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Motivation as a Mediator of Social Disparities in Academic Achievement

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Abstract: The present study aimed at contributing to the understanding of social disparities in relation to students' academic achievement in the science, technology, engineering and mathematics domains. A sample of n=321 German 11th graders completed measures of their family socio-economic status (SES), general intelligence, domain-specific ability self-concepts and subjective scholastic values in math, physics and chemistry. Students' grades in these subjects received four months after testing served as criteria. Significant mediation effects were found for all motivational variables between fathers' SES and students' achievement, whereas for mothers' SES, only children's academic self-concept in chemistry was a significant mediator. These results also held when students' general intelligence was controlled. Additionally, we controlled for students' grades before testing to investigate which variables mediated the influence of SES on change in school performance. Motivational variables significantly mediated the influence of fathers' SES on change in school performance in math but not in chemistry and physics. Intelligence significantly mediated the influence of fathers' SES on change in school performance in physics and chemistry but not in mathematics. The impact of mothers' SES on change in grades in chemistry was mediated by intelligence. Among others, the reasons potentially accounting for the differential influences of fathers' and mothers' SES are discussed. Copyright © 2011 John Wiley & Sons, Ltd.

Key words: socio-economic status; academic achievement; STEM; ability self-concept; subjective values

INTRODUCTION

Positive associations between children's social background and their academic achievement have repeatedly been reported (e.g. Sirin, 2005; White, 1982). Lately, large scale scholastic achievement assessments, such as the Programme for International Student Assessment (PISA) study or the Trends in International Mathematics and Science Study (TIMSS) have shown that this is the case in virtually all Organisation for Economic Co-operation and Development (OECD) countries, and the PISA study (but not the TIMSS) demonstrated that the associations between measures of social background and academic attainment are especially high in Germany (cf. OECD, 2007, pp. 127, 129, 131). It seems that this association is slightly stronger for students' competencies in mathematics and science than for children's performances in reading. Generally, no country can afford not to fully benefit from young people's potential, but in light of the widely bemoaned lack of specialised workforces in science, technology, engineering and mathematics (STEM), this is particularly true for these domains. Hence, these findings represent a major societal problem because students' academic achievement is known to be highly relevant for their later career choices (Bleeker & Jacobs, 2004).

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The present study aimed at exploring the reasons underlying the relation between children's social background and their academic attainment in STEM subjects. The study is distinguished with regard to several aspects. First, we concentrated on students' intelligence, ability self-concepts and subjective scholastic values as potential mediators. The last two motivational variables have not been investigated before in this context even though students' characteristics are more and more identified as playing an important role in explaining the correlation between social background and academic achievement (e.g. Johnson, McGue, & Iacono, 2007; Steinmayr, Dinger, & Spinath, 2010). Second, we realised a longitudinal approach by assessing school performance before and after testing. Thus, we could investigate the role of socio-economic status (SES) for change in academic achievement and whether the aforementioned mediators also mediated this association. Third, we investigated fathers' and mothers' SES as two separate indicators, which previous studies rarely did. The literature on the relative importance of parents' socio-economic characteristics for children's academic achievement is inconclusive (for a review, see Marks, 2008). However, there is some evidence suggesting that fathers' SES is relatively more important for children's attainment in STEM subjects than mothers' SES. The First and Second International Science Studies found fathers' occupation and education to be more strongly related to children's science test scores than mothers' occupation and education (cf. Marks, 2008). Furthermore,

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analysing PISA 2000 data, Marks (2008) reported students' mathematics scores in Germany to be slightly more strongly related to fathers' occupational status plus education than to mothers'. Analyses accounting for possible differential effects of parents' SES thus seem to be most appropriate for the domain under focus in this study.

Relationship between parents' socio-economic status and children's academic achievement

Children's social background is usually referred to as SES. Children's SES has most frequently been indicated by parents' education, occupation or income (Bradley & Corwyn, 2002; Sirin, 2005; White, 1982). Often, only one of these indicators serves as a measure of SES although operationalisations combining different indicators are considered more appropriate (Bradley & Corwyn, 2002; Jeynes, 2002; Mueller & Parcel, 1981) and have been shown to be more predictive of academic achievement (White, 1982).

There are countless studies reporting correlations between measures of SES and children's academic attainment (cf. Bradley & Corwyn, 2002; Sirin, 2005; White, 1982). Two meta-analyses have been conducted to integrate the vast amount of research on this topic. White (1982) reported a mean correlation of $r=.25$ as estimation of the overall effect size of SES on academic achievement for early studies on this issue. Sirin (2005) found a mean correlation of $r=.29$ for this relation by integrating studies conducted from 1990 to 2000. Studies on domain-specific relationships between indicators of SES and academic achievement are rare. In the recent PISA studies, the relation between students' social background and their performances in science/math/reading was $r=.44/.44/.40$ (PISA 2006) and $r=.51/.48/.47$ (PISA 2003) in Germany and $r=.38/.35/.35$ ($r=.40/.41/.39$) for the OECD average, respectively (OECD, 2007, pp. 127, 129, 131). Thus, the relationship between SES and both general academic achievement and academic achievement in the STEM domain is well established and seems to be slightly stronger in the STEM domains than in reading.

Whether this association is stronger for the SES indicated by mothers' education and profession or for the SES indicated by fathers' education and profession has not sufficiently been investigated (cf. Marks, 2008).

Mediators of the relationship between children's social background and academic achievement

Several potential mediators of this relationship have been investigated. Studies often focus on home or school factors (e.g. Marks, Cresswell, & Ainley, 2006). However, how these factors function as mediators and influence children's academic achievement is often not clear. For example, books in the home are a classical home factor that is thought to indicate cultural resources or scholarly culture (Evans, Kelley, Sikora, & Treiman, 2010) and to function as a mediator between SES and academic outcomes (e.g. Aikens & Barbarin, 2008; Marks et al., 2006). According to this logic, parents' SES influences the number of books at home and the number of books at home, in turn, influences children's academic achievement. However, it seems unlikely that raising the number of books in a household actually enhances children's academic achievement. More likely, number of books in a household is just an indicator of parents' education and their cultural practices. It is up to interpretation how they affect children's academic achievement.

Student characteristics are more proximal determinants of children's academic achievement and more likely to be actual mediators of the association between SES and school achievement. There is ample evidence that children's characteristics such as intelligence might indeed be causally related to both SES and academic achievement (cf. Johnson et al., 2007; Steinmayr et al., 2010). Among students' psychological characteristics related to school achievement, intelligence is the one most often investigated. Indeed, several studies showed that intelligence is a mediator of the relationship between SES and children's academic attainment (e.g. Baumert, Watermann, & Schümer, 2003; Hecht, Burgess, Torgesen, Wagner, & Rashotte, 2000; Johnson, Brett, & Deary, 2010; Johnson et al., 2007; Kemp, 1955; Lloyd & Barenblatt, 1984; Steinmayr et al., 2010). However, in these studies, intelligence did not account for the whole covariance of SES and school achievement, which indicates that inter-individual differences in children's intelligence are not the sole reason for this association.

In search for further variables that additionally explain the relation between children's social background and academic achievement, Steinmayr et al. (2010) concentrated on personality traits that are both relevant for school achievement and associated with SES. Additionally, these authors controlled for children's intelligence. In this study, students' openness to experience (and conscientiousness) significantly (marginally) mediated the relation between parental education and children's grade point average even when children's general reasoning abilities were simultaneously controlled (Steinmayr et al., 2010). However, the association between SES and school performance was not completely explained when controlling for personality traits and intelligence. Thus, further student characteristics might account for the covariance between SES and academic attainment.

Motivation as a mediator of the association between parents' socio-economic status and children's academic achievement

Another variable that might partly account for the association between SES and academic achievement is children's motivation. There is a plethora of motivational constructs investigated in the context of academic achievement (for an overview, cf. Covington, 2000; Eccles & Wigfield, 2002). The expectancy–value model by Eccles and colleagues (e.g. Eccles & Wigfield, 2002) focuses on students' subjective expectancies on how to perform on certain tasks and on values that students ascribe to a certain task or subject. As expectancies and ability self-concepts are empirically not distinguishable, they are mostly operationalised by academic self-concepts of ability, that is, how an individual evaluates one's abilities in a given domain (e.g. Eccles & Wigfield, 1995; Guay, Marsh, & Boivin, 2003). Scholastic values are

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defined as intrinsic values in the task, its subjective utility and importance (e.g. Wigfield & Eccles, 1992). As the expectancy–value model explicitly supposes a causal influence of children's background variables on academic self-concepts and values, which both are proximal motivational determinants of school performance, we concentrate on these variables. Furthermore, these variables are typically operationalised domain specifically and thus are adequate variables to investigate between SES and school achievement in certain domains.

