European Journal of Psychology of Education (2023) 38:587–603
https://doi.org/10.1007/s10212-022-00626-9

The influence of SES, cognitive, and non-cognitive abilities on grades: cross-sectional and longitudinal evidence from two Swedish cohorts

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Received: 15 February 2022 / Revised: 25 May 2022 / Accepted: 10 June 2022 /
Published online: 13 July 2022

Abstract
It is well established that socioeconomic status, cognitive ability, and non-cognitive abilities such as self-efficacy are substantially associated with academic achievement. However, the specific relationships of these variables remain a relatively unexplored topic in regard to more recent and representative samples. The current study examined such relations by taking advantage of two cohorts (total $N = 12{,}315$) of Swedish students at the elementary (Grade 6) and lower-secondary school levels (Grade 8) in the compulsory school. The regression models showed that all three variables explained a substantial portion of grade variance, with cognitive ability having the strongest relationship, followed by non-cognitive abilities, and SES. Longitudinal associations, which accounted for previous academic achievement, showed that the three variables did still explain a substantial amount of grade variance.

Keywords Socioeconomic status · Cognitive ability · Non-cognitive ability · Grades · Sweden

Introduction

Apart from cognitive ability (e.g., Deary et al., 2007; Laidra et al., 2007; Li et al., 2019; Roth et al., 2015), it is well established that socioeconomic status (SES) is intimately linked to academic achievement such as grades and scholastic assessment tests in a variety of national and international contexts (e.g., Sirin, 2005; Tan, 2015; Kim et al., 2019), including Sweden (e.g., Gustafsson & Yang Hansen, 2018; Myrberg & Rosén, 2009; Wiberg & Rolfsman, 2021). Although measurement of SES may differ between countries and regions (e.g., Kim et al., 2019), parental education, home resources, or average (parental) income is typically used to indicate SES. These types of measures tend to be highly correlated and estimates do not differ substantially depending on the use of only one of these two forms of indicators (e.g., Falk

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et al., 2021). In the Programme for International Student Assessment (PISA) context, the estimated number of books at home is typically used as an indicator of SES (e.g., Reimer et al., 2018; Tan, 2015). More books at home indicate a higher level of SES (Reimer, et al., 2018, p. 35). The relationship between SES and grades in the Swedish context is moderate but has partially been affected by migration during recent decades (Gustafsson & Yang Hansen, 2018). Thus, the relative impact of migration background (MB), and its relation to SES, on school results has increasingly become an important area of research within the Swedish context (e.g., Gustafsson & Yang Hansen, 2018; Boman, 2021, 2022a, b, c).

Other pertinent factors which are associated with school achievement include in particular conscientiousness, which is a part of the five-factor model of personality (FFM, openness to experience, conscientiousness, extraversion, agreeableness, neuroticism, e.g., Conard, 2006; Duckworth & Seligman, 2005; Poropat, 2009). Such results have also been found among Swedish samples at the elementary and lower-secondary school levels (Rosander & Bäckström, 2014). There are many studies which include both cognitive and non-cognitive or personality factors such as the FFM or other non-cognitive abilities such as self-efficacy or locus of control (e.g., Bandura, 2006; Borghans et al., 2008; Duckworth et al., 2011; Duckworth & Seligman, 2005; Guez et al., 2018; Heckman & Kautz, 2014; Lu et al., 2011; Rammstedt et al., 2016; Sorjonen et al., 2012; Vazsonyi et al., 2022). Humphries and Kosse (2017), however, stress that it is important to separate personality constructs such as the FFM from (other) non-cognitive constructs. It has been known for a long time that personality factors can directly or indirectly influence cognitive abilities as measured by IQ tests (Borghans et al., 2008; Duckworth et al., 2011). Hence, there seem to be interrelationships and interactions between SES, IQ, and non-cognitive abilities/personality traits that require further analysis.

However, the problem with earlier research endeavors which focus on the nexus between cognitive ability, non-cognitive abilities, SES, and academic achievement is that several studies are based on small samples (e.g., Duckworth & Seligman, 2005; Lu et al., 2011; Vazsonyi et al., 2022), or use PISA or Programme for the International Assessment of Adult Competencies (PIAAC) as proxies for cognitive abilities (Rammstedt et al., 2016). Specifically, smaller sample sizes decrease generalizability whereas PIAAC or PISA tests that measure literacy are likely influenced by school knowledge and teacher's cognitive skills, domain-specific skills, and instructional competence (Hanushek et al., 2019), to a substantially larger extent than "pure" cognitive ability tests (Bardach & Klassen, 2020; Borghans et al., 2016).

