Family, socioeconomic status and mathematics motivation

Exploring pathways through latent variable analysis

Ingvild Ulven Østbø

Masteroppgave i spesialpedagogikk
Institutt for spesialpedagogikk
Det utdanningsvitenskapelige fakultet

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Ingvild Ulven Østbø

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Abstract

This article-based Master's Thesis begins with an extended summary ("kappen") touching on theoretical underpinnings and methodological concerns applicable to the study of socioeconomic status, motivation and educational achievement. Following is the article manuscript "Student motivation and parental attitude as mediators for SES effects : Evidence from TIMSS 2015," written for submission to Scandinavian Journal of Educational Research. The article explores student motivation and parent attitudes as mediators of SES effects on student achievement using TIMSS 2015 data through the research problem "how do 1) motivation and 2) attitudes at home mediate the relationship between socioeconomic status and mathematics achievement?". The data includes achievement items and context questionnaires collected from Norwegian fifth graders (n = 4329) and their parents (n = 1819) and are analyzed using structural equation modelling and latent variable analysis in the statistical software R. Findings indicate that intrinsic motivation and parent attitudes do not explain any of the SES effects on achievement in our sample. Extrinsic motivation mediates some of the total SES effects, controlled for age and gender, though much remains unexplained by the variables included in the current analyses.

Preface

Thank you, Sean, for your patience and support. Takk til Izakaya som ga meg kontorplass når universitetet (og byen) stengte ned. Takk til alle kloke, reflekterte og morsomme hoder i vårt kull med spesialpedagoger. Og mange, mange takk til Henrik Daae Zachrisson, som har vært en mer nøye, ambisiøs, støttende og oppmuntrende veileder enn jeg kunne turt å håpe på.

Figures in extended summary

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Number of words in extended summary: 7933

Number of words in article manuscript: 6735

1 Introduction

As per the requirements for the submission of an article-based Master's Thesis to the University of Oslo, the thesis is organized in two parts. First presented is a longer text containing a wider range of theoretical background for the research problem; an elaboration on methodological issues; and ethical considerations not fit for the article submission. This extended summary is meant to contextualize the choices I made in the research work put together for the article manuscript. The second part of the thesis submitted is the article manuscript, written to fit the requirements of a relevant academic journal. The core results are presented and discussed in the article draft and will not be explained in the first text. Details on the journal submission requirements are appended to the first text.

1.1 Two parts and the relationship between them

This first text is organized thematically, where theory and research on central topics is outlined and discussed. These include the concept and construct of socioeconomic status in the case of children, parents and families, and motivation and typologies and theories on how motivation influences outcomes. After the central thematic delineations, I discuss ethical and methodological concerns of the study, including the reliability of the data and the validity of the analyses performed on the basis of the data. The second text, consisting of the article manuscript, is written to approximate standards for academic journals presenting novel empirical evidence. The text presents the topic and themes, as in the previous text, but in a more concise manner related to the analyses and results. The data and methods used are described next. Then follows technical aspects of the analyses and the measurement- and structural models employed. Finally, a presentation of pertinent results and discussion of possible conclusions ends the article draft. My hope is that together, the two texts will present meaningful accounts of both my own research and previous research into families, socioeconomic resources and school achievement that are of practical use to inclusive education workers like myself.

1.1.1 Scandinavian Journal of Educational Research

The journal for which the article draft was written is Scandinavian Journal of Educational Research (SJER), published by Taylor & Francis. I chose this journal due to its wide focus on education among Scandinavian researchers, and because of its previously published research

on mathematics interest among students (Høgheim & Reber, 2019), school achievement in Norway and Scandinavia (Gustafsson & Blömeke, 2018; Daus, Nilsen & Braeken, 2018; Ulriksen, Sagatun, Zachrisson., Waaktaar & Lervåg, 2015) and on large scale assessments and the measurement of socioeconomic status (Gustafsson, 2018; Yang, 2003).

1.1.2 Choice of data

In the article draft, I analyze data collected in the Trends in Mathematics and Science Study (TIMSS) in 2015. The TIMSS data lends itself well to a large-scale quantitative analysis at the graduate level, as the data are freely available, as are the questionnaire and a range of published material on the study development. This alleviated the time constraints around writing a masters level thesis as data collection amounted only to downloading data from the web – data that is already well organized and coded. Saving time on data collection meant I had more time to become familiar with the data sets and their structure, including the student sample (n = 4239) and the parent sample (n = 1819). Since the project proposal and my idea for the thesis project were spun around exploring socioeconomic differences, a study that collects information on parents' education and assets was of major importance. The TIMSS study was the only large-scale assessment I found that included a parent questionnaire in its latest cycle.

1.1.3 Implications for inclusive education science

As a student in special needs- and inclusive education, it was important to me to use data that would capture a wide range of students in terms of ability and background. Being a student, and teacher, oriented toward social and emotional difficulties demands attention to the context that children live in. Socioeconomic conditions and resources at home are one of the contextual characteristics of student lives that influences every student's ability to achieve and attain within the education system, yet something I rarely hear explicitly considered in the day-to-day work as an educator. I wanted to understand better *how* socioeconomic conditions translate from family life to school performance. Using large scale data presented an opportunity to exercise methodological skills acquired during the masters program in social- and emotional difficulties ("psykososiale vansker") while approximating an understanding of family influences on the students I teach based on a large sample.

1.2 The research problem

Educational equity is the principle that regardless of social background, students should have a fair chance to achieve their individual academic potential. Substantial amounts of previous research show that the relationship between socioeconomic background and school achievement is statistically significant and predictive of outcomes such as future income (Chmielewski & Reardon, 2016), future education attainment (Watkins & Howard, 2015) and adult socioeconomic status (Braun & Stuhler, 2018; Vosters & Nyborn, 2017). Equitable opportunities concern a range of personal characteristics and privileges, from gender and ethnicity to financial and social resources. In Norway, despite a 2015 GINI-coefficient of 27.5 (World Bank, 2019), indicating relative economic equality in a global perspective, inequalities persist to the extent that a social gradient can still be observed in school achievement. I propose that motivation may be one mediating variable for the effects of SES, suggesting that how much motivation a student feels and whether the motivation is intrinsic or extrinsic may matter for the pathways of SES effects. Theories of expectancy-value, stress and investment and self-determination underpin these understandings of motivation as multi-faceted and impacted by family life, parenting strategies and home dynamics.

Wadsworth and Ahlkvist provide evidence of parenting as a mediating factor in the relationship between parental economic and educational background and their children's academic achievement (2015, p. 95). Building on the logic of Lareau's theoretical divide between 'concerted cultivation' and 'natural growth' as parenting strategies, other scholars have found quantitative evidence for the use of concerted cultivation-like parenting strategies among advantaged parents and the positive effect of these strategies on their children's educational outcomes (Lareau, 2003; Wadsworth & Ahlkvist, 2016, p. 98). Choice of parenting strategies, including how and how much (time, resources) to invest in their children's education and learning, mediates the effect of SES on achievement. One way of operationalizing these strategies is to ask parents about their attitude to school and subjects, hoping to glean whether the parent finds the subject at hand or school in general a worthwhile investment for them and their child, encouraging children to consider education an arena in which motivated effort will yield results.