Indeed, it seems that these motivational constructs fulfil the prerequisites for being a mediator (cf. Baron & Kenny, 1986) of the association between families' SES and children's school performance. Both are related to children's academic achievement (e.g. Hansford & Hattie, 1982; Schiefele, Krapp, & Winteler, 1992; Spinath, Spinath, Harlaar, & Plomin, 2006; Steinmayr & Spinath, 2009) and to parents' SES (e.g. Dotterer, McHale, & Crouter, 2009; Marsh & Parker, 1984; Johnson et al., 2007; Muijs, 1997, OECD, 2007).

The question on whether the link between these variables and school achievement is causal has received considerable attention in educational–psychological research. Longitudinal studies conducted to reveal the pattern of mutual influences between ability self-concept and academic achievement demonstrate that prior academic achievement affects subsequent academic self-concepts of ability (skill development) and vice versa (self-enhancement) (e.g. Guay et al., 2003; Marsh, Byrne, & Yeung, 1999; Marsh & Yeung, 1997). In their meta-analysis of longitudinal research on the causal ordering of self-belief measures and academic achievement, Valentine, Dubois, and Cooper (2004) also found clear support for self-enhancement effects. Furthermore, these authors reported that the effects of prior self-beliefs on later academic achievement were stronger when domain-specific rather than global measures of academic self-beliefs and academic achievement measures were used.

Steinmayr and Spinath (2009) demonstrated that values concerning subjects math and language predicted subsequent school performance after controlling for prior school performance and intelligence in these domains. Similar results were presented for the value component mathematical interest and academic achievement in further longitudinal studies (Köller Baumert, & Schnabel, 2001; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005). These results are in line with those of the self-enhancement effect found for ability self-concepts. Furthermore, Schiefele (1996) investigated the role of interest in learning with texts and found that participants' initial interest in the topics of diverse texts significantly predicted their later performance on various measures of reading achievement. This result emerged even though cognitive factors, that is, participants' intelligence, prior knowledge and reading ability, were controlled.

Thus, we conclude that the influence of domain-specific ability self-concepts and values on academic achievement might indeed be causal. Furthermore, there is evidence that this effect is stronger when constructs are assessed domain specifically (Valentine et al., 2004).

There is some evidence that the association between parents' SES and children's motivation might be causal. As motivation is also a good predictor of both academic attainment and professional success in adults (cf. Amelang & Steinmayr, 2006; Jolibert & Baumgartner, 1997; Robbins et al., 2004), parents' education might be interpreted as a proxy of parents' motivation (cf. Steinmayr et al., 2010, offered the same argumentation concerning possible causal relationships of SES with intelligence and personality, respectively).

Several causal mechanisms might explain the association between parents' SES and children's motivation. First, motivational characteristics might be transmitted genetically from the parents to their children; that is, higher motivated parents have higher motivated offspring. Using data from two different twin studies, Spinath and colleagues (Spinath, Spinath, & Plomin, 2008; Spinath, Toussaint, Spengler, & Spinath, 2008) demonstrated genetic influences on academic self-concepts of ability and intrinsic values in math and in German. Second, children's motivation might be influenced by the more motivating environment that more motivated parents might provide to their children. For example, from an observational learning viewpoint, parents function as role models; that is, children might learn about desirable behaviours and values within the academic domain by observing their parents. Third, an interaction of both genes and environment might cause children's motivation; that is, more motivated children might respond better to the environment that their more motivated parents provide.

Furthermore, parents' SES might additionally influence their children's motivation by mechanisms independent from parents' motivation. Bourdieu (1986) claims that more educated parents provide their children with more cultural and social capital, for example, visiting a theatre or a museum and introducing them to successful people that are most likely highly motivated. These cultural and social experiences might also foster children's motivation. Furthermore, parents' communication with their children might also impact on children's motivation. Tenenbaum and Leaper (2003) demonstrated that the more demanding fathers' communication styles were with regard to a scientific task (causal explanation, conceptual questions and science vocabulary), the higher children's science interest was. Additionally, there is evidence that parents from high-SES homes also have more demanding and complex communication styles with their children than parents from low-income homes (Schachter, Marquis, Shore, Bundy, & McNair, 1979). Thus, it might be that children's motivation, such as intrinsic or utility values, is shaped by their parents' communication differing by SES.

Summing up, the presented results support the assumption that both ability self-concepts and values might function as actual mediators of the association between SES and school achievement according to the prerequisites established by Baron and Kenny (1986). The expectancy–value model of Eccles and colleagues (e.g. Eccles & Wigfield, 2002) considers intelligence both to be related to families' SES and to be a distal determinant of ability self-concepts and values. Consequently, intelligence might alter the mediation effect of motivation as has been demonstrated for other mediators such as parental expectations (cf. Johnson et al., 2007). Thus, we additionally investigated intelligence.

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Predictors of change in academic achievement

Besides investigating predictors of academic achievement, it is also of great interest to determine which variables predict *change* in academic achievement. To address this research question, longitudinal designs are needed that, at least, assess academic achievement longitudinally. Several studies using cross-lagged or regression analysis designs demonstrate that intelligence as well as subjective school values and ability self-concepts predict change in scholastic achievement (e.g. Marsh et al., 2005; Steinmayr & Spinath, 2009; Watkins, Lei, & Canivez, 2007). Whether this is true for SES, to our knowledge, has not been investigated yet. However, studies using longitudinal data that assessed each variable one at a time demonstrate that children's social background predict their SES and educational achievement later on (e.g. Johnson et al., 2010). Thus, it is highly likely that SES predicts change in grades. Whether the influence of SES on change in scholastic attainment is also mediated by intelligence, subjective scholastic values and ability self-concepts will be investigated in the present study. As these variables have been found to significantly predict change in academic achievement and are related to SES, we assume that they will also mediate the influence of SES on change in academic achievement.

Hypotheses

The present study aimed at investigating the following hypotheses:

Hypothesis 1: *Parents' SES, as indicated by their education and occupation, is significantly positively correlated with children's academic self-concept and scholastic values in mathematics, physics and chemistry.*

Hypothesis 2: *Children's scholastic values and academic self-concept partially mediate the association between parents' SES and children's academic achievement in mathematics, physics and chemistry.*

Hypothesis 3: *Children's intelligence partially mediates the association between parents' SES and children's academic achievement in mathematics, physics and chemistry.*

Hypothesis 4: *The mediating effects of children's motivation will still hold when children's intelligence is controlled simultaneously.*

Hypothesis 5: *SES will predict change in academic achievement in mathematics, physics and chemistry.*

Hypothesis 6: *The impact of SES on the change in academic achievement in mathematics, physics and chemistry will be mediated by intelligence as well as domain-specific ability self-concept and values.*

METHOD

Sample

The sample consisted of $n=321$ 11th graders (145 women; mean age $M=16.46$, $SD=.55$). All students attended a 'gymnasium', that is, the highest and most selective educational level in the German school system. About 30% of the investigated cohort graduated from this kind of school (Statistisches Bundesamt, 2011). Students were recruited from three different schools located in three mid-sized towns in Germany. At each school, the complete 11th grade was tested. Participation was voluntary, and we received signed consent forms from parents of underage students. Almost all students were willing to participate, and only some students were missing at the day of testing because they were ill, which resulted in an overall participation rate of about 95%. The sample can be considered typical of the population from this type of school (i.e. the majority are White people from medium to high-SES homes). Consequently, we expect a range restriction in intelligence and SES, which will most likely result in weaker associations between the investigated variables than those found in more representative samples. Thus, the found results probably present a lower bound estimation of the actual associations.