Moreover, Sorjonen et al. (2012) used a very large register data sample but the sample consisted of older Swedish men and used education level as a predictor rather than as an outcome variable. Similarly, that is also the case with Cusina et al. (2016) whose samples majorly consisted of individuals who were born in first half of the twentieth century. Moreover, in the Swedish context, educational researchers may not satisfactorily account for cognitive ability in studies that focus on SES and non-cognitive abilities (e.g., Thorsen et al., 2021). Specifically, if cognitive ability is omitted, multivariate models may suffer from omitted variable bias. Thus, the results might be partly unreliable. Furthermore, although several meta-analyses (e.g., Kim, 2019; Sackett et al., 2009) have found strong relationships between SES and academic achievement such as grades or test scores, these have had a cross-sectional constitution.

Hence, the current study used two longitudinal cohorts of Swedish students who were born in 1998 and 2004 (Svensson et al., 2007). These were analyzed both cross-sectionally and longitudinally. Thus, it contributes with more recent data on both SES, cognitive abilities, non-cognitive abilities, and educational achievement. The regression models tested these three major explanatory variables (SES, cognitive ability, non-cognitive ability) as well as interaction terms and control variables. As migration background might be closely connected to SES in the Swedish context (e.g., Holmlund et al., 2019), particular attention was paid to such relationships. Because of the longitudinal constitution of the data, it was also possible to measure the impact of previous school achievement on later school achievement in one of the cohorts. Predominantly, the current article adds to the literature on the nexus between SES, cognitive abilities, and non-cognitive abilities and their relationship with grades (e.g., Duckworth & Seligman, 2005; Guez et al., 2018; Li et al., 2019; Lu et al., 2011), although some attention is also paid to teaching quality–grade relationships.

The influence of SES, cognitive ability, and non-cognitive ability on grades

It is a general pattern that high-SES students outperform their lower-SES peers (e.g., Sirin, 2005). That might occur because high-SES parents are more involved in their children's lives and have higher aspirations as regards their children's future trajectories in education and the labor market. In the home environment, high-SES parents spend more time reading with and to their children which likely stimulates cognitive growth and learning (e.g., Myrberg & Rosén, 2009). Moreover, children whose parents have higher SES do generally develop higher cognitive ability levels which are then transmitted to their children through both genes and the environment (Engelhardt et al., 2018; Falk et al., 2021; Turkheimer et al., 2003). Conversely, the lower degree of nurture and support among lower-SES children can affect the cognitive ability levels, and hence outputs in for example school tests, negatively (Flynn, 2012; Sackett et al., 2009; Turkheimer et al., 2003).

There are strong theoretical and empirical reasons to assert that school achievement such as grades is influenced by SES, cognitive ability and non-cognitive abilities (e.g., Duckworth & Seligman, 2005; Falk et al., 2021). There are also strong reasons to believe that SES influences cognitive ability (Flynn, 2012; Myrberg & Rosén, 2009; Turkheimer et al., 2003), and that non-cognitive ability affects cognitive ability (Borghans et al., 2008; Heckman & Kautz, 2014). For instance, more conscientious students tend to perform slightly better in IQ tests because they are more intrinsically motivated and concentrated to do well whereas less conscientious students' performance is substantially influenced by external motivation such as financial rewards (Borghans et al., 2008; Duckworth et al., 2011). Secondly, and perhaps more importantly, conscientious students learn more through effort such as obtaining more school knowledge and larger vocabularies which may boost, in particular, crystallized intelligence such as verbal reasoning (Gustafsson, 1984; Heckman & Kautz, 2014; Ritchie & Tucker-drob, 2018).

On the other hand, non-cognitive abilities such as concentration and conscientiousness may function in a compensatory way for average cognitive ability individuals or low cognitive ability individuals (Rammstedt et al., 2016). Furthermore, more conscientious students are partly awarded for attendance in relation to grades (Westphal et al., 2021). Hence, while it might be possible to build complex and dynamic models that demonstrate the relations and sometimes mutual influence of SES, cognitive ability, and non-cognitive abilities on, for example, school grades, it is appropriate to measure these factors as separate constructs.

Then the relative influence of each factor can be assessed empirically with regard to both separate variables and interactions between several variables.

Teaching quality and grades

In Sweden, there is a dearth of studies on the relationships between teaching quality and academic performance but Holmlund et al., (2019; see also Darling-Hammond, 2021) stress that it seems crucial to include some indicators of teaching quality as a covariate in studies on academic achievement if the data includes such variables.

The contemporary Swedish education context

As Gustafsson and Yang Hansen (2018) underscore, Sweden has since 1998 moved from a normed-referenced grading system to a criterion-based grading system. The Swedish national curriculum has been revised several times, and the last major revision for the entire school system was introduced in 2011 (Lgr 11), with a partial revision in 2018. Sweden offers 9 years of compulsory education, in which "Årskurs 7–9" can be translated into lower-secondary education (Swedish National Agency for Education, 2018).

