Shin, 2020), policy documents (Jääskelä et al., 2020; Klemenčič, 2017), and international educational frameworks (OECD, 2019) have converged around the importance of student agency in promoting educational success and personal well-being, stressing the need to support it to enable learners to meet the challenges of the future and navigate the evolving demands of the 21st century (Leijen et al., 2024).

Given the crucial role that student agency has assumed in the educational debate in the last fifteen years, a number of cross-sectional (e.g., Molinari & Mameli, 2018; Tas, 2016) and longitudinal (e.g., Reeve, 2013) studies have shed light on some of the *contextual* factors that can promote it (e.g., Grazia et al., 2021; Mameli et al., 2022; Matos et al., 2018). However, there are persistent gaps in our understanding of how student agency evolves over time, and the interplay between student agency and *individual* factors has been scarcely explored. Among these, student gender and personality traits warrant closer examination: while existing evidence suggests they may play a meaningful role, research in this area is still limited, highlighting the need for more systematic investigation. Based on these premises, the present study explores the developmental trajectory of student agency in the domain of mathematics, concurrently examining whether this trajectory can be

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influenced by individual factors, specifically gender and personality traits.

1.1. Student agency

Agency is a complex concept investigated across a variety of disciplines, including sociology, philosophy, psychology, and education. It is generally understood as individuals' capacity to act intentionally, make choices, and influence their environment, while also being situated within the social, cultural, and institutional contexts in which they operate (Eteläpelto et al., 2013; Matusov et al., 2016).

Within school contexts, agency is typically referred to as 'student agency', broadly defined as students' capacity to intentionally and meaningfully influence their own learning paths and educational environments (Mameli et al., 2023). To account for the various ways in which student agency has been conceptualized, Bae et al. (2025) have recently offered a clarifying framework by delineating three major theoretical approaches that have informed educational research on this construct – i.e., *sociocultural*, *critical*, and *psychosocial* – which, while rooted in distinct epistemological traditions, are not mutually exclusive but rather offer complementary lenses for understanding how student agency is intended and enacted. From a sociocultural perspective, student agency is defined as a distributed and emergent phenomenon, co-constructed within activity systems and sustained through interactions with peers, teachers, and tools (Ko & Krist, 2019; Miller et al., 2018). The critical framework, on the other hand, situates student agency within broader power structures and emphasizes students' capacity to challenge, resist, or transform inequitable social environments (Dotson, 2014; Gutiérrez & Calabrese Barton, 2015). Finally, the psychosocial framework, which informs the present study, conceptualizes student agency primarily in terms of individual intentionality and motivation, and focuses on students' proactive involvement in the learning process and their efforts to actively influence classroom practices (Reeve & Shin, 2020; Reeve & Tseng, 2011). While this approach on student agency focuses on individual-level processes, which are precisely the focus of the present study, it acknowledges that agentic behaviors unfold within relational contexts and depend on the responsiveness of the interpersonal context to student agentic instances.

According to the synthesis offered by Bae et al. (2025), within the psychosocial theoretical framework, student agency has been commonly operationalized through the construct of agentic engagement (Bae et al., 2025; Reeve, 2013; Reeve & Tseng, 2011), indicating the actions students take to potentially transform, and ultimately improve, their learning environment. Such agentic actions may include suggesting ideas, expressing interests, preferences, or needs, asking questions, and seeking support (Reeve & Shin, 2020), but also expressing disagreement or proposing alternative approaches when the learning environment is perceived as unsatisfactory (Mameli et al., 2020; Rainio, 2008). According to Reeve and Jang (2022), agentic engagement represents a unique form of engagement which differs from other forms (i.e., behavioral, cognitive, and emotional; Christenson et al., 2012) due to three interrelated and co-occurring properties: (a) it is proactive, as it requires students taking active and intentional steps to influence their learning environment; (b) it is reciprocal, as it involves a mutual interplay between students and the teacher, who can either accept, ignore, or reject the transformation potential introduced by the learner; and (c) it is constructive, as it is acted with the final aim of improving students' own educational experiences. These are not separate dimensions, but essential and simultaneous qualities of each agentic act: for example, when a student raises a critical question about a topic discussed in class, this agentic action is concurrently proactive (as it is initiated by the student), reciprocal (as achieving its purpose requires a response from the teacher), and constructive (as it reflects the student's intention to contribute in modeling the learning environment in a way that better meets their educational needs). Building on the psychosocial perspective discussed above, this study focuses on student agency as its core construct and consistently operationalizes and assesses it through the lens of agentic engagement, as manifested in students' intentional and proactive contributions to classroom dynamics.

1.2. Student agency in mathematics

In mathematics classrooms – where teaching and learning processes often reflect conventional structures whereby teachers hold authority over knowledge dissemination and students take on a passive role (Brown, 2020) – student agency assumes crucial significance (Boaler, 2002; Brown, 2020). Scholars (Leijen et al., 2024; Nieminen et al., 2022; Norén, 2015) have argued that the fostering of student agency in mathematics is crucial to developing long-term mathematical competences for potential use in real-life situations (Boaler, 2002). In classrooms where teachers go beyond the traditional transmissive approach, which is based on the application of pre-explained practices and algorithms to solve exercises, and where learners see themselves as capable problem-solvers and feel encouraged to explore, be curious, take risks, and tackle and inquire challenging problems (Aguirre et al., 2013; Boaler, 2002; Huinker et al., 2020; Woods & Salem, 2024), students become better prepared for lifelong learning and continuous improvement beyond formal education (Leijen et al., 2024).