Measures and procedure

Data were collected in the autumn of 2008. Students were tested on a regular school day in their classrooms in groups of about 20. Trained and experienced research assistants conducted the testing. First, students answered the questions on their parents' education and occupation as well as some demographic information, then they completed the measures assessing participants' motivation, and finally, the intelligence test was administered.

Parents' socio-economic status

There are diverse approaches to determine a family's SES (cf. Marks, 2008). The index of economic, social and cultural status used in the PISA studies conducted since 2003 considers the highest educational and occupational level that one parent has attained plus an index of families' prosperity. However, in PISA 2000, authors did not consider the later items as an indicator of SES, which is in line with the suggestions made by Bradley and Corwyn (2002). Thus, in the present study, we also considered the highest secondary and tertiary educational attainments and status of current occupation of both parents. However, unlike in the PISA studies that only consider the highest SES indicators of both parents as a measure of students' SES, we preferred to conduct analyses separately for each parent's SES. Thus, we explore potential differential effects of mothers' and fathers' SES on students' academic achievement. So far, it is an unresolved issue whether there are such differential effects (cf. Marks, 2008).

The measurement approach to assess the indicators of SES was identical to the one used in the PISA studies (cf. Kunter et al., 2002). Students indicated on four items the highest scholastic and vocational degrees that their mothers and fathers had attained. Alternatives reached from 'no school leaving certificate at all' (0) up to 'A-levels' (4) and from 'no vocational training at all' (0) to 'PhD' (5), respectively. There was also a category 'other' to allow participants to indicate graduations that had not been stated. Because no participant used this category, it can be concluded that the alternatives given were sufficient to map

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parents' educational level. In our sample, 0.3% (0.6%) of the fathers (of the mothers, respectively) had no school leaving certificate at all; 18.1% (17.1%) had the lowest school leaving certificate; 23.1% (38.6%) held a school leaving certificate that equals to the UK O-level; 16.2% (11.2%) had a school leaving certificate enabling them to pursue a bachelor's degree; 39.6% (30.5%) had the highest school leaving certificate; and 2.8% (1.9%) of the participants did not indicate the highest scholastic degree that their parents obtained. For occupational training, 1.2% (4.4%) of the fathers (of the mothers, respectively) had no occupational training; 23.4% (49.2%) had the most basic occupational training; 17.8% (4.4%) had an advanced occupational training; 17.8% (15.9%) had a bachelor's degree; 32.4% (19.3%) had a university degree; 1.6% (0.6%) had a PhD degree; and for 5.9% (6.2%), we did not have information about the highest vocational degrees held. Scores were *z*-standardised and served as indicators of parents' educational level.

Furthermore, students gave information on the current occupations of both parents and stated typical tasks that their parents would perform in their jobs. A trained research assistant first coded the answers according to the International Standard Classification of Occupations (ILO, 1990) and then identified the respective scores on the International Socio-economic Index of Occupational Status (ISEI; Ganzeboom, De Graaf, & Treiman, 1992; Ganzeboom & Treiman, 1996). Controlling the quality of the coding, a randomly selected sample of 10% of the answers was again coded by a second trained research assistant. The intraclass correlations (cf. McGraw & Wong, 1996; Shrout & Fleiss, 1979) indicated a good consistency: .94 and .74 for fathers' and mothers' occupations, respectively. Cases with differing codings were revised and discussed until all inconsistencies were resolved. Fathers' mean ISEI (*SD*) was $M=53.1$ (15.0). Mothers' mean ISEI (*SD*) was $M=50.3$ (12.5). Scores were *z*-standardised and served as indicators of parents' occupational status. When modelling mothers' and fathers' SES as a latent factor, standardised measurement weights of the different indicators ranged between .69 and .89.

Academic achievement

Students' domain-specific academic achievement before (t1) and after testing (t2) was measured by grades in mathematics, physics and chemistry as indicated by participants' report cards before and after the testing. Considering school achievement before testing (t1), either students brought their report cards to the testing session or schools provided copies of them. Furthermore, schools provided copies of the report cards that students received about four months after testing (t2). Some students did not provide their names at the testing day (nine students) or left school in the meantime (two students). Thus, for 11 students, information on school achievement at t2 could not be matched to the rest of the data. In Germany, grades range from 1 to 6, with 1 indicating the best and 6 the poorest achievement. To facilitate interpretation, grades were reversed.

Intelligence

Participants completed the German Intelligence Structure Test 2000 R (Amthauer Brocke, Liepmann, & Beauducel, 2001). The test consists of a verbal, numeric and figural subscale, which are measured by three subtests comprising a total of 60 items each. The composite score of the verbal, numeric and figural subscale measures general reasoning and served as an indicator for participants' general intelligence. Internal consistencies (Cronbach's alphas) were $\alpha=.71$ (verbal), $\alpha=.89$ (numeric), $\alpha=.76$ (figural) and $\alpha=.88$ (general reasoning), respectively. When modelling general intelligence as a latent factor loading figural, numeric and verbal intelligence, standardised measurement weights of the three intelligence subscales ranged between .53 and .70.

Ability self-concept

Students' academic self-concepts of ability in mathematics, physics and chemistry were assessed using four items each. These were taken from a German instrument for assessing the ability self-concept (Skalen zur Erfassung des schulischen Selbstkonzepts; SESSKO; Schöne, Dickhäuser, Spinath, & Stiensmeier-Pelster, 2002) and adapted to the respective domains. Items were 'In mathematics/physics/chemistry I know little/a lot', 'To learn new things in mathematics/physics/chemistry is hard/easy for me', 'For mathematics/physics/chemistry I am not talented/very talented' and 'Most assignments in mathematics/physics/chemistry are hard/easy for me'. Participants used a 5-point Likert scale to indicate their answers. Internal consistencies (Cronbach's alphas) were $\alpha=.96$ (mathematics), $\alpha=.94$ (physics) and $\alpha=.95$ (chemistry), respectively. When modelling ability self-concepts as latent factors, measurement weights in all domains ranged between .90 and .93.

Scholastic values

A German scale assessing subjective task values (Skala zur Erfassung subjektiver schulischer Werte; SESSW; Steinmayr & Spinath, 2010) was used to measure students' scholastic values. The SESSW assesses students' intrinsic value, importance and utility with three items per subtest, which can be summed up to represent overall domain-specific subjective scholastic value. Sample items were 'How much do you like doing mathematics/physics/chemistry?' (intrinsic value), 'For me, being good in mathematics/physics/chemistry is not at all/very important?' (importance) and 'In general, how useful is what you learn in mathematics/physics/chemistry?' (utility). Participants answered the items on a 5-point scale. Internal consistencies (Cronbach's alphas) were $\alpha=.92$ (mathematics), $\alpha=.95$ (physics) and .95 (chemistry). When modelling domain-specific values as latent factors, measurement weights ranged between .76 and .89.

Analyses

Mediation analyses

Mediation analyses were conducted using structural equation modelling (SEM) as it has been recommended by Baron and Kenny (1986). First, only one mediator at a time (general intelligence, ability self-concept, values and prior school achievement, respectively) was specified. We also investigated prior school achievement (t1) as a mediator to check

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whether SES had already an impact on prior school performance, which might carry on to later school performance. Second, we tested each motivational construct as a mediator variable while simultaneously controlling for students' general intelligence. As depicted previously, some meditational effects of motivation on school performance did not hold after controlling for intelligence (cf. Johnson et al., 2007). Third, we tested both motivational constructs and intelligence as potential mediators of the influence on SES on the change in school grades from t1 to t2.

Model specification

In all models, children's grades in mathematics (physics and chemistry, respectively) assessed after testing (t2) served as criteria and mothers' or fathers' SES as the predictor. Parents' SES was indicated by either fathers' or mothers' educational attainments and occupational status. Domain-specific ability self-concepts were indicated by the items of the respective scale. Domain-specific scholastic values were loaded by the three subscales of the corresponding domain. Students' general intelligence was indicated by their verbal, numeric and figural intelligence.

As an example of all models analysed in step 1, Figure 1 shows the model specified to test students' mathematical subjective values as a mediator of the relation between fathers' SES and children's academic achievement in mathematics.

As an example of all models analysed in step 2, Figure 2 shows the model specified to test the mathematical values as a mediator of the relationship between fathers' SES and children's academic achievement in mathematics controlling for children's general intelligence.