Apart from the knowledge-centered national curriculum of compulsory education, the current education system is affected by the free school choice on a voucher based quasi-market, which leads to increased school segregation (Hennerdal et al., 2020), and high rates of low-skilled migrants the 1990s onwards (Ruist, 2015). Fundamentally, the Swedish educational context is signified by a hybrid system of on the one hand neoliberal-oriented decentralization and school accountability and centralized control and bureaucracy on the other hand (Bunar, 2010; Hennerdal et al., 2020).

Aim, research questions and hypotheses

The aim of the study is to examine the relationships between SES, cognitive ability, non-cognitive ability, and grades. In addition, appropriate covariates such as migration background and its interaction with SES (e.g., Wiberg & Rolfsman, 2021) as well as teaching quality (Alatalo et al., 2021) have been included in some of the ordinary least squares regression models.

The following research questions are addressed:

RQ1: What are the associations between SES, cognitive ability, and non-cognitive ability, and grades?
RQ2: Do SES, cognitive ability, and non-cognitive ability have a longitudinal association with grades, even when previous school achievement is controlled for?

These research questions were related to the following hypotheses:

H1: SES, cognitive ability, and non-cognitive ability explain a substantial amount of variance of grades when they are included in the same multivariate models (e.g.., Duckworth & Seligman, 2005; Guez et al., 2018; Laidra et al., 2007; Lu et al., 2011; Poropat, 2009; Roth et al., 2015).

The second hypothesis is based on earlier research which indicates that cognitive ability is a slightly stronger predictor compared to non-cognitive abilities such as conscientiousness and self-control, which in turn is a slightly stronger predictor than SES (e.g., Hartmann et al., 2010; Laidra et al., 2007; O'Conell & Marks, 2022; Roth et al., 2015; Vazsonyi et al., 2022). In particular, recent research by Vazsonyi et al. (2022), whose analyses were based on a rather large sample (but considerably smaller and less representative compared to the ones in the current study), shows that cognitive ability outdoes self-control in predicting academic performance as measured on a later occasion (i.e., longitudinally).

H2: Cognitive ability has a slightly stronger association with grades, relative to non-cognitive ability, and SES

The third hypothesis is based on earlier research which indicates that earlier school achievement explains the most variability of later school achievement (e.g., Gustafsson, 2007; Heckman & Kautz, 2014). Moreover, Vazsonyi et al. (2022) show that cognitive ability is a strong longitudinal predictor of academic achievement. Hence, it is likely that these main explanatory variables (cognitive ability, non-cognitive ability, SES) to different extents explain variance in grades, even when earlier academic performance is included in a longitudinal model.

H3: SES, cognitive ability, and non-cognitive ability do still explain a substantial amount of variance, even when previous school achievement is controlled for.

Method

Dependent variable and data

When examining educational achievement among Swedish students in compulsory school, there are typically four standardized procedures to evaluate them: grades, national tests, international tests (e.g., PISA), and specific tests constructed by researchers (Holmlund et al., 2019; Björklund et al., 2010). While all these assessments have their set of strengths and weaknesses (Lundahl, 2014), grades — especially non-self-reported such (Kuncel et al., 2005) — are pertinent because they are predictive for the future life course among individuals (Borghans et al., 2016). Although grades might be slightly less reliable than national test results and prone to inflation (e.g., Molin, & Fjellborg, 2021), the correlations between grades and national test results are moderate to large (Boman, 2022b).

Sweden offers 9 years of mandatory school education, in which"Årskurs 7–9" can be translated into lower-secondary education (Swedish National Agency for Education, 2018). In Grade 6 ("Årskurs 6″), which is the last school year at the elementary level, students are typically 12 to 13 years old, and 14 to 15 years old in Grade 8 ("Årskurs 8″). In the current grading system, F counts as O points, E as 10 points, D as 12.5 points, C as 15 points, B as 17.5 points, and A as 20 points, in all subjects.