The correlation between parental socioeconomic status (SES) and children's educational achievement is weaker in Norway than in most other national contexts (Hyggen, Brattbakk

and Borgeraas, 2018, p. 184), but the correlation and inequity that does persist has real bearing on real lives – primarily the lives of those in lower-SES segments of the population. In a country with extensive redistributive policies and a well-funded public school system, how can we explain these inequalities? I try to approximate this question through a research problem with two hypotheses to be tested. First, I suggest that student motivation mediates some of the effects of SES on achievement. Second, I suggest that parental attitudes mediate some of the SES effects on achievement, and also some of the SES effects on the student motivation. In the article draft, I present current research pertinent to the connection between SES, attitudes and motivation, and between motivation and achievement. In this first text, I will present broader fields of theory around socioeconomic status and its impact on children, as well as sociology of families and parenting and psychological typologies of motivation, that provide further background for the research problem.

1.3 Mediation analysis

The methods employed for testing the hypotheses are thoroughly explained in the article draft. Here, I will briefly outline the logic of the mediation analyses and how they are useful for examining the current research problem. In model 1, using student data, I hypothesize that the relationship between socioeconomic background and test results in TIMSS are partially, but significantly, explained by that student's motivation for school and for specific subjects, illustrated in figure 1.1. A more sophisticated view of the same relationship takes into account how a combined measure of parental SES influences student motivation through the attitudes and values they are exposed to at home, illustrated in figure 1.2.

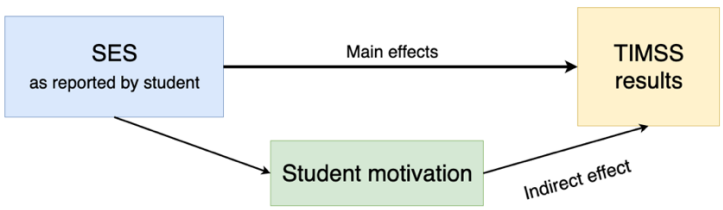


Figure 1.1

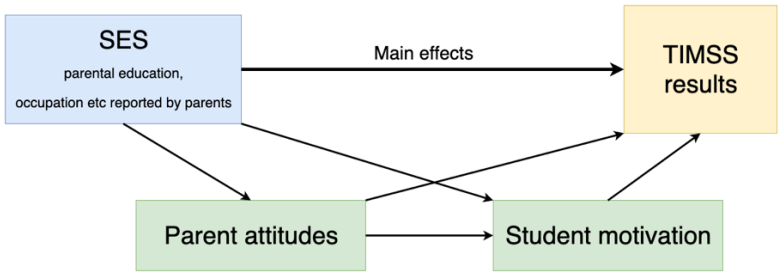


Figure 1.2

Thus, a working hypothesis to confront the above research problem is that the relationship between socioeconomic status of Norwegian students (X) and school achievement on TIMSS tests in the fifth grade (Y) is mediated by their parents' attitudes to school (M1) and their own motivation (M2).

The mathematical expression for this mediating effect is illustrated in the below series of equations, as delineated in Baron and Kenny's seminal article on moderator- and mediator effects (1986) and recaptured in Kenny and Judd's considerations on statistical power in mediation (2014; p. 334):

$$M1 = i_{M1} + aX + U$$

Where $M1$ is the first mediating effect, i_{M1} is the intercept, X is the causal variable and U is the residual.

$$M2 = i_{M2} + bX + V$$

Where $M2$ is the second mediating effect, i_{M2} is the intercept, X is the causal variable and V is the residual.

$$Y = i_y + cM1 + dM2 + e'X + W$$

Where Y is the outcome, i_y is the intercept, W is the residual and c, d and e' are the effects to be estimated.

For the mediation hypothesis of model 1 to hold, variations in the independent variable (SES) must significantly account for variations in the mediation variable (motivation). Second, variations in the mediator (motivation) must significantly account for variations in the outcome variable (results) (Baron & Kenny, 1986, p. 1176). While these kinds of path relationships (where path A is identified by regressing the outcome on the independent

variable, path B by regressing the outcome on the mediator variable and path C is the control for whether path B eliminates significant effects of path A) can be tested using a series of regressions, statistical software now allows for this to be done using one and the same model.

1.3.1 Structural equation modelling

Determining the pathways through which an independent variable has effect on an outcome can be done through path analysis in structural equation modelling (SEM). In SEM, a system of regressions is defined and run interdependently according to their proposed structure of interaction. Path analysis adds the definition of exogeneity and endogeneity to traditional regression (Kline, 2016, p. 129). While a variable is endogenous, meaning dependent on another, in one regression, it can be exogenous in the next step. Effects that move through one of these endogenous-exogenous variables are mediated and the effects travel through an indirect path. Path analysis in SEM is a multivariate technique, meaning it is suited to capture dynamic relationships between a series of variables (Gunzler, Chen, Wu and Zhang, 2013, p. 390). Using SEM to explore mediation allows for a more straightforward analysis of direct and indirect effects as it allows us to analyze paths simultaneously, rather than the traditional Baron and Kenny method of mediation using stepwise regression (Baron & Kenny, 1986). Instead, we may combine multiple steps and even multiple mediators in the same model (Hayes, 2009, p. 409). The use of causal mediation models is particularly interesting in the study of large-scale assessment data like TIMSS, as we assume many variables are at play simultaneously and impact the outcome interdependently (Caro, 2015).

2 Families and socioeconomic status

2.1 Why do family resources matter in education?

Underpinning much of the empirical research on how material resources benefit people in social ways is the work of sociologist Pierre Bourdieu. Material resources, or economic capital in Bourdieu's terminology, translate to cultural and social capital through socialization and demarcation of cultural positions (Bourdieu, 1986a). People identify cultural and social markers of resource, associating language, tastes and style choices with a hierarchy of power. The differences, or distinctions, between lifestyles translate to behavior as well. The "sense of what is comfortable or what is natural" is part of the socialization children receive within families and that may or may not benefit them in the school environment (Lareau, 2011, p. 361). Not only do some forms of cultural capital benefit students at school, but the educational system itself tends to reproduce structural inequalities based off cultural capital (Bourdieu, 1977, p. 488). While cultural and social capital accrues over time (much like economic capital) it also reproduces itself through embodied, objectified and institutionalized states (Bourdieu, 1986b, p. 242-3). Education is one of the institutionalized settings where cultural capital takes the form of *qualification* and changes from a more informal and intangible form of resource to a formalized and objectified form of access to restricted arenas of social life (Bourdieu, 1986b, p. 248).

Lareau, in her longitudinal field studies of families in various class positions, identifies two distinct forms of parenting and family life associated with differing levels of economic, cultural and social capital (Lareau, 2011). She identifies a pattern of "concerted cultivation" among middle-class parents, fostering in their children "a robust sense of entitlement" and comfortable ease when facing institutions within health care and education (Lareau, 2011, p. 2; 125; 165). In contrast, poor and working-class families reared children in a pattern Lareau calls "the accomplishment of natural growth," less comfortable with the institutions of society but more tight-knit in relation to extended family and with more autonomy in children's free time (2011, p. 3; 141; 198). Neither pattern of child rearing seems better or worse in terms of caring for the children's physical or emotional needs. However, the discrepancies in opportunity seem to arise when the children navigate society outside of family. Children from families prioritizing child rearing more focused on natural growth tended to be more insecure when speaking to teachers and other authoritative figures. Children from families whose child

rearing tended toward the concerted cultivation were more confident and practiced when facing society's demands.

Many facets of family life affect how children are reared. A 1998 study of family structure and its effect on high school graduation found that in many cases, controlling for economic resources explained effects of family structure (Boggess, 1998). This was true for single mother families, while stepfather families had a negative effect on educational attainment even when controlling for economic resources. Both scenarios were analyzed in comparison to living in a two-parent household. Poverty rates among single-parent families have remained high (Cohen, 2015, p. 30). While the Boggess study identified the impact of different family structures, only economic resources were measured, meaning social or cultural forms of capital that may be connected to family structure were not identified in this study. The scholarly culture, family dynamics and parenting styles of the families may be interesting paths or mediating variables for how family structure and academic achievement or attainment covariate. What Boggess calls "the stepparent effect" is attributed to family stress and loss of community resources (1998, p. 206). The study also found that the effects of growing up in a one-parent household was less detrimental for children with never-married mothers than divorced or widowed mothers, suggesting that the stress of change in family structure is a significant moderator for SES effects (Boggess, 1998, p. 213; 220).