As an example of all models analysed in step 3, Figure 3 shows the model specified to test the mathematical values as a mediator of the relationship between fathers' SES and children's change in academic achievement in mathematics controlling for children's general intelligence.

Estimation procedure and missing values

Analyses were conducted using the statistical software package AMOS 18 (SPSS Inc., 2009). Parameters were estimated applying the full information maximum-likelihood estimator. This procedure allows accounting for cases with incomplete data.

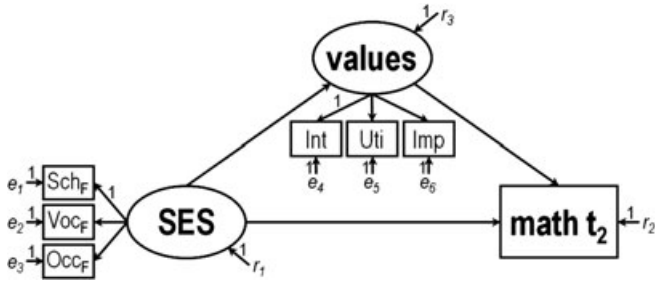

Figure 1. Structural equation model specified to test students' subjective scholastic values for mathematics as a mediator of the relation between fathers' socio-economic status and children's subsequent academic achievement in mathematics. Children's grades in mathematics (math t2) are explained by fathers' socio-economic status (SES), indicated by fathers' scholastic and vocational degree (Sch_F and Voc_F, respectively) and occupational status (Occ_F), and by students' subjective scholastic values for mathematics (values) as the investigated mediator variable, indicated by the intrinsic value (Int), importance (Imp) and utility (Uti) of mathematics. The depicted model serves as an example for all models testing one mediator variable at a time.

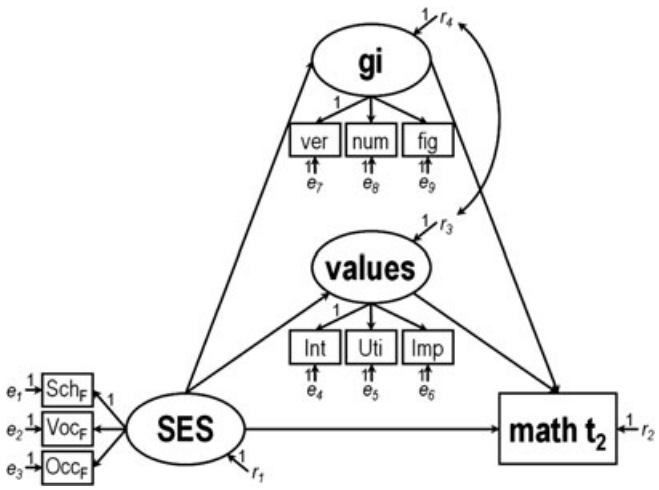

Figure 2. Structural equation model specified to test students' subjective scholastic values for mathematics as a mediator of the relation between fathers' socio-economic status and children's subsequent academic achievement in mathematics controlling for students' general intelligence. Children's grades in mathematics (math t2) are explained by fathers' socio-economic status (SES), indicated by fathers' scholastic and vocational degree (Sch_F and Voc_F, respectively) and occupational status (Occ_F); by students' subjective scholastic values for mathematics (values), indicated by the intrinsic value (Int), importance (Imp) and utility (Uti) of mathematics; and by general intelligence (gi), indicated by three subscales (ver, num and fig, respectively). The depicted model serves as an example for all models testing motivational constructs as a mediator variable while controlling for students' general intelligence.

Testing for significance of the mediation effects

Significance of the mediation effects observed was tested ($\alpha = .05$) following the procedure proposed by MacKinnon and colleagues (MacKinnon, Fairchild, & Fritz, 2007). Specifically, 95% confidence intervals were calculated for each mediation effect using the computer programme PRODCLIN (MacKinnon, Fritz, Williams, & Lockwood, 2007). Confidence intervals *not* containing 0 indicate that the mediation effect observed is significantly different from zero.

RESULTS

Table 1 shows the means, standard deviations, internal consistencies and intercorrelations among all variables.

Internal consistencies of all constructs were good. As expected, children's SES was higher than would be expected in the general population (cf. Statistisches Bundesamt, 2010, pp. 142, 147). Distributions of the highest scholastic and vocational degrees attained by parents in our sample significantly differed from those of all parents whose children attended school in Germany in the year of data collection ($\chi^2_3 = 158.3$, $p < .001$ and $\chi^2_3 = 318.9$, $p < .001$, respectively). The present sample also had a higher mean ISEI as compared with the population ($t_{315} = 14.5$, $p < .001$). Unfortunately, no information on distribution parameter concerning parents' education and profession were available. As parents from

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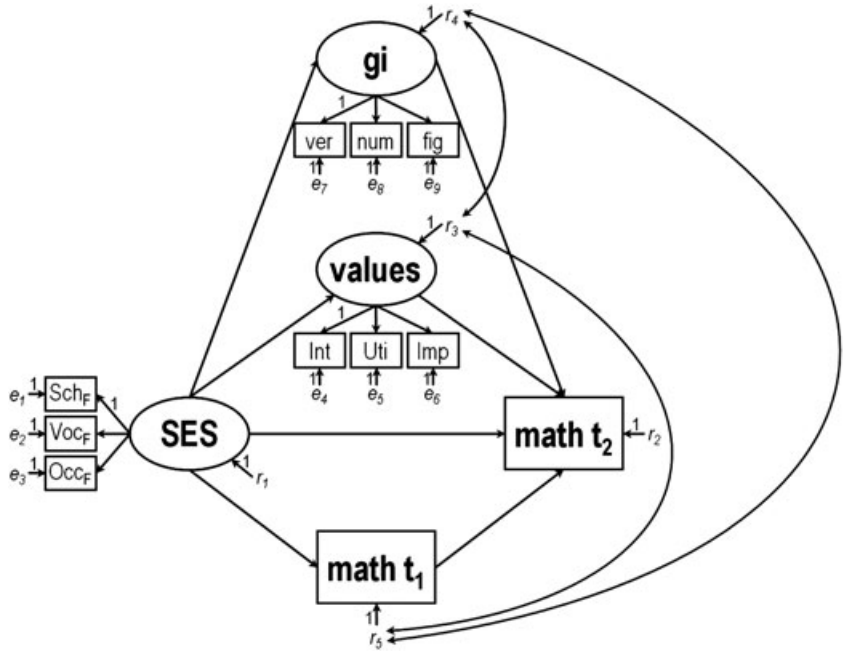

Figure 3. Structural equation model specified to test students' subjective scholastic values for mathematics as a mediator of the relation between fathers' socio-economic status and children's subsequent academic achievement in mathematics controlling for students' general intelligence and prior academic achievement in mathematics. Children's grades in mathematics (math t2) are explained by fathers' socio-economic status (SES), indicated by fathers' scholastic and vocational degree (Sch_F and Voc_F, respectively) and occupational status (Occ_F); by students' subjective scholastic values for mathematics (values), indicated by the intrinsic value (Int), importance (Imp) and utility (Uti) of mathematics; by general intelligence (gi), indicated by three subscales (ver, num and fig, respectively); and by prior academic achievement in mathematics, indicated by children's precursory grades in mathematics. The depicted model serves as an example for all models testing motivational constructs as a mediator variable while controlling for students' general intelligence and prior academic achievement.