This growing interest in the educational value of student agency in mathematics has been accompanied by an increasing number of empirical studies exploring its impact on learning outcomes. Several longitudinal studies from the psychosocial perspective have pointed to the importance of sustaining proactive student growth by showing that student agentic engagement positively predicts successful educational results in secondary school, including student academic achievement (Reeve, 2013; Reeve et al., 2020; Reeve & Tseng, 2011) and motivation (Patall et al., 2019). In line with these findings, quantitative studies concerning student agency within specific domains, including mathematics, have indicated a positive association between student agency and basic psychological needs satisfaction (Maralani et al., 2018) and academic achievement (Leijen et al., 2024; Reeve et al., 2020), and a negative association between the former and mathematics test anxiety (Maralani et al., 2018).

Notwithstanding this empirical evidence, the longitudinal trajectory of student agency, especially in mathematics, remains unknown. In fact, although research indicates a typical decline in student engagement during adolescence (Mahatmya et al., 2012; Wang & Eccles, 2012) – also due to a mismatch between the increasing autonomy needs of students in their transition from primary to secondary school and the more controlled structure of secondary education (Eccles et al., 1993) – specific insights into the longitudinal dynamics of student agency are yet to be elucidated. In this regard, investigating student agency and its trajectory during the first year of secondary school appears to be particularly crucial, as it represents the very moment in which students are navigating a major educational and developmental transition (for more information see the Aims of the present study).

Beyond the lack of previous research, a deeper exploration of the development of student agency in mathematics over time has become even more urgent in the post-pandemic era, which resulted in a rather pronounced learning loss in the discipline, arguably due, at least in part, to the fact that the sudden transition to distance learning led many teachers to abandon constructivist approaches to mathematics education for more transmissive approaches (Bakker & Wagner, 2020). In 2022, the OECD's PISA (Programme for International Student Assessment) report highlighted a significant decline in the average mathematics score among 15-year-olds as compared to 2018. Moreover, 31 % of students did not achieve proficiency level 2 in mathematics, considered the baseline for full participation in society (OECD, 2023). This was also confirmed by OECD data at the national level in Italy, where the present study was conducted. A closer look at Italian national surveys raises even more concerns, as the INVALSI (INVALSI, 2024) report – which provides a comprehensive assessment of student performance and

competencies across various subjects, including mathematics – indicated a decrease in national scores, compounded with a worrisome trajectory as students transition from primary to secondary school (in 2024, 32 % of fifth-grade students did not achieve the basic proficiency level in mathematics, while this percentage grows to 47 % in 8th graders, 45 % in 10th graders, and 48 % in 13th graders).

1.3. Student agency and student individual characteristics

From a psychosocial theoretical perspective (Bae et al., 2025), student agentic engagement, which is inherently reciprocal in relation to individual action (Reeve & Jang, 2022), is exposed to the influence of both contextual and individual factors. Regarding the former, a number of studies have found that effective teaching practices – characterized by an autonomy-supportive motivating style (e.g., Matos et al., 2018; Reeve & Shin, 2020), the provision of structure (Michou et al., 2023), and responsiveness to student needs and perspectives (e.g., Jang et al., 2016; Molinari & Mameli, 2018; Reeve & Tseng, 2011) – positively affect student agentic engagement, including in the realm of mathematics education (Leijen et al., 2024; Maralani et al., 2018; Nieminen et al., 2022), and that student agentic engagement in turn has an impact on the learning environment by making it more motivationally supportive (e.g., Michou et al., 2023; Reeve, 2013). Conversely, in terms of the individual factors, the literature remains sparse, and further research is warranted to explore the nuanced interplay of personal attributes and their associations with student agency.

To start addressing this gap, in this study we chose to focus on student gender and personality traits. The focus on gender was motivated by the relevance it has in the current debate on performance gaps in scientific disciplines between male and female students (Beroíza-Valenzuela & Salas-Guzmán, 2024; OECD, 2023). Previous research that includes academic achievement as an outcome variable (Reeve, 2013; Reeve et al., 2020) in fact suggests that student agentic engagement may play an important role in explaining this gap. Thus, in this study we aimed to clarify whether female and male students experience different trajectories of agentic engagement upon entering secondary school. The second variable, personality traits, was chosen to address the crucial question of whether agentic engagement is something that students mostly bring *with* them when entering the learning environment, or something that the learning environment brings *out* in them. While a few studies (e.g., Michou et al., 2023) suggest the answer rests at the intersection of the two alternatives, there is a need of evidence clarifying this issue. Below, we provide a succinct overview of the literature pertaining to both individual variables.