In fieldwork focused specifically on parents' relationship to schools and teachers, Lareau examined how some parents benefited from a "symbolic access" to the world of professionals stemming from their own education experiences and professional status (2000, p. 112). These parents were more proactive in regard to their children's schooling and thought of themselves as equal to the teachers and administrators, therefore being confident about advocating for their views. On the other hand, parents who did not benefit from this symbolic access, due to lower levels of education, being unemployed or working in a profession regarded as lower skilled, tended to defer more to teachers and administrators. The contrast between independence and proactivity on the one hand and deference and passivity on the other led to benefits for the children of more culturally resourceful parents (Lareau, 2000, p. 123). Specifically, low-achieving children in most need of support at school were the children who benefited the most from their parents advocating for them.

2.2 Measuring socioeconomic status

Parental SES is often measured as education level and occupational status. Another popular proxy measure for SES is the number of books at home. This latter measure portends to the cultural aspects of SES, as in habits, taste, lifestyle and such. Others argue that because employment, education, income and cultural aspects of SES all impact outcomes in different ways, combining these measures into a single SES scale is inadvisable (Duncan et al, 2015, p. 3). When isolating measures, "home atmosphere" alone as an SES measure yielded the highest correlation with achievement at the individual student level (White, 1982, p. 470). Similarly, in a later replication of the meta-analysis, "home resources" had the largest mean effect size among SES measures (Sirin, 2005, p. 434).

Parental income, education and occupation are the three most traditional measures of socioeconomic status used in research on socioeconomic status and academic achievement (Sirin, 2005, p. 419). The three indicators measure adjacent but separate aspects of SES: income as potential for resource, education as a stable and lasting measure, and occupation adhering to social prestige. All three are interrelated and all three correlate with student achievement, and a composite measure including these as well as other potential information about social and cultural resources are recommended (Sirin, 2005, p. 444). The problem is gathering this information from students, especially young students, whose reporting of parental income, education and occupation may be of low accuracy.

2.3 Parental education and the home environment

Feinstein, Duckworth and Sabates (2008, p. 15) frame the understanding of achievement gaps in how cognitive development can be predicted by early levels of functioning. Knowing that the achievement gap exist prior to schooling, genetic and environmental traits of the family context become central to understanding mechanisms of disparity. Feinstein (2003) has demonstrated in the UK context how the social class gradient present at 22 months of age predicts educational qualifications as young adults. The same study suggests that high socioeconomic status at an early age predicts higher educational mobility compared with lower-SES students (2003, p. 89). Gustafsson, Hansen and Rosén study the extent and mechanisms of influence from parental education and gender on achievement, and do so by counting numbers of books in the home, literacy and numeracy activities (2013, p. 183). They

find that, in the 2011 TIMSS study of all participating countries, the effect of parental education was mediated via books, activities and abilities (Gustafson et al, 2013, p. 241-242). These were the three basic patterns found in the path analysis of mediating effects – despite other similarities and differences that made many countries stand out as generally having differing path strengths. Other studies on TIMSS data find that the number of books in the home remains the most stable and reliably measured proxy for socioeconomic status (Bellens et al, 2019, p. 6). In the Norwegian subset of Gustafsson et al's study (2013, p. 266), total effects of parental education on achievement was relatively weak, while the indirect effects of the mediating variables (books in the home, early learning activities and abilities when starting school) accounted for a relatively large part of the total effects. The number of books in the home was the strongest mediating effect of parental education on achievement in the fourth grade in Norway.

2.4 Genetic components of individual achievement

As we have seen, parenting strategies, family atmosphere and cognitive ability are all predictors of academic achievement while also being related to socioeconomic status in the family. But to what extent are each of these, and SES itself, associated with genetic components? A study of genetic differences between students attending selective and non-selective schools in the UK found "substantial mean genetic differences" in favor of students attending selective schools (Smith-Woolley et al, 2018). Similarly, a study of DNA methylation signatures found that there were genetic attributions associated with educational attainment through "neuronal, immune and developmental processes" in adults (van Dongen et al, 2018). But the results did not necessarily suggest that educational attainment is hereditary: rather, the DNA methylation signatures associated with educational attainment were also associated with cigarette smoke exposure, which in turn is associated with negative health outcomes at foetal exposure but also epigenetic changes to attention and mental health in adolescence and later (van Dongen et al, 2018, p. 10). In other words, the genetic components of educational success are heavily tied to social and behavioral aspects of childhood and health. The collective impact of a complex combination of genes may together be important for understanding educational inequality, while keeping in mind that the epigenetic effects of families and parenting are also at play (Martin, 2018).

2.5 Family pathways

The above outlined work of Lareau on families and schooling contributed to "establish robust, causal effects of education" (Fernstein et al, 2008, p. 18) and has had a seminal influence of how we understand the mechanisms of family influence and socialization on the life chances of children. These qualitative descriptions of family lives and the differences between them illustrate causal explanations of intergenerational transmittance of educational chances. The problem becomes generalization and understanding how these mechanisms work on an aggregated level. To do this, Feinstein et al (2008, p. 22) argues that it is vital to first construct a conceptual model of how parental education impacts children before we can effectively interpret the results of studies demonstrating the correlation. The range of findings is as wide as the historical and geographical contexts where they are found. A conceptual framework that encapsulates both an ecological model (Bronfenbrenner, 1979, in Fernstein et al, 2008, p. 24) as well as a neo-classical economic model of achievement (Becker, 1973, in Fernstein et al, 2008, p. 30) complimented by Bourdieuan and Marxists aspects of capital and class, is illustrated in figure 2.1 below – adopted from Fernstein et al (2008, p. 26).