Table 1. Means (*M*), standard deviations (*SD*), internal consistencies (α) and intercorrelations† among fathers' and mothers' socio-economic status and children's academic achievement, intelligence and motivation

	Descriptives			Intercorrelations																		
	M	*SD*	α	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1) Father's SES	−0.02	0.90	.88	**.44**	**.17**	**.19**	**.17**	**.19**	**.15**	**.15**	**.19**	**.20**	**.17**	**.16**	**.18**	**.17**	**.16**	**.13**	**.19**	**.18**	−.00	.10	.11
2) Mother's SES	−0.03	0.87	.82		.02	**.12**	.11	.01	.04	**.15**	**.16**	.04	.05	.10	.04	.03	.09	.06	.05	.09	−.09	−.03	.03
3) Grade in mathematics (t1)	4.10	1.04				**.60**	**.55**	**.66**	**.57**	**.45**	**.41**	**.70**	**.31**	**.30**	**.58**	**.19**	**.21**	**.43**	**.20**	**.16**	**.49**	**.19**	**.20**
4) Grade in physics (t1)	4.16	0.89					**.58**	**.49**	**.61**	**.44**	**.34**	**.45**	**.58**	**.34**	**.36**	**.45**	**.26**	**.32**	**.38**	**.24**	**.31**	**.40**	**.22**
5) Grade in chemistry (t1)	4.15	0.92						**.50**	**.52**	**.62**	**.25**	**.39**	**.35**	**.60**	**.32**	**.24**	**.50**	**.27**	**.25**	**.40**	**.25**	**.23**	**.44**
6) Grade in mathematics (t2)	3.94	1.08							**.59**	**.52**	**.33**	**.59**	**.34**	**.33**	**.51**	**.26**	**.23**	**.35**	**.19**	**.18**	**.35**	**.24**	**.22**
7) Grade in physics (t2)	4.08	0.87								**.43**	**.38**	**.50**	**.44**	**.35**	**.41**	**.34**	**.24**	**.34**	**.27**	**.20**	**.27**	**.27**	**.18**
8) Grade in chemistry (t2)	4.20	0.83									**.27**	**.38**	**.32**	**.47**	**.34**	**.22**	**.38**	**.24**	**.25**	**.30**	**.21**	**.26**	**.35**
9) General intelligence	108.1	8.69	.88									**.40**	**.29**	**.26**	**.32**	**.24**	**.21**	**.27**	**.22**	**.14**	**.27**	**.19**	**.14**
10) Asc in mathematics	3.31	1.07	.96										**.53**	**.41**	**.82**	**.39**	**.29**	**.58**	**.34**	**.23**	**.55**	**.33**	**.24**
11) Asc in physics	3.15	0.96	.94											**.47**	**.44**	**.85**	**.33**	**.41**	**.71**	**.36**	**.32**	**.72**	**.25**
12) Asc in chemistry	3.00	1.05	.95												**.33**	**.33**	**.85**	**.33**	**.37**	**.69**	**.22**	**.31**	**.71**
13) Intrinsic value of mathematics	3.29	1.14	.93													**.45**	**.35**	**.63**	**.38**	**.30**	**.59**	**.37**	**.29**
14) Intrinsic value of physics	3.11	1.17	.94														**.33**	**.41**	**.79**	**.37**	**.31**	**.74**	**.22**
15) Intrinsic value of chemistry	3.03	1.23	.94															**.33**	**.38**	**.77**	**.19**	**.24**	**.75**
16) Utility of mathematics	3.46	0.94	.85																**.55**	**.44**	**.64**	**.42**	**.34**
17) Utility of physics	3.29	1.04	.89																	**.56**	**.34**	**.75**	**.37**
18) Utility of chemistry	2.85	1.05	.89																		**.26**	**.39**	**.77**
19) Importance of mathematics	3.86	0.87	.91																			**.52**	**.37**
20) Importance of physics	3.41	0.93	.89																				**.41**
21) Importance of chemistry	3.21	1.02	.91																				

Note: n=300–321. SES=socio-economic status; Asc=academic self-concept of ability. SES variables are composites of three z-standardised indicators. Grades range from 1 to 6, with 6 indicating the best grade. General reasoning scores are standard values (M=100, SD=10); motivational variables range from 1 to 5, with 5 indicating higher values in the direction of the scales. Significant correlations are in bold, with $r \geq |.12|$, $p < .05$; $r \geq |.15|$, $p < .01$; and $r \geq |.20|$, $p < .001$.

†Reported coefficients are product–moment correlations. We also computed rank correlations but only observed marginal differences to the corresponding product–moment correlations. Thus, we limit our depiction of results to the latter.

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the present sample and the general population primarily differed in frequencies concerning the lower and the higher education, we suppose that the distribution of parents' education and occupational status was narrowed in the present population. Furthermore, on average, students had higher intelligence standard scores than the norm sample (t_{314}=14.34, $p<.001$), and present sample's variance was lower ($F_{1189,320}$=1.52, $p<.01$). Because of the range restriction, correlations of both parents' SES and children's intelligence with other variables represent a lower bound estimation of the actual correlations.

Academic achievement at both measurement occasions was positively associated with all variables except mothers' SES. We found mothers' composite scores of SES to be only correlated with children's grades in chemistry at t2 and with children's grades in physics at t1. Both mothers' and fathers' SES was significantly associated with children's general intelligence.

In hypothesis 1, we postulated that parents' SES would be positively correlated with children's motivation. No systematic relations between mothers' SES and most measures of students' motivation could be observed. However, when investigating the relationship by means of SEM (cf. results depicted in Table 2b), we found mothers' SES to be related to children's ability self-concept in chemistry. Thus, concerning children's motivational variables, we only performed mediation analyses for mothers' SES and children's grades in chemistry.

Fathers' SES was positively associated with most measures of students' motivation. Correlations between fathers' SES and students' subjective importance considering physics and chemistry were only marginally significant (p=.08 and p=.06). Thus, results just partly supported assumptions made in hypothesis 1. However, the different correlational patterns for measures of mothers' and fathers' SES are remarkable and will be discussed later on.

Mediation analyses

All mediation analyses were performed by means of SEM. Model fit indices of all models indicated an excellent to satisfactory model fit according to the suggestions made by Hu and Bentler (1995).

In hypothesis 2, we speculated that children's scholastic values and ability self-concepts would partially mediate the association between parents' SES and children's academic achievement in mathematics, physics and chemistry. Results for fathers are depicted in Table 2a, and results for mothers are depicted in Table 2b. Columns 2 to 4 indicate different fit indices, column 5 indicates the variance of academic achievement explained by the model and columns 6 to 8 indicate the standardised path weight coefficients. The last column indicates the confidence intervals for the mediated effects. The basic models describe the results when only SES and academic achievement in the different domains are considered. The models in the rows beneath the basic models indicate the mediation analyses.

The assumptions made in hypothesis 2 were supported by the data for fathers' SES and grades in all domains. Both

Table 2a. Results of structural equation modelling (full information maximum-likelihood estimations) testing children's domain-specific academic self-concept of ability (Asc) and scholastic values in mathematics/physics/chemistry, general intelligence (gi) and prior academic achievement in mathematics/physics/chemistry (Ach t1) as mediators of the relationship between fathers' socio-economic status and children's subsequent academic achievement in mathematics/physics/chemistry (Ach t2) as well as confidence intervals for the mediated effects

	Ach t2 in mathematics, physics and chemistry							
Model	Fit indices			R^2	Standardised coefficients			CIs of the mediated effects
	χ^2 (*df*)	CFI	RMSEA	Model	SES → Ach t2	SES → Med	Med → Ach t2	Med
Basic (math)	5.7 (2)	1.000	.000	.04	**.21*****			
Ach t1 (math)	5.7 (4)	.997	.037	.45	.09#	**.19****	**.65*****	[**.050**; **.213**]
Asc (math)	20.9 (18)	.999	.022	.37	.06	**.23*****	**.59*****	[**.067**; **.221**]
Values (math)	40.2 (12)	.970	.086	.28	**.11***	**.17****	**.50*****	[**.011**; **.151**]
gi (math)	44.4 (12)	.950	.092	.19	.08	**.33*****	**.41*****	[**.055**; **.243**]
Basic(physics)	1.1 (2)	1.000	.000	.03	**.17****			
Ach t1 (physics)	7.4 (4)	.995	.051	.39	.05	**.23*****	**.61*****	[**.059**; **.186**]
Asc (physics)	21.6 (18)	.998	.025	.21	.09#	**.20****	**.43*****	[**.027**; **.122**]
Values (physics)	12.2 (12)	1.000	.007	.12	.11#	**.21****	**.31*****	[**.020**; **.095**]
gi (physics)	36.3 (12)	.963	.080	.24	.01	**.32*****	**.49*****	[**.058**; **.224**]
Basic (chemistry)	3.1 (2)	.998	.041	.03	**.18****			
Ach t1 (chemistry)	3.5 (4)	1.000	.000	.04	.08	**.19****	**.61*****	[**.038**; **.157**]
Asc (chemistry)	12.7 (18)	1.000	.000	.03	.10#	**.18****	**.46*****	[**.023**; **.118**]
Values (chemistry)	15.7 (12)	.997	.031	.04	.11#	**.19****	**.37*****	[**.020**; **.101**]
gi (chemistry)	38.5 (12)	.958	.083	.10	.08	**.32*****	**.33*****	[**.030**; **.151**]

Notes: n=321. *df*=model degrees of freedom; CFI=comparative fit index; RMSEA=root mean square error of approximation; →=path weight; SES=socio-economic status; Ach t1=academic achievement before testing; Ach t2=academic achievement after testing; gi=general intelligence; Asc=academic self-concept; Values=scholastic values; Med=mediator; CI=95% confidence interval (based upon the unstandardised coefficients). CIs *not* including zero indicate a significant mediation effect. Significant coefficients and mediated effects are in bold.
#$p<.10$; *$p<.05$; **$p<.01$; ***$p<.001$.