1.3.1. Student gender

As anticipated, the interest toward student gender stems from the currently hot, long-due debate on the *gender gap* in STEM disciplines and, in particular, in mathematics. Indeed, despite advancements in gender equality (Tao & Michalopoulos, 2018), disparities persist in mathematical achievement, participation, and career choices between male and female students (Ellison & Swanson, 2023). Data provided by standardized assessments, such as PISA, TIMSS (Trends in International Mathematics and Science Study), and INVALSI, show on average a statistically significant gap favoring boys in mathematics, which persists and worsens over time (Mullis et al., 2020; OECD, 2019; OECD, 2023) and increases with students' age (Contini et al., 2017; INVALSI, 2024; OECD, 2023). The same data also point to the role of social and cultural influences, as the extent of the gender gap varies considerably across countries, suggesting that biological factors alone cannot account for the observed differences (Hill et al., 2010). In this regard, the Italian context appears particularly concerning, with female students systematically scoring lower than their male peers, with the highest gender gap of all countries (Giberti, 2019; INVALSI, 2024; OECD, 2023). The importance of social and cultural factors is supported also by other studies that found a reduced math gender gap in societies with greater gender equality (e.g., González de San Román & De La Rica, 2016; Guiso et al., 2008). Such disparities have thus been linked to processes of gender socialization, including the influence of parents' and teachers' beliefs, expectations, and attitudes, often shaped by cultural stereotypes, which can affect students' own confidence, self-efficacy, and learning behaviors in mathematics (Jacobs & Bleeker, 2004; Passolunghi et al., 2014; Tomasetto et al., 2015). For instance, studies have shown that girls are inclined to choose routine strategies in problem-solving activities to avoid risk-taking (e.g., Bell & Norwood, 2007) and can be supported implementing active learning methodologies in mathematics (Di Tommaso et al., 2024).

On the basis of this previous literature, we argue that gender differences in student agency may play a relevant, but previously overlooked, role in the complex dynamic toward academic achievement in mathematics. To the best of our knowledge, very few previous quantitative studies investigated student agency in the specific subject of mathematics, reporting higher values for male students (Leijen et al., 2024), and no previous studies adopted a longitudinal perspective, focusing on change over time. However, although limited in number, other studies based on different research designs and not specifically focused on mathematics, suggest that gender differences in student agency processes may be expected. Mameli and Passini (2017), for instance, observed significantly higher self-reported levels of student agentic engagement among male students in a cross-sectional study on more than 1000 Italian secondary school students. Luo et al. (2019), in an experimental study investigating flipped classroom settings that involved different levels of agency granted to students, found gender discrepancies in academic performance and satisfaction with learning processes: female students showed greater learning performance compared to male students in low-agency environments, while male students reported greater learning-satisfaction compared to female students in high-agency contexts. Other findings, however, were sometimes conflicting, as neither Reeve (2013) nor Holm (2010) reported significant gender differences in students' perceptions of agentic engagement or agency-related behaviors. Given the sparse and diverse previous literature, with our longitudinal study we aimed to provide further evidence on the role of student gender by examining whether the developmental trajectory of student agentic engagement in mathematics differs between male and female students.

1.3.2. Student personality

While much of the previous research on student agency has emphasized contextual factors that facilitate its expression in the classroom (Grazia et al., 2021; Michou et al., 2023; Molinari & Mameli, 2018; Patall et al., 2019), recent theoretical contributions (Bae et al., 2025; Mameli et al., 2023; Reeve & Jang, 2022) increasingly stress its reciprocal nature, highlighting how individual and contextual factors mutually influence one another. Thus, it is relevant to collect evidence on whether individual dispositions to extraverted and proactive behavior may play a role in student agency dynamics in the classroom, an area that remains largely underexplored (Wang & Degol, 2014). Indeed, while some studies have predominantly examined the association between personality traits and student engagement (e.g., Moreira et al., 2021) through the lens of the widely acknowledged Big Five personality model (Qureshi et al., 2016), a focused exploration of how personality influences the specific dimension of student agency is relatively scarce. Moreover, to the best of our knowledge, no study to date has investigated whether and how much learners' personality traits can influence the developmental trajectory of student agency.

The few existing previous studies did not provide enough evidence to clarify whether or not personality traits play a significant role in student agency manifestation. On one hand, some studies have suggested that more extroverted and proactive personalities may solicit students to act in more agentically engaged ways in classroom environments. For instance, Zambrano et al. (2022) conducted a qualitative investigation into secondary school students' beliefs about agentic engagement and

found that personality traits, such as extraversion and openness to experience, were perceived as potential facilitators of agentic behaviors. On the other hand, quantitative studies have suggested that personality exerts only a marginal influence on student agency when other variables are considered. Luo et al. (2019) conducted an experimental study examining the effects of different levels of student agency in flipped classroom settings. They found that an extroverted personality was positively associated with better performance in high and medium-agency settings, but not in low-agency settings, suggesting that the benefits of extroverted traits might be contingent on the level of agency afforded by the educational environment. In line with these findings, Michou et al. (2023) conducted a five-week diary study to explore the dynamic relationships between teachers' motivating styles – in terms of teacher autonomy support and structure – and middle school students' behavioral and agentic engagement, taking into account students' motivation and proactive personality. Their study revealed that students' perceptions of autonomy support were consistently associated with higher levels of agentic engagement. More interestingly for the purposes of this study, the analyses showed that while proactive personality positively predicted agentic engagement, its predictive power tended to weaken once autonomous motivation was added as a predictor. This arguably suggests that personality traits interact with and are sometimes overshadowed by other contextual and individual factors related to the learning environment. As these studies provide insights but no clear answer as to the role of personality traits in student agency, in our study we set out to test their role in student agentic engagement trajectories, in order to assess their effect both on initial levels and changes over time.