In this article, the author chose to have three composite grade point averages (GPA) in Grade 8 as the outcome variable. As, for example, Gustafsson and Yang Hansen (2018) stress due to the importance of to include more grades to increase reliability, an aggregated grade point average (GPA) was created for the three subjects that constitute the national test results: English, mathematics, and Swedish. Because there are missing values as

Table 1 Descriptive statistics, 1998 cohort

Variable	*N*	Minimum	Maximum	Mean	Std. deviation
GPA Grade 8	8593	.00	60.00	38,139	11,581
Cognitive ability	7682	15.00	134.00	79,470	19,802
Non-cognitive (1)	7898	.00	2.00	1,543	.737
Non-cogniitive (2)	7880	.00	2.00	1,312	.870
SES	9671	− .46	-54	.0112	.498

Table 2 Descriptive statistics, 2004 cohort

Variable	*N*	Minimum	Maximum	Mean	Std. deviation
GPA Grade 8	3722	.00	60.00	39,434	12,269
GPA Grade 6	8453	.00	60.00	41,880	11,705
Cognitive ability	5247	6.00	136.00	80,814	21,028
Non-cognitive ability	5117	2.00	10.00	4,077	1,449
SES	9268	99,49	998,49	417,144	143,144

regards the grades in other subjects, it was deemed appropriate to include three basic subjects. The GPA for both cohorts were normally distributed (see Fig. 1 and Fig. 2 in supplementary information) and sample sizes large (Tables 1 and 2), and therefore linear regressions without bootstrapping techniques were conducted (e.g., MacKinnon et al., 2002). Moreover, a two-way mixed effect model (see supplementary information) indicated that the intra-class correlation was non-existent and therefore, no problematic nested effects of the data (i.e., individuals within schools that share the same characteristics) were identified (e.g., Musca et al., 2011), and which further indicated that the linear regression model technique was appropriate.

The current article is built on the UGU database, which is a longitudinal data set associated with the University of Gothenburg that consists of ten cohorts that are born between 1948 and 2004. These data are based on random and representative samples that are, in the first instance, based on school administration data from Statistics Sweden. Specifically, the two latest cohorts include 9671 students who were born in 1998 and 9775 students who were born in 2004 (total $N = 19{,}446$, 51% male) and these two cohorts are used in the current study. All students were tested in Grade 6 (Giota et al., 2008) but in Grade 8, there were only 5257 students and in regard to several items, there were even less responses or collected grades, typically ranging from about 4200 to 9700 students (Tables 1 and 2). The students' grades in Grade 8 were received in the spring term in 2013 for the 1998 cohort and in 2019 for the 2004 cohort.

The UGU data set includes multiple indicators of parental education (Svensson et al., 2007), migration background, grades, and national test results for all subjects and subtests, as well as various cognitive test results, and non-cognitive indicators and attitudes towards their school situation and well-being, as well as information about special needs programs and physical health development indicators (e.g., height, weight). The information which the data builds upon was retrieved from the schools' administration (e.g., grades and national test results) but also, the students, their parents, and teachers filled in

questionnaires, typically at one or two occasions. In the current study, background information (e.g., parental and family SES) was retrieved in Grade 3, while student questionnaires and cognitive tests were administered in Grade 6. In order to have consistency, the dependent variables were grade point averages (English, mathematics, Swedish) in Grade 8 in all models. However, in relation to the 2004 cohort, the author used GPA from Grade 6 as a predictor which enables longitudinal associations. Hence, the research design might be described as both cross-sectional and longitudinal.

Independent variables

SES

In accordance with the suggestions conveyed by Svensson et al. (2007), the current study focused on a measure that covers parental education in a way that reflects parents that are typically born in the 1970s. It consists of 11 categories where 1 represents pre-secondary education, and a doctoral degree represents 11. The intermediate levels of education consist of various degrees of secondary and tertiary education, as well as licentiate degree (= 10) which means a half doctoral degree (2-year post-master's level). This information was then captured by a dummy variable that measured the highest educational level by both the biological parents and the parents living with the child, where 0 = no higher education and 1 = higher education (at least 2 years). While complete SES consists of a composite of parental education, parental income, and occupational position (Sackett et al., 2009), many researchers believe that a single SES indicator is sufficient (e.g., Falk et al., 2021; Wiberg & Rolfsman, 2021).

SES and migration background interaction

Because SES is assumed to be intimately linked to migration background (e.g., Wiberg & Rolfsman, 2021), an interaction term was used to capture a potential interaction effect between SES and MB. Specifically, the same SES variable and a dichotomous MB variable, which consists of two options, Swedish = 0, immigrant = 1, were included alongside the interaction term. The correlation between SES and MB was $r = -0.129$ which signifies a small relationship (Cohen, 1988). The SES term was aggregated and mean centered to avoid problems with multicollinearity.

Cognitive abilities

The data set includes four different cognitive ability measures which to different extents are linked to fluid and crystallized dimensions of cognitive abilities: antonyms, synonyms, reversed number series, and metal folding. Metal folding is the item which is the most reminiscent of Raven's progressive matrices whereas the others are mainly associated with verbal abilities. All represent sub-dimensions of the so-called general factor of intelligence, *g* (Catell, 1987; Giota & Gustafsson, 2021; Giota et al., 2008; Gustafsson, 1984). The number of correct answers items was used as a continuous measure of the cognitive ability levels among the students. The Cronbach's alpha for the 1998 cohort was acceptable ($\alpha = 0.732$, valid cases $N = 7682$), as well as with regard to the 2004 cohort ($\alpha = 0.737$, valid cases $N = 5247$). The cognitive ability test is described by Svensson (1964) as having both verbal, spatial, and inductive features.