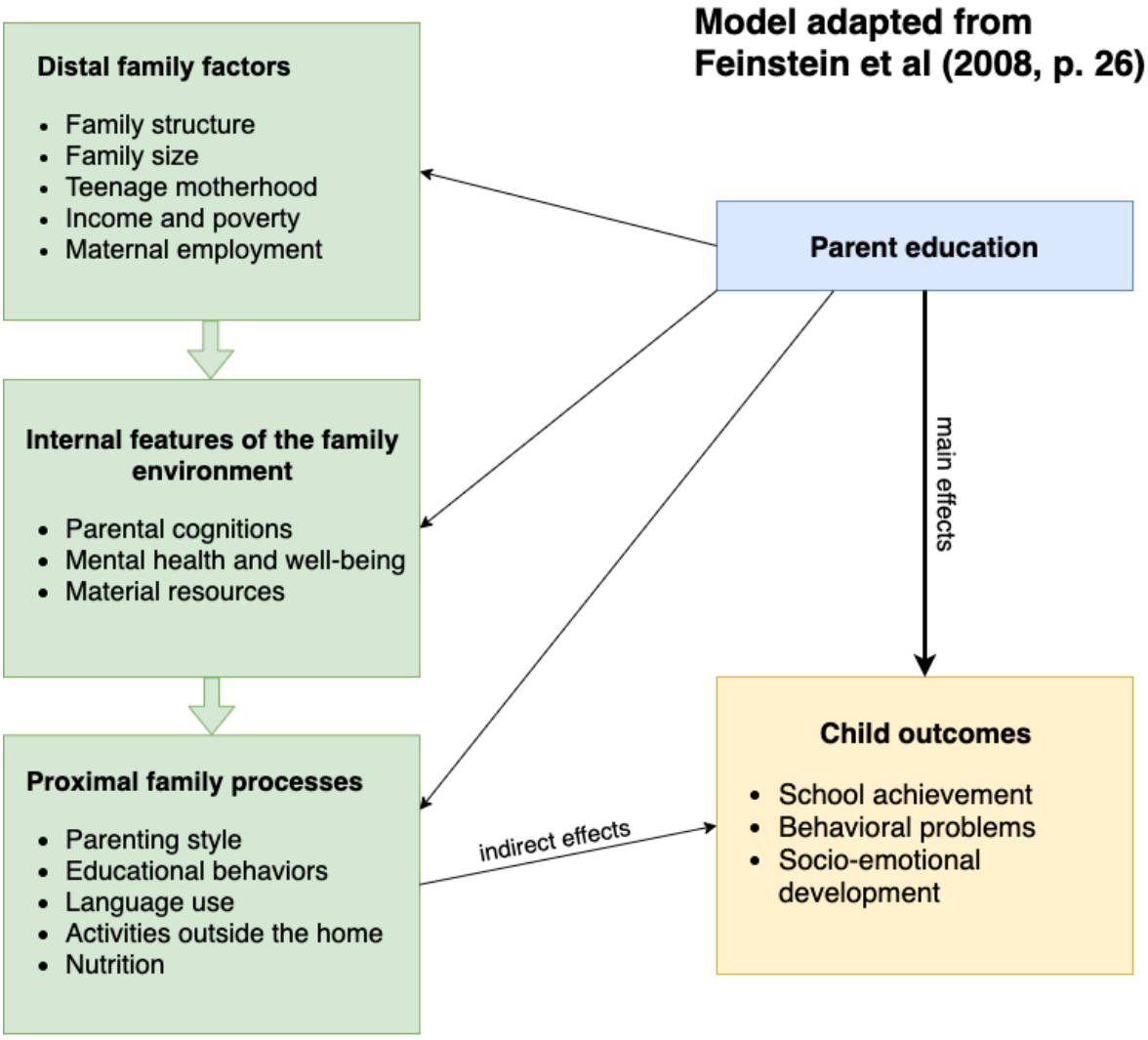


Figure 2.1: *Feinstein (2008), a framework combining an ecological model and a neo-classical economic model of achievement*

When focusing on the proximal family processes, the authors work with concepts of everyday life: the interactions between parents and children on a daily basis, "interactions that support, sustain or hinder development" (Fernstein et al, 2008, p. 45). From this perspective, they separate two types of interaction and consider evidence for the strength of each factor. The two types of interactions are parenting style and educational behaviors. Among the effects of parenting style, warmth and affective relationships are proven significantly predictive of school readiness and IQ (Estrada et al, 1987, in Feinstein et al, 2008, p. 54). Parenting style itself is found to be associated with mother's education – independent of family income level (Klebanov et al, 1994, in Feinstein et al, 2008, p. 59). Separated from parenting style is the educational behaviors in the home, including educational behaviors such as reading to

children in pre-school age and helping with homework when starting school. Maternal levels of formal education are associated with conversational behavior (Hoff-Ginsberg, 1991, 1992, in Feinstein et al, 2008, p. 68); structure and verbal guidance (Hess and Shipman, 1965, in Feinstein et al, 2008, p. 67); and cognitive stimulation (EPPE Project, 2004, in Feinstein et al, 2008, p. 69). When focusing on material resources, Feinstein et al (2008) call this the "internal features of the family environment" and group the material resources together with parental cognition, mental health and well-being. Material resources can also be understood as the interaction between distal family factors such as income, poverty, affluence and employment, and the internal features. The distal factors come first in the conceptual model, meaning that these factors are mediated through the internal features. In other words, employment and income (as well as family size and structure) are prior factors, but influence family processes and child outcome *through* the family environment. Well-being in families can be particularly affected by economic strain in the first years of children's lives (Duncan, Magnuson, Murnane and Votruba-Drzal, 2019, p. 320). Duncan et al conceptualize two perspectives on economic strain that influences family health and well-being; a resource- and investment perspective, and a stress perspective (2019, p. 316).

The resource/investment perspective highlights the resources, both economic and time, that parents have available to spend on (money) or with (time) their children. Economic resources cover investments not only in physical items for learning such as books and computers, but also activities and lessons in music, sports and tutoring. In Lareau's work, a form of investment is seen in the time and effort parents put into communication with their children's teachers and in following up the work administered at school (2000, p. 144). She argues that parental involvement, and particularly lack of involvement, is not random (Lareau, 2000, p. 3). Rather, involvement is powerfully influenced by social class and Lareau exemplifies this with the much higher rates of failing to attend parent-teacher conferences among working class parents compared with middle class parents. The stress perspective is inherited from Elder's family stress model (1974, in Duncan et al, 2019, p. 317). This model illustrates how economic strain create higher levels of depressive and hostile feelings among poor parents, which in turn increases the stress and negatively affects the well-being of their children. Parents who experience higher levels of conflict and psychological distress tend toward parenting practices that are "more punitive, harsh, inconsistent, and detached" (Duncan et al, 2019, p. 317). The environmental stress is not limited to families but also in other contexts

such as overcrowded and underfunded schools. Weinberg et al (2019) suggest three pathways for SES effects on educational attainment; cognitive ability, primary school teacher assessment, and educational expectations. Out of the three, educational expectations accounted for very little of the total SES effects among the 2,814 Dutch adolescents studied. Cognitive ability was the strongest predictor for adolescent educational attainment, explaining 30% of total association between parental SES and educational attainment (Weinberg et al 2019, p. 11). Yet 40% of the association between parental SES and attainment remained unexplained by the pathways identified.

2.6 Schools and neighborhoods

Neighborhood effects is a popular field of research within sociology, though some education scholars advice against overemphasizing the neighborhood context in understanding differences in academic achievement. Referred to as the "ecological fallacy," inferring individual-level predictions based on group-aggregated data have problematic implications (Sirin, 2005, p. 419). Yet using group-aggregated data on schools and neighborhood does present more accessible information on a larger number of subjects. Aikens and Barbarin (2008) found that school and neighborhood conditions contributed more to children's early reading skills than did family characteristics. Weinberg (2019), on the other hand, did not find that neighborhood SES contributed to the association between SES and educational attainment in the Netherlands – contrary to their hypothesis. In Norway, Hermansen, Borge and Mastekaasa (2019) have studied the long-term effects of neighborhood and school contexts on educational attainment and adult earnings. Here we do not observe evidence of school achievement in the form of a dependent *achievement* variable, but Hermansen et al do provide evidence of effects on a dependent *attainment* variable. They use multilevel modelling to test the extent of which the combination of neighborhoods as key social context and school-level characteristics matter for children's educational outcomes in Norway, as they have been demonstrated to do in other geographic contexts (Hermansen et al, 2019, p. 1). Their findings, however, show that the variation in adult socioeconomic attainment within the common neighborhood and school context is larger than across these contexts. These differences from international data on the importance of neighborhood and school contexts are explained by the lesser spatial variation in socioeconomic resources in Norway (Hermansen et al, 2019, p. 3-4). High degrees of resource redistribution and -compensation through the social welfare state seem, in these results, to fulfill their intended purpose of

mitigating sociodemographic inequalities. Prior research shows that in Norway, the correlations between schools and neighborhoods on the one side and socioeconomic outcomes on the other has declined through the 20th century (Hermansen et al, 2019, p. 4). Hermansen et al conclude that the low and stable correlations between neighborhoods, schools and outcomes after a long and slow decline is due to a decline in parental socioeconomic segregation (2019, p. 10).