1.4. Aims of the present study

In the present study, we aimed to investigate how student agentic engagement in mathematics changes over the course of a school year and whether its trajectory can be influenced by two individual factors, i.e., gender and personality traits. In pursuing this aim, we focused on the first year of middle school, i.e., the very first year of secondary school, a key period marked by rapid developmental transitions and evolving school demands. During early adolescence, students develop more advanced metacognitive abilities (Weil et al., 2013) and become increasingly sensitive to issues of identity, autonomy, and social relationships (Harris et al., 2024), which may enhance their awareness of learning processes. Research has also documented gender differences in how students respond to these changes, with girls often reporting greater sensitivity to social and academic expectations (Evans et al., 2018). Concurrently, entering secondary school introduces new challenges – such as multiple teachers, higher academic pressure, and shifting peer dynamics (Jindal-Snape et al., 2020) – that may limit students' perceived opportunities to act agentically. As a result, agentic engagement may fluctuate even within a single school year, depending on how students, with their unique set of personal characteristics and dispositions, adapt to contextual demands (Jindal-Snape & Bagnall, 2023).

We formulated three research questions and related hypotheses based on previous literature. Our first research question (RQ1) was to test changes in the levels of student agentic engagement in mathematics over time, using as time points the beginning, middle, and end of the first year of middle school. Based on previous studies documenting a general decrease throughout school years in student engagement (Wang & Eccles, 2012), and in light of the less than encouraging data on the decline in student proficiency in mathematics in Italy (INVALSI, 2024) and other countries (Mullis et al., 2020; OECD, 2023), we hypothesized (HP1) that we would find a downward trajectory, with a significant decrease from the beginning to the end of the school year.

Our second research question (RQ2) was to explore the role of two relevant individual characteristics in the trajectory of student agentic engagement: gender and personality traits. Based on previous studies (Leijen et al., 2024; Mameli & Passini, 2017), we expected (HP2) that female students would start at the beginning of the school year with lower levels of agentic engagement. Furthermore, in light of previous considerations on the gender gap in mathematics, which tends to increase as students age (Contini et al., 2017; OECD, 2023), we expected (HP3) that girls would report a steeper decrease over time. On the association between student agentic engagement and personality traits, based on the limited number of previous studies (Michou et al., 2023; Zambrano et al., 2022), we expected that traits associated with a proactive personality, such as openness and extraversion, would predict higher initial levels of student agentic engagement (HP4). Regarding other traits included in the Big Five personality model and their potential impact on the longitudinal development of student agentic engagement, the absence of prior research did not allow us to advance specific hypotheses. Consequently, we adopted an exploratory approach.

2. Method

2.1. Participants and procedure

The study protocol followed the ethical guidelines for the protection of human participants set out by the Italian National Psychological Association and received formal approval from the Research Ethics Board of the University of (*blinded for review*; protocol number: 0238390). The study was directed at sixth graders; in Italy, this grade (the first year of middle school) constitutes the moment of transition from primary to secondary school, a crucial time of passage when the learning environment becomes more rigidly organized, and negative experiences with mathematics have been found to lead to negative cycles (Passolunghi et al., 2014). To recruit the sample, several principals of middle schools located in various regions of Northern Italy were contacted; six accepted the invitation, resulting in a total of 23 school classes. The six participating schools were located in suburban cities (less than 50,000 citizens), with a mixed socioeconomic background. Considering the 2023 Economic, Social, and Cultural Status (ESCS) index provided by INVALSI to each school every year, our sample included schools from low to high ESCS. In particular, the compositions of the schools in our sample were as follows: one school with a high ESCS, one with a medium-high ESCS, two with a medium–low ESCS, and two with a low ESCS.

The data collection involved all students in sixth grade and included three waves: the beginning (T1), middle (T2), and end (T3) of the 2022–2023 school year. In the first wave (November 2022), 410 students gave valid responses (45.1 % female, 93.2 % born in Italy, $M_{age} = 10.97$, $SD_{age} = 0.36$), 464 in the second wave in February 2023 (44.5 % female, 93.5 % born in Italy, $M_{age} = 11.23$, $SD_{age} = 0.46$), and 454 in the third wave in May 2023 (44.3 % female, 94.1 % born in Italy, $M_{age} = 11.45$, $SD_{age} = 0.55$). Responses for each participant in each wave were matched by use of an alphanumeric code; students completing at least two data collections were included in the sample, for a total sample of 538 students, and statistical tools were used to deal with missing data (see the Data analysis paragraph for further details). Missingness was mostly due to pupils being absent from school on the day of the data collection (for example, in the first wave, several participating schools were hit with a seasonal flu epidemic). The missing completely at random test (MCAR, Little, 1988) revealed a χ^2 of 8.93 ($df = 9$; $p = .444$), supporting the hypothesis of random missingness.

Data were collected during regular classroom hours in the slots dedicated to mathematics lessons using school computers and an online platform (Qualtrics). For each wave, a researcher was always present to personally introduce the study goals to the students, explain that participation was voluntary and that the data would be treated confidentially, and address any doubts or questions. Informed consent from the students' guardians was collected before the first wave of data collection with the collaboration of mathematics teachers, with less than 1 % of families declining to participate. The students were asked to fill in questionnaires on the study variables (described in more detail below)

while focusing on their experiences in mathematics classes during the last month of school.