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Table 2b. Results of structural equation modelling (full information maximum-likelihood estimations) testing children's academic self-concept of ability (Asc) in chemistry, general intelligence (gi) and prior school achievement in chemistry (Ach t1) as mediators of the relationship between mothers' socio-economic status and children's academic achievement in chemistry (Ach t2) as well as confidence intervals for the mediated effects

	Ach t2 in chemistry							
Model	Fit indices			R^2	Standardised coefficients			CIs of the mediated effects
	χ^2 (*df*)	CFI	RMSEA	Model	SES → Ach t2	SES → Med	Med → Ach t2	Med
Basic (chemistry)	0.4 (2)	1.000	.000	.03	**.17****			
Ach t1 (chemistry)	3.0 (4)	1.000	.000	.40	**.11***	.12#	**.61*****	[**.000**; **.015**]
Asc (chemistry)	13.3 (18)	1.000	.000	.24	**.12***	**.13***	**.47*****	[**.002**; **.120**]
gi (chemistry)	16.6 (12)	.989	.035	.13	.10	**.22****	**.32*****	[**.016**; **.142**]

Notes: n=321; *df*=model degrees of freedom; CFI=comparative fit index; RMSEA=root mean square error of approximation; →=path weight; SES=socio-economic status; Ach=academic achievement in chemistry; gi=general intelligence; Asc=academic self-concept of ability; Values=scholastic values; Med=mediator; CI=95% confidence interval (based upon the unstandardised coefficients). CIs *not* including zero indicate a significant mediation effect. Significant coefficients and mediated effects are in bold.
#$p<.10$; *$p<.05$; **$p<.01$; ***$p<.001$.

values and ability self-concepts functioned as significant mediators of the association between fathers' SES and grades in mathematics, physics and chemistry at t2 (cf. last column of Table 2a). Values explained between 38% (physics) and 41% (mathematics) and ability self-concepts explained between 50% (physics) and 92% (mathematics) of the relationship between SES and grades.

Mediation analyses for the association between mothers' SES and grades were performed if mothers' SES was at least marginally significantly related to any motivational variable. This only applied to the ability self-concept in chemistry. Results for this mediation analysis are illustrated in Table 2b. The ability self-concept in chemistry significantly mediated the association between mothers' SES and grades in chemistry at t2 (cf. model 'Asc (chemistry)' in Table 2b) and explained 35% of the association between mothers' SES and subsequent school achievement in chemistry. Consequently, hypothesis 2 was largely supported by the data concerning the association between fathers' SES and children's academic achievement but not for mothers' SES.

Furthermore, we hypothesised that children's intelligence would partially mediate the association between parents' SES and children's academic achievement in mathematics, physics and chemistry (hypothesis 3). In line with the assumptions made in hypothesis 3, general intelligence significantly mediated the association between fathers' SES and school performance in mathematics, physics and chemistry at t2 (cf. Table 2a) (explaining 64%, 93% and 58% of the shared variance between fathers' SES and grades in these subjects), as well as the relationship between mothers' SES and grades in chemistry (cf. Table 2b) (intelligence explained 42% of this association). General intelligence even reduced the association between fathers' SES and grades in physics to zero (β=.01). We also inspected the possibility of inconsistent mediations (cf. MacKinnon, Fairchild et al., 2007, pp. 602, 603) even though there is no theoretical rationale for the assumption that mothers' SES has a direct effect on mathematics or physics achievement that is about equal in magnitude but opposite, that is, negative, in sign to the mediated effect of general intelligence. The results of these analyses were not significant and are not reported. Thus, results were only partly in line with hypothesis 3.

As none of the results so far yielded significant effects for mothers' SES and academic achievement in physics and mathematics, these two domains will not be considered with regard to mothers' SES and academic achievement in the following analysis.

Table 2a and 2b also report the findings of the mediation analyses when considering academic achievement as a mediator (cf. Ach t1 models). In all cases, prior achievement mediated the association between SES and subsequent school achievement. These results indicate that a substantial part of the shared variance between SES and school achievement can be attributed to prior school achievement.

In hypothesis 4, we assumed that the mediating effects of children's motivation would still hold when children's intelligence was controlled simultaneously. Results of the mediation analyses additionally controlling for intelligence are shown in Table 3.

The results of the models that initially yielded significant mediation effects were in line with that assumption. After controlling for general intelligence, ability self-concepts and subjective scholastic values were still significant mediators of the association between fathers' SES and grades in these subjects. The same was true for the ability self-concept in chemistry as a mediator of the relationship between mothers' SES and children's grade in chemistry. Most interestingly, the mediating effect of students' general intelligence was no longer significant in the model incorporating fathers' SES and children's ability self-concept in chemistry (cf. Table 4). Furthermore, the mediating effect of children's ability self-concepts in chemistry concerning the association between mothers' SES and students' school grades in this subject was also still significant after controlling for children's

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Table 3. Results of structural equation modelling (full information maximum-likelihood estimations) testing children's domain-specific academic self-concept (Asc) and scholastic values in mathematics/physics/chemistry as mediators of the relationship between fathers' and mothers' socio-economic status and children's subsequent academic achievement in mathematics/physics/chemistry (Ach t2) controlling for children's general intelligence if prerequisites were fulfilled

		Ach t2 in mathematics, physics, chemistry											
Parent	Model	Fit indices			R^2	Standardised coefficients						CIs of the mediated effects	
		χ^2 (df)	CFI	RMSEA	Model	SES → Ach t2	SES → Mot	Mot → Ach t2	SES → gi	gi → Ach t2	Mot ←→ gi	Mot	gi
Father	Asc+gi (math)	95.8 (39)	.975	.067	.38	.04	.23***	.52***	.32***	.13#	.52***	[.058; .198]	[−.006; .108]
	Values+gi (math)	95.0 (30)	.943	.082	.31	.06	.17**	.40***	.32***	.22*	.45***	[.018; .135]	[.015; .152]
	Asc+gi (physics)	78.1 (39)	.980	.056	.32	−.01	.20**	.31***	.33***	.37***	.36***	[.018; .091]	[.039; .181]
	Values+gi (physics)	58.9 (30)	.978	.055	.28	−.01	.21***	.20**	.33***	.43***	.28***	[.010; .067]	[.048; .204]
	Asc+gi (chemistry)	59.2 (39)	.990	.040	.28	.05	.18**	.41***	.32***	.20**	.29***	[.020; .104]	[.012; .107]
	Values+gi (chemistry)	54.7 (30)	.981	.051	.22	.04	.19**	.32***	.32***	.26**	.20*	[.016; .087]	[.020; .127]
Mother	Asc+gi (chemistry)	38.2 (39)	1.000	.000	.04	.08	.13*	.41***	.22**	.20**	.31***	[.004; .107]	[.007; .097]

Notes: n=321; *df*=model degrees of freedom; CFI=Comparative Fit Index; RMSEA=root mean square error of approximation; →=path weight; ←→=correlation; SES=socio-economic status; Ach=academic achievement in mathematics/physics/chemistry; gi=general intelligence; Asc=academic self-concept of ability; Values=scholastic values; Mot=motivational variables, that is, ability self-concepts or values; CI=95% confidence interval (based upon the unstandardised coefficients). CIs *not* including zero indicate a significant mediation effect, Significant coefficients and mediated effects are in bold.
#$p<.10$; *$p<.05$; **$p<.01$; ***$p<.001$.

intelligence. Thus, the assumptions made in hypothesis 4 were supported by the data for those models that yielded significant mediations effects of motivational variables.