Non-cognitive abilities

To examine the relationship between Swedish Grade 8 students' non-cognitive abilities, mostly related to self-efficacy and achievement striving, and their grade point averages, a set of items from the 1998 cohort was included. These items constitute indicators of self-confidence in one's abilities within the frames of the school context (Giota et al., 2008; see also Andersen et al., 2020). Not all of them had a strong consistency with other similar items. For example:

A) "How true are the following statements: I can normally manage to do the tasks that I am given"
B) "How true are the following statements: I can normally answer the questions that I am given correctly"

Here, Cronbach's alpha was not acceptable ($\alpha = 0.602$, valid cases $N = 7839$) and the two items therefore included as separate variables as regards the 1998 data. The parsimony of this non-cognitive ability is similar to Rammstedt and John's (2007) brief version of the five-factor model which only includes two items for each personality trait. However, this construct cannot be said to fully represent conscientiousness although a few other items were similar to the ones included as conscientiousness measures in Andersen et al. (2020). Instead, it is mostly related to self-efficacy as well as academic self-concept, which means the belief in one's own academic capabilities (e.g., Affuso et al., 2022; Bandura, 2006; Bandura et al., 1977; Bong & Skaalvik, 2003; Multon et al., 1991; Zysberg & Schwabsky, 2021). Nonetheless, the items do not to fully represent either conscientiousness, academic self-concept, or self-efficacy as regards construct validity. Therefore, they are labeled with a more generic and overarching term, non-cognitive abilities (Boman, 2022c). The two items were measured on reversed 5-point Likert scales and then recoded into dummy variables to have an expected positive relationship with grades.

The 2004 cohort did not include the above-mentioned B item, so instead, the item "It is easy for me to meet the teachers' demands" was included. Cronbach's alpha was acceptable ($\alpha = 0.745$, valid cases $N = 5117$). A composite sum score variable was created based on the items. A negative relationship between the sum scores and grades was expected because the sum score kept the initial reverse coded pattern.

SES × cognitive ability × non-cognitive ability interaction

In order to discern if an interaction effect between SES, cognitive ability and non-cognitive ability were present, two interaction terms (one for each cohort) were created and then tested in consecutive regression models. This interaction term included both SES, cognitive ability, and the composite non-cognitive ability items. For the intercorrelated variables (SES and SES × MB, SES and SES × cognitive ability × non-cognitive ability), the aggregated function in SPSS was used for the creation of mean centered values.

Teaching quality

Within the UGU data set, there are no formal teaching quality (or teacher competence) indicators such as teacher graduation level or the teachers' subject knowledge or cognitive

skills (e.g., Darling-Hammond, 2021; Hanushek et al., 2019). However, there are a few items that measure the students' perceptions of being treated more or less fairly by their teachers or simply how content the students are with their teachers.

The regression models included the items, "How content are you with the teachers?" and "Feel unfairly treated by teachers?" which were measured on an ordinal scale. As the inter-item consistency was only − 0.462, these were not considered to constitute the same construct. The first item was re-coded into a dummy variable so that higher values are associated with higher content (1998 cohort), and lower values are associated with higher content and that higher values are linked with less content (2004 cohort). The second item was likewise re-coded into a dummy variable. Correlation matrices for all variables as regards both cohorts are included in supplementary information.

Analytical strategy

Main models

The analytical strategy was ordinary least squares (OLS) multiple regression models. The main estimation model can be described as follows:

$$Grade^{s} = X^{SES}{}_{f}\beta + X^{Cognitive}{}_{s}\beta + X^{Non-cognitive}{}_{s}\beta + C^{Control}{}_{s} + e^{s},$$

where *Grade* is the grade which students receive in the specific subjects (English, mathematics, Swedish), $SES_f\beta$ is the coefficients of the highest educational level of parents in family $_{f}$, $X^{Cognitive}{}_{s}\beta$ and $X^{Non-cognitive}{}_{s}\beta$ are the cognitive and non-cognitive coefficients of students $_{s}$, $C^{Control}{}_{s}$ is a set of individual level control factors (e.g., perceived teaching quality or fairness), and e^{i} is an error term.

The first step was to test the association between SES, migration background, and SES × MB and GPA and then other variables were added to increase the R^2 value in the consecutive models but still control for multicollinearity. Based on the research of, for example, Laidra et al. (2007), Hartmann et al. (2010), Flores-Mendoza et al. (2021), Giota and Gustafsson (2021), and Thorsen et al. (2021), it was expected that the inclusion of cognitive and non-cognitive ability variables would increase the R^2 value and decrease the relative influence of SES on grades.