2.2. Measures

2.2.1. Student agentic engagement

Consistently with our theoretical conceptualization, student agency was measured with the Agentic Engagement Scale, validated with an Italian population by Mameli and Passini (2019). The measure is composed of 10 items (e.g., "I let my teacher know what I am interested in," "I make sure my teacher understands if there is something I don't like") focusing on the behavioral expression that student agency assumes in the classroom and describing a range of behaviors through which students can express proactive participation in classes, such as providing personal inputs and changing the course of the lesson. With permission from the original authors of the measure, the items used in this study were adapted to the context of mathematics lessons (e.g., "math teacher" instead of "teacher"). The participants answered on a 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7). As our sample was a few years younger than the validation sample, we ran a confirmatory factor analysis (CFA) for all three data collection times points, which showed excellent fit to our data MLR$\chi^2(355) = 524.99$, $p = .000$; RMSEA = 0.030, CFI = 0.944, SRMR = 0.055, with standardized factor loadings ranging from 0.35 to 0.66. The scale also showed acceptable to good reliability, with Cronbach's alphas of 0.72 at T1, 0.77 at T2, and 0.81 at T3.

2.2.2. Personality traits

Student personality was measured at T1 using the short version (Markos & Kokkinos, 2017) of the Big Five Questionnaire for Children (BFQ-C; Barbaranelli et al., 2003). This questionnaire includes five six-item subscales for a total of 30 items. The conscientiousness subscale evaluates the individual's reliability, organization, and precision (sample item: "During class-time I am concentrated on the things I do"). The openness subscale captures the child's openness to new experiences, creativity, and curiosity (sample item: "I easily learn what I study at school"). The agreeableness subscale reflects traits related to altruism, trust, and cooperative behaviors (sample item: "I behave correctly and honestly with others"). The emotional instability subscale assesses the tendency toward emotional distress and mood fluctuations (sample item: "I get nervous for silly things"). Finally, the energy subscale, frequently referred to as extraversion, measures the level of sociability and energy and the propensity to seek stimulation in the company of others (sample item: "I like to be with others"). The students answered on a 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7). As the short version of the BFQ-C had never been tested in Italy, we ran a CFA, which reported a good fit to the data (MLR$\chi^2(377) = 601.86$, $p = .000$; RMSEA = 0.038, CFI = 0.919, SRMR = 0.057), with all items loading on the expected factor. All scales showed acceptable to good reliability, with Cronbach's alphas of 0.70, 0.77, 0.76, 0.78, and 0.68, respectively.

2.2.3. Gender

Students were asked "You are…" and could self-identify by clicking "male" or "female", or could decide not to answer if they felt uncomfortable or if they did not identify with either option. This approach was chosen to facilitate an inclusive survey, acknowledge diverse gender identities, and ensure the comfort of participants in declaring their gender while remaining within the mandate agreed by the schools in allowing the researchers to enter the sixth-grade classrooms.

2.3. Data analysis

Preliminary descriptive statistics and scale reliability were computed using SPSS version 29. Prior to testing our hypotheses, we checked configural metric and scalar longitudinal measurement invariance for the agentic engagement measure, by subsequently constraining factor loading structure, factor loadings and intercepts to be equal across waves. Invariance was considered achieved if deterioration in model fit did not exceed the cut-off values of Δ CFI < -0.010 and Δ RMSEA $<$ 0.015 and Δ SRMR < 0.010 (Chen, 2007). To address our first research question, we used Mplus 8.0 (Muthén & Muthén, 2009) to estimate a latent growth curve model, which allowed us to test the trajectory of change of agentic engagement from T1 to T2 and T3. In this model, scores for each wave were used as observed factors to compute latent variables (i.e., the latent intercept and slope), capturing the direction and size of the change over time. We could also assess whether there was a significant variation among individuals in the starting values (intercept) and trajectory (slope). The full information maximum likelihood (FIML) technique was used for the missing values (Graham, 2009), backed by Little's test to support the MCAR hypothesis for our data. To address our second research question, we added in the latent growth model our hypothesized predictors, gender and personality traits, as time-invariant covariates (see Fig. 1 for a visual representation of the effects tested). As the time-invariant covariates were collected only at T1, we could include in this model only participants who were present at school for the first wave of data collection. To make sure that statistical power could be achieved with this smaller sample, we ran a post-hoc power analysis, by computing a Monte Carlo simulation with Mplus 8.0.

To assess the goodness of fit of each model, we used the following indices and cut-off criteria (Hu & Bentler, 1999; Marsh et al., 2004): comparative fit index (CFI), standardized root-mean-square residual (SRMR), and root-mean-square error of approximation (RMSEA), to indicate acceptable (CFI > 0.90, SRMR < 0.10, RMSEA < 0.08) or excellent fit (CFI > 0.95, SRMR < 0.08, RMSEA < 0.06). The maximum-likelihood with robust standard errors estimator (MLR) was used to compute all the models. To address the nested nature of our sample and the clustering of participants in classrooms, we used the "type = complex" analysis in the Mplus software, along with the "cluster" command to have the models compute corrected standard error estimates, reducing the possibility of Type 1 errors (−).

3. Results

Means and correlations among the study variables are reported in Table 1. The configural invariance model showed acceptable fit to the data, with χ^2 (24) = 111.53, $p = .000$, CFI = 0.95, RMSEA = 0.08 and SRMR = 0.03. The loss of fit was within cut-off values for both metric (ΔCFI = −0.003, ΔRMSEA = −0.003, ΔSRMR = 0.001) and scalar invariance (ΔCFI = −0.003, ΔRMSEA = −0.003, ΔSRMR = 0.001) supporting longitudinal measurement invariance for our data.