In hypothesis 5, we speculated that parents' SES would predict change in academic achievement. We performed SEM in which both SES and school achievement at t1 served as correlated predictors of school achievement at t2. The direct effect of SES on achievement at t2 in this model indicates the share of variance explanation that can only be attributed to SES and not to both achievement at t1 and SES or only to achievement at t1. Model fit was excellent in all cases (father: math grade model χ^2_4=5.7, p=.22; physics grade model χ^2_4=7.4, p=.12; chemistry grade model χ^2_4=3.5, p=.48; mother: chemistry grade model χ^2_4=3.1, p=.56). After controlling for prior school achievement, fathers' SES just had small effects on subsequent school achievement (math: β=.09, p=.07; chemistry: β=.08, p=.10, physics: β=.05, p=.33). The same was true for the impact of mothers' SES on subsequent chemistry achievement after controlling for prior chemistry grades (β=.11, p=.02). Thus, the assumptions made in hypothesis 5 were only partly corroborated.

Hypothesis 6 puts down the assumption that intelligence as well as ability self-concepts and subjective scholastic values mediate the impact of SES on change in school grades. We also tested prior school achievement as a mediator to evaluate whether prior school achievement still explains a substantial share of joint variance of SES and school achievement at t2 when modelled together with intelligence and ability self-concepts or values. Model specification is illustrated in Figure 3. Some of the effects of SES on the change in school achievement are only marginally or not significant. However, mediation analyses regarding the association between SES and change in school grades were analysed nevertheless. A significant direct effect of the predictor to the criterion is not necessarily required in mediation analysis (e.g. MacKinnon, 2000; Shrout & Bolger, 2002). Results of the different models are depicted in Table 4.

The impact of fathers' SES on change in mathematical achievement was mediated by prior school performance in all models. Concerning the prediction of change in mathematical attainment through fathers' SES, the effect was mediated by both ability self-concepts and values but not by general intelligence (cf. models 'Asc+gi+Ach t1 (math)' and 'values+gi+Ach t1 (math)' in Table 4). On the other hand, the association between fathers' SES and change in physics grades was additionally only mediated by general intelligence. The relationship between fathers' SES and change in performance in chemistry was mediated by ability self-concepts, intelligence and prior school performance (cf. model 'Asc+gi+Ach t1 (chemistry)'). When values attributed to chemistry were considered instead of ability self-concepts, motivation did not contribute to the explanation of the shared variance between fathers' SES and change in chemistry grades.

Hypothesis 6 was only tested for mothers' SES as well as grades and ability self-concept in chemistry (we also excluded the possibility of inconsistent mediation effects). When investigated simultaneously, only intelligence and prior school performance mediated the effect.

DISCUSSION

The present study investigated whether students' motivation functions as a mediator of the relationship between parents' SES and children's academic achievement in mathematics, physics and chemistry. Following the

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Table 4. Results of structural equation modelling (full information maximum-likelihood estimations) testing children's motivation in mathematics/physics/chemistry [i.e. domain-specific academic self-concept of ability (Asc) and scholastic values] as mediators of the relationship between fathers' socio-economic status and children's subsequent academic achievement in mathematics/physics/chemistry (Ach t2) controlling for children's general intelligence (gi) and prior academic achievement in mathematics/physics/chemistry (Ach t1) as well as confidence intervals for the mediated effects

		Ach t2 in mathematics, physics, chemistry														
	Model	Fit indices			R^2	Standardised coefficients										CIs of the mediated effects
Parent		χ^2 (*df*)	CFI	RMSEA	Model	SES → Ach t2	SES → Mot	Mot → Ach t2	SES → gi	gi → Ach t2	SES → Ach t1	Ach t1 → Ach t2	Mot ←→ gi	Mot ←→ Ach t1	gi ←→ Ach t1	Mot gi Ach t1
Father	Asc+gi+Ach t1 (math)	114.0 (46)	.973	.068	.48	.05	**.23*****	**.22*****	**.32*****	.05	**.19*****	**.47*****	**.52*****	**.71*****	**.50*****	[**.018**; **.101**] [−.003; .070] [**.036**; **.158**]
	Values+gi+Ach t1 (math)	103.7 (36)	.951	.077	.48	.06	**.18****	**.14***	**.32*****	.07	**.19****	**.53*****	**.45*****	**.63*****	**.51*****	[**.001**; **.060**] [−.025; .080] [**.041**; **.177**]
	Asc+gi+Ach t1 (physics)	87.2 (46)	.981	.053	.45	−.02	**.20****	.08	**.33*****	**.27*****	**.23*****	**.46*****	**.36*****	**.58*****	**.41*****	[−.006; .037] [**.025**; **.139**] [**.043**; **.145**]
	Values+gi+Ach t1 (physics)	68.6 (36)	.978	.053	.45	−.02	**.21*****	.03	**.33*****	**.28*****	**.23*****	**.49*****	**.28*****	**.44*****	**.41*****	[−.013; .026] [**.028**; **.143**] [**.046**; **.152**]
	Asc+gi+Ach t1 (chemistry)	71.2 (46)	.989	.041	.43	.03	**.18****	**.13***	**.32*****	**.15***	**.19****	**.49*****	**.30*****	**.59*****	**.18*****	[**.002**; **.042**] [**.004**; **.085**] [**.030**; **.128**]
	Values+gi+Ach t1 (chemistry)	72.4 (36)	.976	.056	.42	.02	**.19****	.08	**.32*****	**.16***	**.19****	**.53*****	**.20***	**.48*****	**.28*****	[−.003; .034] [**.007**; **.090**] [**.033**; **.136**]
Mother	Asc+gi+Ach t1 (chemistry)	51.8 (46)	.997	.020	.43	.08	**.13***	**.12***	**.23****	**.14***	**.13***	**.50*****	**.31*****	**.60*****	**.30*****	[−.000; .041] [**.003**; **.076**] [**.002**; **.125**]

Notes: n=321; *df*=model degrees of freedom; CFI=Comparative Fit Index; RMSEA=root mean square error of approximation; →=path weight; ←→=correlation; SES=socio-economic status; Ach=academic achievement in mathematics/physics/chemistry; gi=general intelligence; Asc=academic self-concept of ability; values=scholastic values; Mot=motivational variables, that is, ability self-concepts or values; CI=95% confidence interval (based upon the unstandardised coefficients). CIs *not* including zero indicate a significant mediation effect. Significant coefficients and mediated effects are in bold.
$^{\#}p<.10$; *$p<.05$; **$p<.01$; ***$p<.001$.

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expectancy–value model by Eccles and colleagues (e.g. Eccles & Wigfield, 2002), we concentrated on ability self-concepts and subjective scholastic values. Furthermore, we controlled for students' intelligence. Ability self-concepts and subjective values significantly mediated the association between fathers' SES and children's subsequent academic achievement in the STEM domains even after controlling for intelligence. Furthermore, ability self-concepts and values mediated the impact of fathers' SES on the change of mathematical attainment but intelligence did not. The converse pattern was observed when performance change in chemistry and physics was considered. A second main finding of the present study is that results were different for the associations between mothers' SES and children's academic achievement.

The first aim of the present study was to investigate whether there is an association between parental SES and children's motivation (hypothesis 1). We found fathers' but not mothers' SES to be related to children's ability self-concepts and values in mathematics, physics and chemistry. It might be that fathers in general shape their children's motivation more than mothers in the STEM domain. Tenenbaum and Leaper (2003) demonstrated that fathers' more demanding communication styles concerning a technical subject when talking with their sons was associated with gender differences in children's science interest and self-concept. This was not the case for mothers' communication styles. This effect might be amplified by fathers' SES as parents with a high SES have also more demanding communication styles (Schachter et al., 1979). Thus, it might be that children from home in which fathers have a high SES are more self-confident in academic STEM domains and also value them more. It would be interesting to see whether this result also extends to non-STEM domains, such as language or social science.