Longitudinal model

Because of the longitudinal constitution of the data sets, the Grade 6 GPA was added as a predictor of the Grade 8 GPA alongside the other main variables for the 2004 cohort. However, the 1998 cohort did not include grades from Grade 6. Hence, a "full" longitudinal model was only included for the 2004 cohort.

The longitudinal model had the following equational constitution:

$$Grade8_{s} = Grade6_{s-1} + X^{SES}{}_{f}\beta + X^{Cognitive}{}_{s}\beta + X^{Non-cognitive}{}_{s}\beta + C^{Control}{}_{s} + e^{s},$$

where $Grade8_s$ is the GPA which students receive in Grade 8 (in English, mathematics, Swedish), $Grade6_{s-1}$ is the Grade 6 GPA, $SES_f\beta$ is the coefficients of the highest educational level of parents in family $_{f}$, $X^{Cognitive}{}_{s}\beta$ and $X^{Non-cognitive}{}_{s}\beta$ are the cognitive and non-cognitive coefficients of the students $_{s}$, $C^{Control}{}_{s}$ is a set of individual level control factors, and e^{s} is an error term.

Based on earlier research in similar contexts (e.g., Giota & Gustafsson, 2021; Guez et al., 2018; Gustafsson, 2007; Heckman & Kautz, 2014), it was expected that the earlier school achievement (Grade 6) would substantially increase the statistical power of the longitudinal model.

All statistical analyses, as well as collinearity diagnostics, were conducted in SPSS Statistics 26. In both studies, condition indexes above 30 indicate substantial multicollinearity. Moreover, bivariate correlations were used to control for multicollinearity, where values substantially above $r = 0.50$ above may indicate multicollinearity (e.g., Cohen, 1988; Dohoo et al., 1997). The regression results were compared with the multiple imputation function for missing values, but the models were very robust (see supplementary information). Hence, missing values were not considered an issue.

Results

Main findings

The models that only included SES and migration background as predictors showed a small relationship between migration background and grades and a rather strong relationship between SES and grades. The model which includes SES and migration background was statistically significant as regards the interaction term in the 2004 cohort but not in the 1998 cohort (Tables 3 and 6). That may suggest that the most recent cohort consists of more low-performing students with a migration background (e.g., Holmlund et al., 2019). In the 1998 cohort, the cognitive ability factor is by far the strongest among the predictors ($\beta = .548$), while in the 2004 cohort, the non-cognitive abilities had a larger effect size compared to the congruent variables in the 1998 cohort. Nonetheless, cognitive ability was still a stronger predictor than both non-cognitive abilities and SES in regard to the 2004 cohort. This might be because grades in mathematics and languages have a high general intelligence loading (e.g., Gustafsson, 1984; Hilbert et al., 2019). However, when the interaction term that included both SES, cognitive ability, and non-cognitive ability was included, the effect size of cognitive ability decreased to the extent that non-cognitive ability was a stronger predictor. However, the interaction term was not statistically significant which may lead to unreliable results in this regard.

Overall, the models (Tables 4, 5, 7, 8, and 9) that included more predictors, and especially introduced the cognitive variable as well as the non-cognitive variable(s), increased the statistical power of the model, decreased the impact of SES and MB, and showed that the cognitive and non-cognitive variables were significantly and substantially associated with GPA. There were no statistically significant interaction effects between SES, cognitive ability, and non-cognitive ability in the 2004 cohort (see supplementary information), which

Table 3 Results of a linear regression analysis (1998 cohort)

			(*CI*) 95%			
Variable	Beta	*SE*	*LL*	*UL*	β	*p*
SES	7.801	.238	7.333	8.268	.337	.000
Migration background	− .417	.369	− 1.140	.306	− .012	.258
Interaction	− .613	.743	− 2.089	.824	− .009	.394

R^2 .115. *CI* confidence interval for the unstandardized beta coefficient

Table 4 Results of a linear regression analysis (1998 cohort)

			(*CI*) 95%			
Variable	Beta	*SE*	*LL*	*UL*	β	*p*
SES	3.918	.215	3.496	4.340	.174	.000
Migration background	2.364	.340	1.697	3.031	.065	.000
Cognitive ability	.319	.006	.307	.330	.548	.000
Non-cognitive ability (1)	.824	.152	.525	1.122	.053	.000
Non-cognitive ability (2)	.845	.128	.597	1.097	.065	.000
Teacher content	.391	.151	.095	.686	.024	.010