The latent growth curve model estimated for RQ1 reported excellent fit to our data (Hu & Bentler, 1999): MLR$\chi^2(1) = 2.07$, $p = .151$; RMSEA = 0.045, CFI = 0.996, SRMR = 0.014. The mean latent intercept (i.e., the mean level of agentic engagement at T1) was B(SE) = 5.50 (0.50), and the mean latent slope (i.e. the coefficient of change over time) was (B(SE) = −0.48 (0.19), $p = .011$). The negative sign of the mean latent slope indicated that agentic engagement decreased during the school year (from T1 to T2 and T3); the p value lower than 0.05 suggests that this decrease was significant, supporting our first hypothesis (HP1). The latent intercept and slope were not significantly correlated ($r = -0.02$; $p = .944$), indicating that the starting levels of agentic engagement were not related to the change over time. Neither the latent intercept nor the slope reported a significant variance among individuals (both B(SE) = 1.00 (0.00), $p = .999$).

After adding the predictors for our RQ2 as time-invariant covariates (i.e., gender and personality traits), the latent growth curve model again reported excellent fit to the data (MLR$\chi^2(7) = 6.81$, $p = .449$, RMSEA = 0.000, CFI = 1.000, SRMR = 0.011). Contrary to our first hypothesis (HP2), gender was not significantly related to the latent intercept (B(SE) = −0.06 (0.05), $p = .266$), but it had a significant effect on the slope (B (SE) = −0.19 (0.07), $p = .006$), supporting our second hypothesis (HP3).

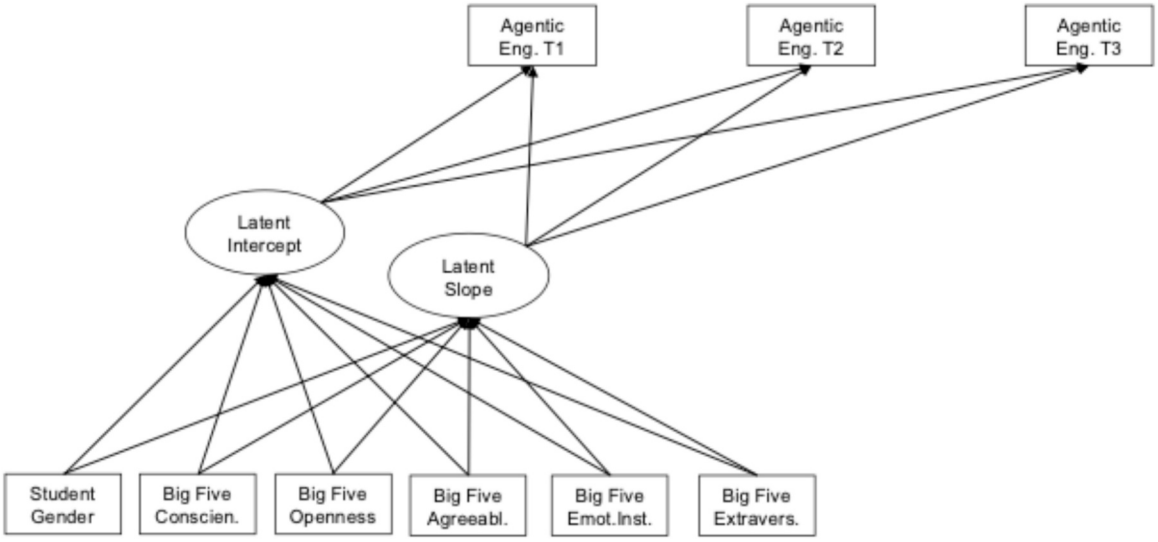

Fig. 1. The estimated latent growth model with time-invariant covariates.

Table 1
Means and correlations among the study variables.

	Variables	1**	2	3**	4	5	6	7*	8**
1	Big Five: Conscien.	1	0.47**	0.53**	−0.20**	0.21**	0.10	0.06	0.19*
2	Big Five: Openness	0.58**	1	0.44**	−0.11	0.32**	0.23**	0.13	0.17*
3	Big Five: Agreeabl.	0.61**	0.51**	1	−0.26**	0.29**	0.09	0.12	0.03
4	Big Five: Neurot.	−0.17**	−0.13	−0.25**	1	−0.02	0.00	−0.07	−0.03
5	Big Five: Extraver.	0.28**	0.39**	0.42**	−0.07	1	0.32**	0.44**	0.40**
6	Agentic Eng. T1	0.11	0.29**	0.19**	0.08	0.30**	1	0.54**	0.55**
7	Agentic Eng. T2	0.03	0.25**	0.16*	0.09	0.30**	0.61**	1	0.60**
8	Agentic Eng. T3	0.07	0.22**	0.20**	0.09	0.33**	0.54**	0.74**	1
	M (female stud.)	3.68	3.08	3.90	2.75	3.58	4.12	3.84	3.71
	SD (female stud.)	0.71	0.72	0.67	0.93	0.77	0.95	0.98	1.04
	M (male stud.)	3.45	3.15	3.63	2.60	3.66	4.29	4.07	4.05
	SD (male stud.)	0.75	0.81	0.71	0.79	0.71	1.02	1.11	1.16

Note. Asterisks next to the numbers in the variable line refer to a significant difference between female and male students' mean scores in each variable based on the comparison of means through an ANOVA test. In the correlation section, above the middle line are the reported intercorrelations for female participants, and those for male participants are below the line.