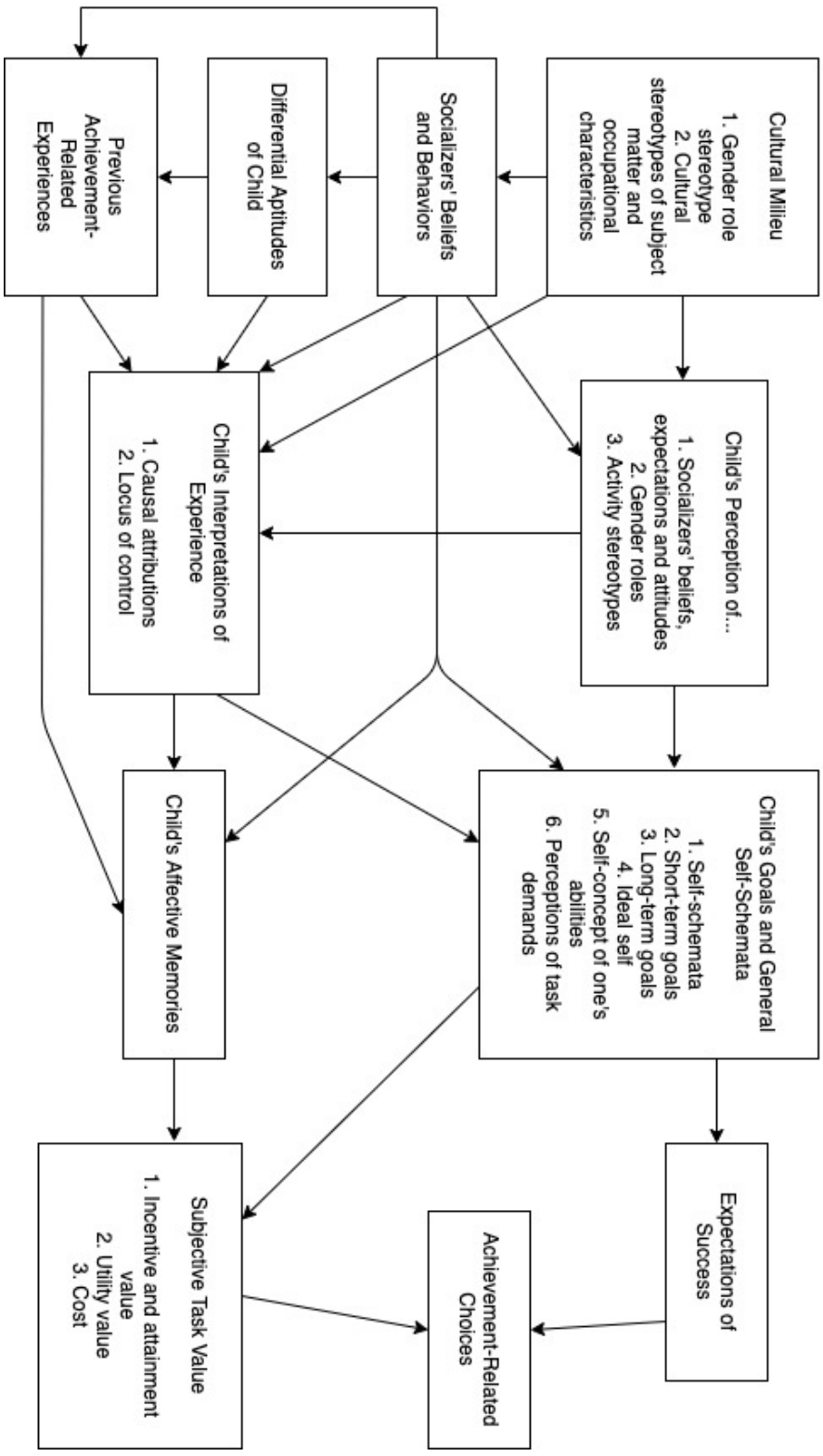
Gustafsson, Nilsen and Hansen (2016) included in their study how schools moderate the effects of SES on achievement using TIMSS 2011 results for grade eight students. Their interest is in identifying which school characteristics *reduce* the relationship between SES and achievement. They tease out the school level of SES-distribution in what they call "collective SES" measured as the mean level of SES in the defined group. The authors also claim that "there are reasons to assume that the disparity in educational outcomes of different schools is partially determined by differences in the social and institutional factors that are associated with school SES, over and above effect of individual SES" (Gustafsson et al, 2016, p. 17). Therefore, it is crucial to identify mechanisms that SES works through at the collective level as well as the individual.

3 Motivation

3.1 Expectancy-value

The expectancy-value theory of achievement motivation, developed by Wigfield and Eccles (2000), focuses on how subjective task value in combination with beliefs about one's own ability and expectations for success determine motivation for achievement-oriented tasks. The full model, adapted from Wigfield and Eccles (2000, p. 69) is pictured in figure 3.1. Expectancy is the individual beliefs in one's capability to succeed or fail, while value is the degree to which the individual believes succeeding will be valuable in one's life. When doubting one's capability to succeed, expectancy-value theory proposes that the individual is less likely to engage in the task at hand (Schunk et al, 2008, p. 44). The higher the individual values a task and its possible outcome, for any variety of reasons, the more likely they are to engage in it. Subjective value may be both the possible enjoyment the student may find in completing the task, or the value they see in having completed it (Eccles & Wigfield, 2002, p. 118).

Eccles proposes four specific components of task-value, being attainment value, intrinsic value, utility value and cost (Eccles, 1983 in Eccles & Wigfield, 2002, p. 119). Intrinsic value here may be more narrowly defined than in the Ryan and Deci framework discussed below and also more narrowly defined than in my analyses. Here, Eccles and Wigfield describe intrinsic value as enjoying the task, through interest in the subject. Separately, they describe utility value as a form of value that relates to achieving a goal or to please an important other. While utility presents as an outwardly oriented, extrinsic, form of value, the last two value aspects of attainment and cost may be more closely related to intrinsic motivation in so far as we use this conceptual distinction in the analyses below. This is because attainment value here is delineated as "the relevance of engaging in a task for confirming or disconfirming salient aspects of one's self-schema" and therefore relates more closely to the TIMSS questionnaire in questions of personal value and emotion that it does to opinions of one's own expectancy for success (Eccles & Wigfield, 2002, p. 220). Finally, cost aspects are the emotional costs to completing a task, such as fear, nervousness or anxiety.



Adapted from
Eccles, Wigfield and colleagues
Fig. 1, p. 69
"Expectancy-Value Theory of Achievement Motivation"
Wigfield & Eccles,
Contemporary Educational Psychology 25(68-81)
2000

***Figure 3.1**: Eccles and Wigfield's model of expectancy-value*

To visualize aspects from Eccles and Wigfield's model that are touched upon in the TIMSS questionnaire about students' motivation and the home questionnaire, figure 3.2 is simplified and highlighted. Cultural milieu applies to socioeconomic status through mechanisms discussed above through Lareau and Bourdieu's research. Subject specific attitudes, and especially parents' attitudes, may be reflected in the cultural stereotypes of subjects and occupations. Parental attitudes are also reflected in how children perceive their parents' expectations and attitudes. Extrinsic motivation is reflected in prior experiences of success or failure, and expectations arising from these prior experiences, while intrinsic motivation manifests in affective memories and subjective task value.