R^2 .418. *CI* confidence interval for the unstandardized beta coefficient. Non-cognitive ability 1 signifies the dummy coded item "I can normally manage to do the tasks that I am given", whereas non-cognitive ability 2 signifies the dummy coded item "I can normally answer the questions that I am given correctly". The teacher fairness variable was removed in this model

Table 5 Results of a linear regression analysis (1998 cohort)

			(*CI*) 95%			
Variable	Beta	*SE*	*LL*	*UL*	β	*p*
SES	4.071	.219	3.641	4.500	.181	.000
Migration background	2.327	.338	1.664	2.989	.064	.000
Cognitive ability	.321	.006	.309	.332	.551	.000
Non-cognitive ability (1)	.876	.152	.579	1.174	.056	.000
Non-cognitive ability (2)	.894	.128	.642	1.145	.051	.000
Interaction	− .016	.006	− .028	− .004	− .025	.010

R^2 .419. *CI* confidence interval for the unstandardized beta coefficient

Table 6 Results of a linear regression analysis (2004 cohort)

			(*CI*) 95%			
Variable	Beta	*SE*	*LL*	*UL*	β	*p*
SES	.052	.005	.042	.061	.533	.000
Migration background	6,274	1.501	3.331	9.217	.174	.000
Interaction	− .017	.004	− .024	− .009	− .263	.000

R^2 .108. *CI* confidence interval for the unstandardized beta coefficient

indicate that these three might be regarded as separate factors. However, that was the case in the 1998 cohort. Hence, it appears important to examine potential interaction effects.

The teacher item "How content are you with your teachers?" was statistically significant in relation to the 1998 cohort but not in the 2004 counterpart (Tables 4 and 6). The "Feel fairly treated by teachers?" item was statistically significant in relation to the 2004 cohort. However, these differences should not be overinterpreted as the item does not capture any objective kind of teaching quality (e.g., Darling-Hammond, 2021). Rather, it is the subjective opinions of students that are measured.

The results from the longitudinal analysis which included Grade 6 GPA as a predictor (Table 9) show that this variable, as expected, had the strongest relationship with

Table 7 Results of a linear regression analysis (2004 cohort)

			(*CI*) 95%			
Variable	Beta	*SE*	*LL*	*UL*	β	*p*
SES	3,011	.563	1.907	4.116	.147	.000
Migration background	− 746	.955	− 2.621	1.128	− .021	.435
Cognitive ability	.252	.016	.220	.284	.462	.000
Non-cognitive ability	− 2.064	.204	− 2.464	− 1.664	− .297	.000
Teacher fairness	2.005	.610	.808	3.203	.089	.001
Teacher content	.515	1,534	− 2.496	3.526	.009	.737

R^2 .499. *CI* confidence interval for the unstandardized beta coefficient

Table 8 Results of a linear regression analysis (2004 cohort)

			(*CI*) 95%			
Variable	Beta	*SE*	*LL*	*UL*	β	*p*
SES (centered)	0.009	.005	− .001	.020	.108	.064
Migration background	.421	.975	− 2.621	1.128	.012	.666
Cognitive ability	.224	.028	.220	.168	.279	.000
Non-cognitive ability	− 2.634	.552	− 3.718	− 1.550	− .380	.000
Teacher fairness	2.009	.598	.835	3.182	.090	.001
Interaction	1.169	.000	.000	.000	.078	.387

R^2 .512. *CI* confidence interval for the unstandardized beta coefficient

Table 9 Results of a linear regression analysis (2004 cohort)

			(*CI*) 95%			
Variable	Beta	*SE*	*LL*	*UL*	β	*p*
SES (centered)	.008	.004	.001	.016	.094	.032
GPA 6	.676	.030	.617	.735	.696	.000
Cognitive ability	.053	.023	.008	.098	.098	.021
Non-cognitive ability	− .568	.434	− 1.428	.284	− .082	.191
Teacher content	− 2.066	1.201	− 4.423	.292	− .036	.086
Interaction	− 4.889	.000	.000	.000	− .033	.638

R^2 .716. *CI* confidence interval for the unstandardized beta coefficient

later achievement (Grade 8). However, the other major predictors (i.e., SES, cognitive ability, non-cognitive ability) were still statistically significant.