The second aim of the study was to test several mediation hypotheses for the relationship of children's academic achievement with both fathers' and mothers' SES. Mothers' SES was not only unrelated to most of the investigated children's motivational variables but also uncorrelated with grades in mathematics and physics and more weakly associated with grades in chemistry than fathers' SES. A further reason for the constant lower correlations of mothers' SES with children's achievement or achievement-related characteristics might be found in different career tracks of men and women. Recent surveys on different occupational careers of men and women report that women are more family oriented and that men are career oriented (Ceci, Williams, & Barnett, 2009). Among others, this is one main explanation for women's underrepresentation in different careers, for example, science (Ceci et al., 2009). If this is the case, then mothers' (but not fathers') SES will be artificially depressed in comparison with their actual potential. This would lead to a range restriction, which would lead to weaker correlations. However, we had no information on the potential of the parents that we could compare with their attained status. Future studies should collect more information on the potential and reached attainment of parents and check whether these variables function as moderators of the association between parental SES and children's academic achievement.

Furthermore, we demonstrated that the investigated motivational variables significantly mediated the association between fathers' SES and children's academic achievement (hypothesis 2). This was also true for students' ability self-concepts in chemistry and mothers' SES and children's chemistry grades. Thus, it seems that especially the associations between fathers' SES and grades are mediated by children's motivation in the STEM domains. However, it must be noted that even the association between fathers' SES and academic achievement in the present study is slightly lower than what would be expected from meta-analysis. A possible explanation might be the range restriction in parents' SES. It is very likely that the association between children's academic achievement and both mothers' and fathers' SES would be higher in a study with a more representative sample than the present one. This is certainly also true for the correlation between SES and the other variables. Consequently, the presented results present a lower bound estimation of the actual associations.

The possible explanations for the relationship between fathers' SES and children's motivation are discussed previously. As the scholastic values and ability self-concepts of children from homes in which the father has a high SES are higher, they most likely also show better academic performance in the STEM domains. It has been demonstrated that changes towards more positive subjective values and ability self-concepts are related to better academic performance (cf. Eccles & Wigfield, 2002; Marsh et al., 1999). Thus, teachers in the STEM domains should be encouraged to motivate especially children from homes where fathers have low SES. Both ability self-concepts and scholastic values are known to be enhanced, for example, by pursuing a class climate that focuses on learning goals, that is, to focus on learning and enhancing one's individual competences instead of focusing on social comparisons (e.g. Wigfield & Cambria, 2010).

Moreover, we found students' intelligence to be a significant mediator of the observed associations between fathers' SES and children's academic achievement in all investigated domains as well as for mothers' SES and children's scholastic attainment in chemistry. The association between mothers' SES and children's grades in physics and mathematics were extremely weak and were not mediated by intelligence. When intelligence was introduced in the analysis, the association between fathers' SES and physics grades were nearly reduced to zero. Thus, the well-known finding that intelligence mediates the association between families' SES and children's general academic achievement (e.g. Johnson et al., 2007; Steinmayr et al., 2010) was also corroborated for the association between parents' SES and domain-specific school performance in the STEM domains.

The mediation effect of children's motivation even held after controlling for intelligence (hypothesis 4) although zero-order correlations between intelligence and all investigated motivational variables were significantly positive (cf. Table 1). Spinath et al. (2006) demonstrated that specific portions of variance in mathematical school performance were explained by both intelligence and ability

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self-concepts as well as intelligence and intrinsic values. We replicated this finding, as both motivational constructs and intelligence explained unique variance and were significantly correlated, which indicates their jointly explained variance (cf. Table 4). Moreover, we extended the findings by Spinath et al. (2006) as the analyses performed in the present study demonstrated that part of the shared variance of motivational constructs and intelligence in school grades in mathematics, physics and chemistry is attributable to parental SES. It might be that parents and especially fathers with higher SES provide their children with experiences in the STEM domains that foster both children's intelligence and motivation, which in turn influence their academic achievement.

The effects of unique and shared variance explanation are especially interesting with regard to the analyses performed to inspect hypotheses 5 and 6. The analyses illustrated in Figure 3 were rather complex. Among all predictors, prior school achievement had the highest direct effect on subsequent school performance. This effect is independent from intelligence, SES or motivation and just represents the unique variance explanation of prior school achievement in subsequent school achievement. The finding is in line with results on expertise research that demonstrated that at a certain expertise level, aptitude is not as relevant as previous knowledge (e.g. Schneider, Körkel, & Weinert, 1989). As the investigated students were already in the 11th grade and are thus at the end of their school career, it might well be that their school performance at this stage relied to a great extent on previous knowledge.

However, prior school performance was strongly correlated to both motivational variables and general intelligence in all domains, which indicates a substantial share of commonly explained variance. This correlation might reflect the importance that both motivation and intelligence had for prior school achievement. The same was true for prior school performance. SES had a small but substantial effect on school performance at t1.

Furthermore, both students' characteristics explained unique variance in some domains. Intelligence did not contribute to the prediction of subsequent math performance when simultaneously controlling for SES, prior school performance and motivation. These results replicate the finding by Steinmayr and Spinath (2009) who also found intelligence not to be incrementally valid in the prediction of subsequent mathematical performance when additionally introducing prior mathematical performance and domain-specific ability self-concepts or values in the analysis. As the authors (Steinmayr & Spinath, 2009) investigated a comparable age cohort, it can be concluded that for this age group, motivation is more important for change in mathematical performance than is intelligence. However, the converse results were observed for physics and chemistry, with one exception. Additionally to intelligence and prior physics achievement, the corresponding ability self-concept predicted subsequent physics grades. With this exception, it seems that intelligence is more important to change in school performance in these subjects than is motivation.

Limitations and future directions

The reported analyses are subject to two main limitations. First, our sample exclusively consisted of students of the highest and most selective German school level. As a result, variances of the variables measured were restricted compared with more inclusive samples as that, for example, in the PISA studies. However, as it is less likely to observe systematic associations between variables if their variances are reduced, the tests of mediation hypotheses conducted in our selected sample can be considered rather conservative. It is remarkable that we found several significant mediated effects despite this fact, and it can be assumed that these effects could be replicated in a sample covering a wider range of students. Nevertheless, the properties of the sample underlying the current results need to be kept in mind when interpreting these, and future studies should especially aim at replicating the mediation effects of students' motivational characteristics, which are for the first time reported here.

Second, the strict definition of a mediator variable includes that the predictor causally influences the mediator that in turn causally determines the criterion (cf. Baron & Kenny, 1986). Because of the partly cross-sectional nature of the study reported here, the current data do not allow for such inferences of causality. However, as we explicated previously, there is plenty of evidence in favour of our interpretation. Among other evidence, we pointed to parents' SES as a proxy for their intelligence and motivation. Nonetheless, future studies should test both students' and their parents' characteristics investigated as mediators underlying social disparities in children's academic achievement.

Moreover, we assessed school achievement longitudinally. Demonstrating that one variable can predict the change in another variable is a powerful demonstration concerning its importance for this variable. This was shown for both intelligence and motivation. However, if one variable cannot predict the change in another variable, it does not necessarily demonstrate that this variable does not determine the other variable. Motivation, SES and intelligence already determined school achievement at t1. As prior achievement, already reflecting the other constructs, is the best predictor of subsequent achievement, the only variance that is left and might be explained by the other variables is the change in school performance from t1 to t2. For example, the fact that intelligence did not longer significantly mediate the relationship between SES and math achievement at t2 after controlling for achievement at t1 and values and ability self-concepts, respectively, cannot be interpreted in a way that children's intelligence does not mediate the association between SES and children's school performance in math at t2. It just shows that intelligence does not predict the change in mathematical performance at this school stage. It might well be that intelligence mediated the association between SES and mathematical performance at t1 or at an earlier point in time. Thus, the different analysis steps were necessary to objectively judge the role of motivation and intelligence for the association between SES and school achievement. If only the last analysis was performed (controlling for academic achievement at t1), the role of motivation and intelligence might have been underestimated.

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Summing up, the different analysis demonstrated that the association between SES and school performance is a complex one that is partly established in the past, partly explained by intelligence and motivation. This is the first study that demonstrated this for motivation and highlighted the importance to consider student's motivation in order to understand the association between parental SES and children's academic achievement. In light of the fact that motivation, unlike intelligence, is thought to be more easily shaped by certain learning arrangements, the current results are of high relevance concerning any interventions to loosen the association between parental SES and children's academic achievement.

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