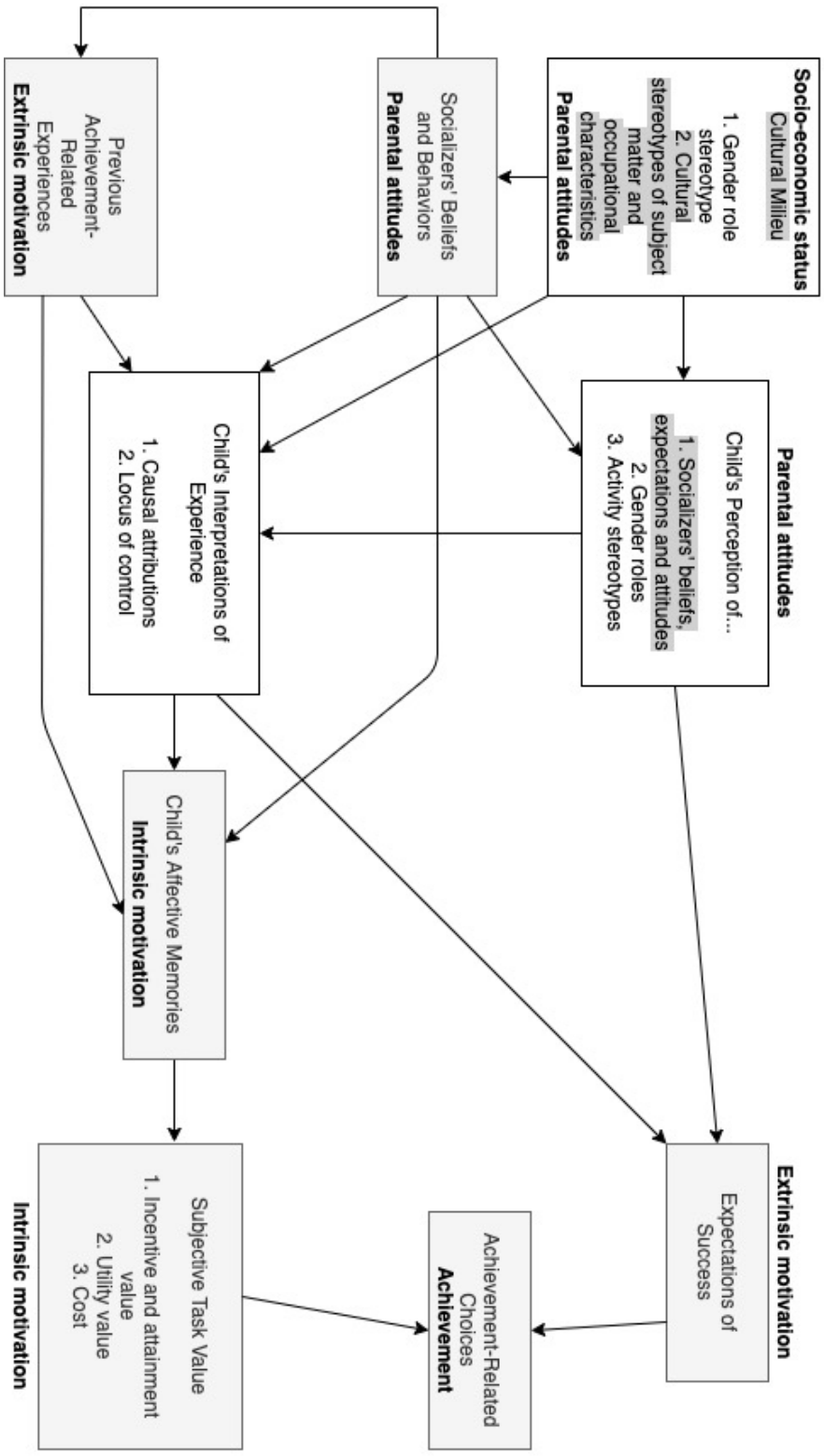


Figure 3.2: *Eccles & Wigfield's model of expectancy-value, highlighted for areas measured in the current study*

3.2 Resource, stress and investment

Related to the theory of expectancy and value are theories within a resource- and investment perspective. As the value of a task is important for the individual's motivation to complete it and the value placed upon its completion, efforts to succeed can be seen as investment in the pursuit of a goal. But investments are not just motivation and effort: academic achievement is also a matter of more explicit resources. Investing heavily in their child's future is a privilege not available to all parents. Whether investments take the form of financial, social or human capital resources, families' investments promote children's development (Bradley, Corwyn, McAdoo and Coll, 2001). Poverty status has been found to be more predictive of home environment than negative differences associated with systemic discrimination of ethnic groups (Bradley et al, 2001, p. 1863-4). The study found that "nonpoor mothers were twice as likely to read to their children than were poor mothers" (Bradley et al, 2001, p. 1861). This example points not only toward the economic investment in material for learning like books, but to the investment in form of having time to read with children. Parents who have exacerbated work schedules or strenuous care duties in the family may not have the time to invest as parents of families with more comfortable economic margins. Longo et al (2017) frame family process and parenting strategies as investment and found that supervision and organization were more predictive of positive socioemotional outcomes than sensitive parenting).

In a longitudinal study of family resilience, Conger and Conger found that economic hardship had detrimental effects on families through parental relationships, emotions and parenting (2002). Resilience among youth to hardship of life transitions was fostered through "nurturant and involved parenting" (Conger & Conger, 2002, p. 362). Conger and Conger's model suggest that biological, psychological and social resources mediate the effect of economic hardship on family resilience (2002, p. 364). Nurturant parenting is defined as being high in warmth and low in hostility (Conger & Conger, 2002, p. 370). In addition, what Conger and Conger define as "nurturant-involved" parents also set reasonable boundaries for behavior and are involved in their children's activities (2002, p. 372). Homes also differ in the extent to which adults are available and attentive to educational developments and needs (Schunk et al, 2008, p. 283). As well as the resources mentioned, discipline style, organization and involvement can foster or hinder learning. Family chaos is associated with maternal education, which in turn had a negative association with mothers' complexity of talk and time

spent speaking with their children (Vernon-Feagens et al, 2015, p. 47). Indirect effects of "compromised" parenting are an important additive stressor to the direct effects of economic strain and family conflict on achievement (Wadsworth & Alkvist, 2015, p. 96). In turn, decelerated development, particularly of language, may lead to lower levels of school readiness and achievement in early schooling. While Longo et al found that sensitive parenting, including warmth and responsiveness, was consistently negatively associated with behavioral problems, the effects of order, surveillance and safety outweighed the importance of sensitivity and warmth (2017, p. 2286). Results from Longo et al suggest that establishing structure and avoiding aforementioned "family chaos," while often hand in hand with warm and sensitive parenting, is more important in mitigating detrimental effects of economic hardship.

3.3 Intrinsic motivation and self-determination

Ryan and Deci, when establishing a theory of self-determination, observe how "social context catalyze both within- and between-person differences in motivation and personal growth" (2000, p. 68). Motivation, to them, is a matter of how individuals respond to their social environments. Does it feel good to work hard? Does it seem feasible to work toward a goal and achieve it? In the encyclopedic definition, intrinsic motivation is dependent on a sense of autonomy and in the educational context to an individual desire to learn or obtain skills (Hsieh, 2011a). Extrinsic motivation is more dependent on consequences, and on an evaluation by another (Hsieh, 2011b). The desire aspect intrinsic motivation is captured in self-determination theory as three needs: the need for competence, need for relatedness and need for autonomy (Ryan & Deci, 2000, p. 68). Ryan and Deci are convinced that authentic, intrinsic motivation enhanced performance more so than extrinsic or externally driven motivation (2000, p. 69). This type of motivation cannot be coerced, but can it be encouraged through parenting or socialization? Diseth deems implicit motives, which give incentive, as forms of social need (2019, p. 56). Two forms of these incentivized, implicit and social need-based forms of motivation may apply to the school context. A social need for *achievement* stems from an implicit motivation for challenge and positive reinforcement. A social need for *affiliation* is connected to positive affect, trust and well-being in relationships (Diseth, 2019, p. 75). The need for affiliation and it's counterpoint, the fear of rejection, may be pertinent in understanding how expectations for achievement in the home environment, and the precedent

set by parental education levels, may create incentive for achievement among higher-SES students if parenting styles at home are warm, affectionate and positively reinforce learning activities and achievements. Ryan and Deci believe that all children are born active and inquisitive, with "spontaneous interest," but that these inclinations require maintenance and support to carry on into adolescence and adulthood (2000, p. 70). They state that children with "autonomy-supportive parents" are more intrinsically motivated, versus children with more controlling parents (Ryan & Deci, 2000, p. 71). While stress and investment perspectives on motivation would encourage more supervision, more organization, to encourage performance among children – parenting in line with what Lareau would call concerted cultivation – the Ryan and Deci line of thinking of intrinsic motivation would encourage parenting more supportive of child-led initiative and less organization, supervision and control.