* $p < .05$.

** $p < .01$.

This means that while female and male students on average started from similar levels of agentic engagement at the beginning of the year, agentic engagement decreased more steeply over time for female students. Conversely, personality traits were not significantly related to the latent slope (conscientiousness B(SE) = 0.13 (0.12), $p = .301$, openness B(SE) = −0.16 (0.12), $p = .193$, agreeableness B(SE) = −0.09 (0.13), $p = .479$, emotional instability B(SE) = −0.01 (0.09), $p = .938$, extraversion B(SE) = 0.21 (0.11), $p = .066$), while openness and extraversion were positively related to the latent intercept (respectively B(SE) = 0.27 (0.07), $p = .000$ and B(SE) = 0.33 (0.07), $p = .000$), supporting our final hypothesis (HP4). This suggests that higher levels of these two personality traits were associated with higher agentic engagement at the beginning of the year, but their effect became increasingly irrelevant over time. As some coefficients approached statistical significance and our sample was relatively small, to test statistical power in detecting significant effects, we ran a Monte Carlo simulation with 1000 replications of a sample of 400 individuals, looking for statistical power in detecting significance for a 0.2 coefficient for the covariate effects on both intercept and slope. The other parameters (mean and residual variance for the intercept and slope, intercept and slope correlation) were fixed to be similar to our estimated model. The simulation indicated low parameter bias (estimates averages were all approximately 0.2) and standard error bias, good 95 % coverage (between 0.94 and 96 for all coefficients) and suggested that our sample could provide good statistical power (between 0.98 and 1.00 for all coefficients).

4. Discussion

The present study aimed to advance the literature on student agency, understood within a psychosocial theoretical perspective (Bae et al., 2025), by testing its longitudinal trajectory in mathematics classrooms over one school year and its associations with student gender and personality. Our results provide original insights on the worrisome decline in student agentic engagement over time and the role of individual variables in this process. The main results are discussed below, along with their implications for research and practice.

4.1. The trajectory of student agentic engagement over time

As expected (HP1), our study showed that student agentic engagement in mathematics significantly declined from the beginning to the end of the school year in a sample of sixth grade ~~six~~ students. This means that the students felt that, over time, they tended to express their needs and desires to a lesser extent, voice fewer opinions and preferences, and propose fewer topics for discussion. The finding of a significant change over one year of school is consistent with previous studies highlighting

how the passage to secondary school is a moment of change, related to both the developmental stage students are crossing (Harris et al., 2024; Weil et al., 2013) and to the changing learning environment (Jindal-Snape et al., 2020). Our study thus suggests that, in this time of new challenges and transition, agentic participation suffers a detrimental rather than flourishing process. This is a novel, albeit not unexpected, finding, as to the best of our knowledge, no previous study has tested the longitudinal trajectory of agentic engagement, with existing longitudinal research focusing instead on its antecedents and consequences (Jang et al., 2016; Michou et al., 2023; Patall et al., 2019). This is an important point of reflection for researchers and practitioners alike: despite the importance placed on active student participation in all school activities, especially mathematics, for quite some time in the research literature and political arena (Jääskelä et al., 2020; OECD, 2019; Reeve & Jang, 2022), our results suggest that the problem remains as crucial as ever. Moreover, this decline in agentic engagement is particularly alarming because it was specific to students transitioning from primary to secondary education, a critical developmental stage of adolescence. This period demands opportunities for young people to build autonomy, develop critical thinking, and feel that their voices are heard and valued. However, our results suggest that the contrary ensued.

The absence of correlation found between the starting levels (i.e., the latent intercept) and the trajectory (i.e., the latent slope) of agentic engagement suggests that the crux of the matter is that this problem occurs *during* the school year. Indeed, this finding disproves the idea that students who start out dejected then proceed to follow a downward trajectory; rather, it indicates that the decline stems from elsewhere, which begs the question of where. As discussed in the introduction, student agency is conceptualized as an intrinsically interactive construct (Mameli et al., 2023; Reeve & Jang, 2022), situated at the meeting point of individual and contextual factors, both of which can be expected to contribute to its declining trajectory. In this study, we chose to focus on clarifying the issue of the role of individual factors. The results are presented in the following paragraphs.

4.2. The role of individual variables

Our latent growth approach to the study of student agency in mathematics led to novel and nuanced findings on its associations with gender, allowing us to distinguish between the instant measurement of agentic engagement at the beginning of the school year and its trajectory over time. Indeed, on one hand, gender was not significantly associated with the latent intercept, that is, the level of agentic engagement at the beginning of the school year. This finding, contrary to our expectations (HP2) and previous findings regarding high school Italian students (Mameli & Passini, 2017), was nonetheless consistent with that of other studies conducted with middle school students (Reeve, 2013). Interestingly, our second hypothesis on student gender (HP3) was instead corroborated by our data, as female students reported a steeper decline in agentic engagement than their male counterparts. These findings together suggest that female students do not start the year with lower agentic engagement than male students; rather, they *become* less agentic over time, possibly explaining the discrepancy among previous studies, a suggestion that needs to be corroborated in future research. Given our focus on mathematics education, it should also be noted that this result is consistent with findings on the gender gap in mathematics achievement, which is low at the beginning of schooling but increases throughout the school years (Contini et al., 2017).