Discussion

The main purpose of the present study was to analyze the relationships between SES, cognitive ability, and non-cognitive abilities and school achievement (here measured by grade point averages in the Swedish compulsory school context), both cross-sectionally

and longitudinally, by using two recent and fairly representative data sets. It was proposed that all main variables (SES, cognitive ability, non-cognitive ability) had a substantial association with grades, even when all of them were included in the same regression models alongside other control variables. It was also hypothesized that cognitive ability had a stronger relationship than non-cognitive ability, followed by SES, in relation to the GPA outcome variable. These hypotheses were confirmed across both cohorts. A meaningful interaction effect between SES and migration background was found in relation to one cohort (2004), which seems to imply that students with a migration background benefit from having a higher SES independently of their migration background. The totality of evidence does also suggest that SES and migration background may be seen as discrete constructs (e.g., see Wiberg & Rolfsman, 2021, for a discussion) but is still potentially interrelated. Moreover, migration background added little to the OLS models alongside other predictors but was statistically significant in most models. This, too, indicates that students perform well in school as long as their parents have obtained a relatively high level of SES, regardless of their socio-demographic (i.e., migration) background. Furthermore, aggregated data may overestimate the negative association between migration background and academic achievement (e.g., Boman, 2022b).

The results from the longitudinal analysis echo that of for example Gustafsson (2007), who stresses that earlier achievement (e.g., Grade 6) is the strongest predictor of later achievement (e.g., Grade 8), as well as Guez et al. (2018) who examined similar relations in the contemporary French context. Nonetheless, the other major predictors are still significant. The overarching results confirm the findings of, for example, Guez et al. (2018), Hartman et al. (2010), Laidra et al. (2007), Roth et al. (2015), and Vazsonyi et al. (2022). The rank order of predictor variables is that cognitive ability is a stronger predictor than non-cognitive abilities such as self-efficacy or academic self-concept, followed by SES. Hence, prior meta-analytic reviews of SES–academic achievement correlations (e.g., Sirin, 2005) may slightly overestimate the relationships because cognitive and non-cognitive abilities are not always included in the analyses. However, the analyses on the 2004 cohort suggest that non-cognitive abilities, SES and migration background have become more important factors in the Swedish educational context.

The current study has several limitations. First of all, the degree of representativeness of the two cohorts is affected by fewer observations in Grade 8 compared to Grade 3 and Grade 6 as regards the 2004 cohort (Tables 1 and 2). Hence, future studies may use even more representative samples. Nonetheless, this sample is undoubtedly more representative compared to for example Duckworth and Seligman (2005), Lu et al. (2011) and Rosander and Bäckström (2014) even if missing values at the end of compulsory school level are accounted for. Another limitation, especially as SES constitutes a main variable in the current study, is that no information about average parental income is included. All in all, the UGU data set is very rich and detailed but to which extent the relationships can be generalized to other national contexts remains unknown. Moreover, non-cognitive items with a higher degree of internal consistency and five-factor model constructs may be useful in future samples.

In the Swedish context and other national and cross-national contexts, several researchers have stressed the importance of teaching quality (and teacher competence) for school achievement (e.g., Alatalo et al., 2021; Bardach & Klassen, 2020; Hanushek et al., 2019; Holmlund et al., 2019). However, the only potential relationship between teaching quality and educational achievement in the UGU data set is based on items such as "How content are you with your teachers?" While this coefficient is still statistically significant in OLS models which include SES, cognitive ability and non-cognitive ability variables, more objective measures of teaching quality are required to, potentially, discern more reliable

and meaningful relationships. Students may be content with their teachers because they receive relatively good grades rather than teachers demonstrating appropriate domain-specific skills and socio-emotional skills (e.g., Jennings & Greenberg, 2009). Nevertheless, the relationships between SES, cognitive ability, non-cognitive abilities, and school achievement might be partially mediated or moderated by teaching quality. This constitutes another potential area of future research. Moreover, because of potential multicausality and reversed causality between for example SES and cognitive ability, cognitive ability and SES, and between school achievement and attainment (e.g., grades, years of schooling) and cognitive ability (e.g., Deary & Johnson, 2010; Ritchie & Tucker-drob, 2018; Turkheimer et al., 2003), additional research is required in that respect. Specifically, the cognitive growth of students as regards the influence of SES, non-cognitive ability, and school inputs requires more longitudinal research.

In conclusion, the regression models showed that all three main variables explained a substantial portion of grade variance, with cognitive ability having a stronger relationship with grades, followed by non-cognitive abilities, and SES. Because these factors are measured as independent constructs, it is important to account for all three in multivariate analyses on academic achievement. Researchers, policy makers, and practitioners should become aware of how, for example, students with a relatively lower SES and/or cognitive ability may increase their non-cognitive and cognitive abilities through effort and persistence (Heckman & Kautz, 2014; Rammstedt et al., 2016; Thorsen et al., 2021).

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10212-022-00626-9.

Acknowledgements Sincerest gratitude is directed towards Alli Klapp, Bo Nielsen, Siri Dahlgren, and Nelika Karimi at the University of Gothenburg for providing me with the UGU data (Evaluation through Follow-up in English) after consent was given. The data files were distributed 22 October 2021.

Funding Open access funding provided by Stockholm University.

Declarations

Conflict of interest The author declares no competing interests.

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