4 Study limitations

"[..] Data doesn't do much if you don't understand it's limits" (Krumme, 2009, p. 217).

Despite the large samples, the replicability and the rigorous measurement instruments in the TIMSS data, and a seemingly limitless array of avenues for research questions, there is a limit to what we can conclude. Krumme warns against committing the narrative fallacy: collecting so much data that we create a story of out what is essentially noise (Krumme, 2009, p. 207). The context items, both those questions posed to students and to parents, have undergone stringent testing and tuning (Hooper, 2016). Yet as I use this contextual information as predictive, independent variables, I need to understand their nature outside of their statistical validity. This has required me to inspect each variable and its distribution and think critically about what it can and cannot tell me about the student represented only by a Likert scale score. The student cannot tell me how she feels about her mathematics class or why she feels that way. All I know is she chose one out of five options on a sheet of paper and, luckily for me, enough students made such choices that even if some checked the wrong box the results are within an error margin. The voice of the individual student remains unheard and when we draw narrative lines, trying to explain how family life influences test achievement, we are creating a story that fits a generalized reality but not a single one of the students' real lives.

4.1 Reliability and validity

The TIMSS data, achievement items and context items alike, depend on rigor in sampling and generalizability as well as rigor in measurement and construct validity. Capturing motivation (as only one of several examples from this dataset) as a concept is dependent on a dialectic movement between the theoretical concepts and scales and values that are discernable in practical experience. Any attempt to turn the experience of motivation into a quantified concept requires simplification or a reduction of complexity (John & Benet-Martínez, 2014, p. 474). Validating how our constructs can be measured means building models and having a way to discern which is a closer approximation to reality. The construct view of validity reminds us that in addition to the random errors of sampling and measuring, there are systematic errors to our measurement (John & Benet-Martínez, 2014, p. 486). No model will ever be a true blue-print of the experience, as none of the models above are (Wigfield and

Eccles for motivation, Feinstein for SES effects), but establish frameworks from which we can build competing models that account for several aspects we suspect are important. In the analyses below we do this by running structural models with two versus only one aspect of motivation, and by using competing models with different measurement of SES. The process to establishing the measurement models also meant examining which items resonated with the assumed latent variables and which items made the models more or less fit to describe the data. The construct validity of the items themselves, not converged in a model but as information collection at the test level, is a matter of item development across several cycles and many years of TIMSS research.

4.1.1 Confidence and significance

Given the size of the TIMSS dataset, significance tests are likely to show significant results even with only minor effects. For this reason, I chose to focus more on the interpretation of effect sizes and on their confidence intervals, estimates of precision, rather than their purported statistical significance. The sheer size of the sample makes most results significant, but substantively still in need of scrutiny. This begets the focus on construct validity, while the error terms of our results relate to the reliability and generalizability of the analyses (John & Benet-Martínez, 2014, p. 476). When estimating the structural models, I employ extra rigor by bootstrapping: a form of resampling where the same data is drawn over and over again, put together into different sample combinations, and used to thus estimate how precise of a sample is possible given the data (Kline, 2016, p. 60). Each resample case is slightly different, composed of a different combination of cases, and with enough iterations can provide an efficient view of how much the cases are likely to vary. Through the many repetitions, bootstrapping creates an empirical sampling distribution (Kline, 2016, p. 61). By feeding the distribution back into the model estimates, we achieve more exact confidence intervals and gain more information about the accuracy of our estimates.

4.2 Ethical considerations

All the information we have about students' feelings and their academic abilities was collected from the students themselves. In addition to the local tests used to assess the students for their own grades and diplomas, school systems around the world subject them to a range of assessments meant to inform us not of the students' individual abilities but of the performance of the system itself. But to what end? Do countries have samples of students

participate in international large-scale assessments to better the conditions for learning that the students are subject to? Or are there other reasons why countries want to participate in ILSAs? In this subchapter, I discuss the influence of organizations like Organization for Economic Co-operation and Development (OECD) in increasing the pressure of international comparison on national education systems and reforms. I will also discuss the conceptual side of quantifying students' feelings about learning and how this can be a problematic way of relating to individual experiences.

4.2.1 Participation rationales

Large-scale assessments are used in education for several purposes. In national settings, they may be used to test schools and individual students against the national curriculum, and develop tracking mechanisms where challenges in certain subject areas can be identified locally. International large-scale assessments (ILSAs) like PISA and TIMSS are less focused on the individual, and designed for the purposes of comparing schools, districts and countries against each other. They are not based on any one curriculum but rather a multifaceted measure of knowledge within chosen subjects. On the national level, large scale and standardized assessments are used to keep administrators and schools accountable (Verger, Parcerisa & Fontdevila, 2018, p. 1). Internationally, Verger and colleagues argue that ILSAs are part of a global education reform movement where all participants strive toward an increasingly similar ideal of successful education. Effective education policies spread through countries that participate in the same assessments, as they strive to emulate high performing nations and get ahead in the "educational race" (Verger et al, 2018, p. 18-19). A rationale for participation is thus to measure and be measured against comparable nations, and to diagnose challenges in local education systems. But are the challenges diagnosed - and the applause received for high performers - indicative of students' learning? Do ILSAs actually contribute to improving education systems to the benefit of students within them? The competitive participation rationale indicates a different focus, as does the influence of PISA administrator OECD (Addey, Sellar, Steiner-Khamsi, Lingard & Verger, 2017, p. 2). Especially in the case of PISA, and especially in the case of low- or middle-income countries, participating in ILSAs open opportunities for financial aid from the OECD, or from the World Bank in the case of TIMSS (Addey et al, 2017, p. 7). While Norway is not a context where funding in and of itself is a rationale for participation, the use of ILSA result as international benchmark and to back up political debates and shifts. Whether economically or politically motivated, neither

of these rationales are about increasing student learnings, especially for those at the bottom of the achievement scale.

4.2.2 Quantification

Ozga has written about the use of educational data to govern and reform education in England (2009). On the forefront of using data to inform policy decisions, English education reform has focused on self-regulation and self-evaluation based on standardized testing. Here, local education governance is accountable for results measured and surveilled from above. Student knowledge is quantified and, in our analyses using TIMSS context questionnaires, we also quantify how students *feel* about school. Ozga points out that while large scale assessments, national and international alike, provide opportunities for local self-evaluation, the authority of demand and of deciding what are important metrics reside more than ever in the centralized governance of education (2009, p. 160). Ranking schools within a country, or ranking countries within an ILSA consortium, means telling a story about knowledge, skill and quality. International rankings are part of creating a narrative, and a ranking particularly good or bad require responses in form of narratives about how that particular school or country managed to do so poorly or so well (Espeland, 2015, p. 72). On a local scale, a ranking in a national or international assessment are a tool for educators to make sense of the challenges they face in disseminating an education. But quantifying skills of individual students is a slim narrative when trying to understand how and why the individual performs as she does. Drawing conclusions from assessments, as I do in the analyses described below, is a slim narrative and a narrow view. Quantifying the socioeconomic experiences of a student and their parent is problematic, as is quantifying how they feel about the education they attend and the subjects they are tested in. The narrative constructed here, from theories of motivation and social circumstance is limited and not nearly enough to understand the real-life students I will teach nor the complexities of their family life.