Again, these findings seem to send one back to what happens within the schooling process. The open question, then, is what occurred during the school year that led trajectories to diverge for male and female students? Several interpretations could be argued and followed-up in further studies. Given that male and female students appear to enter secondary school with similar profiles of agentic engagement, we propose that, in the never-ending dialectic between individual and contextual factors in educational processes, the next step would be to turn again toward the learning environment. In particular, it would be worth to understand whether social and cultural factors, which may acquire increasing emphasis in this delicate transition phase from primary to secondary school (Kaur et al., 2022), could be involved in starting and progressively sustaining vicious cycles of self-silencing for female students (Passolunghi et al., 2014).

This study also aimed to advance the literature on student agency by devoting attention to the role of personality traits, which have received less attention in previous studies, leaving open questions about their weight in students' propensity to openly speak about their needs, preferences, and opinions in the learning process. In this regard, our findings were somewhat opposite to those on student gender. Indeed, as expected (HP4), we found that personality traits consistent with a proactive, energetic, and outgoing profile (i.e., openness and extraversion) were linked to higher levels of agentic engagement at the beginning of the school year. This supports, from a quantitative perspective, the qualitative results of Zambrano et al. (2022) in focus groups with students on possible facilitators of agentic behaviors. However, in our data, there was no significant association with the trajectory of agentic engagement over time. This finding is consistent with insights from other limited research on student agency and personality traits (Luo et al., 2019; Michou et al., 2023), highlighting the role of the learning environment rather than personality factors. This result may add a valuable piece to the puzzle, possibly clarifying previously mixed results, as it shows that while initial levels of student agency may be linked to individual personality, its development over time is not related to a person's individual dispositions. In our study, open and extraverted students began the school year with a higher propensity for self-expression, but the direction and intensity of changes in their perception of agentic engagement over time were not related to these or other personality traits; thus, these traits had not dampened or accelerated the registered decline.

We can now circle back to the open question of the declining trajectory of agentic engagement in mathematics, that is, the role of individual variables, and synthesize our results. On one hand, our study indicates that student gender is significantly related to changes in agentic engagement over time but not with its initial levels, suggesting that there is no intrinsic difference between boys and girls, as they start from similar levels; however, something happens during the school year that leads to varying trajectories. On the other hand, we found that open and extraverted students were more agentic at the beginning of the school year, but they followed the same declining trajectory as other students over time. Overall, through exclusion rather than confirmation, our study found that individual variables alone, while providing crucial insights, play a limited role in the longitudinal development of student agentic engagement, thus bringing to the forefront the responsibility of learning environments in its nurturing.

4.3. Limitations

The present study offers original and nuanced insights on the longitudinal processes behind student agency in mathematics in secondary school; however, there are several limitations that need to be underlined when interpreting the results. First, it is important to note that our data are based on students' evaluations of their own agentic engagement. While this is the standard in the psychosocial literature on student agency and an adequate method to capture individual perceptions, which are at the core of the present study aims, it should be explicitly stated that this study did not measure actual behavior, which may not overlap with self-perceptions. Second, while our longitudinal approach offers a first look at student agentic engagement trajectories over time, it is limited by its duration of a single school year. Future research with longer designs is needed to provide a fuller picture of the longitudinal development of agentic engagement over several school years, within the same school level, and ideally across various levels, as trends may change when following years are considered. Third, as our study had different aims, we accounted for the nested nature of our data, but we

did not adopt a multilevel approach. Future studies may build on our work by also investigating teacher, classroom and school related information. Finally, in this study, we aimed to address the contemporary issue of the gender gap in mathematics education by looking at the differences in agentic engagement between male and female students. The gender gap issue is particularly interesting in the Italian context, where national and international standardized assessments highlight a remarkable gender gap in mathematics; however, due to the strong influence of social and cultural factors on the gender gap, it would be interesting to collect similar data on student agency in other countries and environments. Furthermore, it is important to note that the issue of gender is considerably broad, and future studies may start from our findings to advance this direction of inquiry by also considering other minorities.

5. Conclusion

For years now, scholars and policymakers have "celebrated" the importance of fostering student agency, particularly in science and mathematics, yet our study, at least within its generalizability limitations, highlights a stark reality: we continue to fail at this task. The declining trajectory of student agentic engagement, especially in students transitioning from primary to secondary school, must be a wake-up call in confronting the gap between an educational research field calling for authentic student-centered learning and real educational systems that still appear to be encouraging gradual learner domestication. Further, our findings on gender and personality traits suggest they have an insightful but limited role in shaping students' agentic involvement with learning: if what students *bring with* them plays only a partial role, the question then is how to *bring it out* of them, and, crucially, what is going wrong.

CRediT authorship contribution statement

Valentina Grazia: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Chiara Giberti:** Writing – review & editing, Investigation, Data curation, Conceptualization. **Consuelo Mameli:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization.

Ethics approval

The research was conducted in accordance with the ethical norms of the Italian National Psychological Association and with the approval of the local Ethical Committee. Informed consent was obtained from all individual participants included in the study and their legal guardian.

Declaration of Generative AI and AI-assisted technologies in the writing process

No generative AI was used in the writing of this paper.

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Declaration of competing interest

None.

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