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Appendices

1. Instruction for Authors, SJER

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Scandinavian Journal of Educational Research

Instructions for authors

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Student motivation and parental attitude as mediators for SES effects

Evidence from TIMSS 2015

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Author: Ingvild Ulven Østbø
https://orcid.org/0000-0002-1692-6292

Faculty of Educational Sciences
UNIVERSITY OF OSLO

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Abstract

Using data collected from 4329 students in the 2015 iteration of the Trends in Mathematics and Science Study (TIMSS), we explore two mediators for the relationship between socioeconomic status (SES) and TIMSS-results among Norwegian fifth graders. First, we explore how the students' motivation mediates the relationship between SES and test results. Second, by using parent reported SES resources and the parents' attitudes to school and the tested subjects, we examine how these may constitute a path through which their children's motivation and the family SES are related to achievement. We found that intrinsic motivation does not mediate any of the SES effects on achievement. Extrinsic motivation accounted for a small but statistically significant portion of SES effects. Parental attitudes did not account for any of the association between SES and motivation or achievement.

Keywords

Socioeconomic status (SES), international large-scale assessment (ILSA), latent variable analysis, mediation, motivation.

Manuscript word count including references: 7991

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1 Introduction

Ever since the Equality of Educational Opportunity Report upended assumptions about the origins of educational inequality in the United States, researchers have attempted to uncover mechanisms that connect family background and academic achievement (Coleman et al, 1966; Alexander & Morgan, 2016). Decades of research have confirmed a robust, albeit sometimes modest, association between socioeconomic status (SES) and academic achievement (White, 1982; Sirin, 2005). In 2018, 11.3% of Norwegian children lived in low-income households, a proportion that has increased from previous years (Epland & Nordmann, 2020). This proportion is exacerbated among immigrant families, where 38.7% of children who themselves have immigrated or born to two immigrant parents live in lasting low-income households. Parental tertiary education predicts skills in reading, mathematics and English on nationwide standardized tests (Statistics Norway, 2020; Salvanes, 2017, p. 66) and children from lower SES segments experience lower social satisfaction at school (Bakken, Frøyland & Sletten, 2016, p. 53). Some studies suggest that while income is less predictive in Norway than in comparable countries, parental education is almost as influential on children's SES outcomes in Norway as in the United States (Salvanes, 2017, p. 72-74). Chmielewski and Reardon found that Scandinavian countries, including Norway, had the lowest income-achievement gaps compared to the other countries they studied (2016, p. 17). Yet the gaps remain identifiable and Norwegian students in the top ten income percentiles performed .70 [.51-.76] standard deviations above students in the bottom ten income percentiles on the PIRLS 2001 assessment, compared to the 1.25 [1.1 – 1.3] standard deviation gap in the United States Early Childhood Longitudinal Study (ECLS-K) sample (Chmielewski & Reardon, 2016, p. 11).

1.1 Pathways of family effects

While genetic differences are associated with school selection and attainment, these differences do not explain all effects of SES on achievement nor their pathways (Smith-Woolley et al, 2018; van Dongen et al, 2018). Despite robust evidence for associations, the pathways and mechanisms through which effects are transmitted are not entirely clear, whether the pathways exacerbate difficulties or amplify advantages. Studies of vulnerability and resilience point to how family structure and parenting styles can mitigate the detrimental effects of economic hardship (Boggess, 1998; Conger & Conger, 2002; NASEM, 2019, p.

69). The model of family stress suggests that economic distress negatively impacts family well-being, which in turn explain developmental lag in children, often due to "high levels of psychological distress, including depressive and hostile feelings, in poor parents" (Duncan, Magnusson & Vortruba-Drzal, 2015, p. 12). Disorganization and instability, like cluttered and crowded homes as well as frequent moving or changes in employment is negatively associated with development in childhood (Vernon-Feagans, Burchinal & Mokrova, 2015, p. 43).

Another model of family mechanisms is the investment perspective, in which available resources and/or time is invested in children's learning and school success (Duncan, Magnusson & Vortruba-Drzal, 2015, p. 14). Examples of investments are setting aside space and time for homework and parents involving themselves in their children's schoolwork. A "(…) warm, responsive and supportive home environment" has been proven conducive to accelerated language development (Meece, 2002). Autonomy, as in the opportunity to discuss and suggest decisions at home, is associated with a heightened academic motivation (Schunk, 2008, p. 285). This type of autonomy is associated with parenting styles that are authoritative but not authoritarian; homes where boundaries are clearly communicated but the children's voices are heard and encouraged. Investment and spending of both resources and time may be partly captured by the concept of home atmosphere, functioning as a pathway from parental SES to school achievement (White, 1982, p. 470). Low family SES is correlated with low motivation; not through direct causation, but through motivation being influenced by the factors that "frequently accompany low SES" (Schunk et al, 2008, p. 281). These factors include the lack of resources, investment priorities within families, but also how the socialization in lower-SES homes sometimes are mismatched to the social expectations of middle-class oriented schools and classrooms. At preschool and early elementary age, despite achievement scores being lower among low-SES children, motivation at this early time is nearly equal among differing SES-groups (Stipek and Ryan, 1997). This suggests that the motivational differences may partly arise through school experiences. Parents and extended family generally adhere to cultural behaviors in line with their personal economic and social strata which does not always model the behaviors expected by school staff. Evans et al (2010) demonstrate strong effects of the amount of books at home, independent of parental education. The authors attribute this to a "scholarly culture" in the families, which can exist independent of parental education. In a distinctly sociological point of view, Evans et al consider books a form of cultural marker, a distinctive form of social capital – as well as

cultural toolkit that support cognitive skill building (2010, p. 172-3). A particularly striking finding is that scholarly culture, measured as number of books in the home, has a major causal effect on children's educational attainment. The difference between a large home library and no books at home is, according to Evans et al, "as great as the difference between having parents who are barely literate (…) and having university educated parents" (2010, p. 179).

1.2 Motivation and mathematics achievement

1.2.1 Motivation typologies

Within motivational psychology, educational motivation has been conceptualized as two separate psychological drives: an *intrinsic* drive to pursue topics of interest, or as an *extrinsic* drive to achieve positive reactions from the social environment (Diseth, 2019, p. 85; 98, Ryan & Deci, 2000). Within the Eccles and Wigfield model of expectancy-value, the social world precedes cognitive processes and individual motivational beliefs in the process toward achievement behavior (Eccles & Wigfield, 2000; Schunk et al, 2008, p. 51). Part of the 'social world' is a cultural habitat and the behaviors of instrumental Others in socialization; as such, the cognitive processes following may also revolve around perceptions of the social environment. In this way, when motivational beliefs are formed and in turn shape goals and expectancies, social experiences of task value and task difficulty part of the process. Whether formed at home or at school, these motivational beliefs influence the educational behaviors that lead to differing levels of achievement.

1.2.2 Academic acheivement

Mega, Ronconi and De Beni propose a theory that links emotion and motivation to academic achievement (Mega, Ronconi & De Beni, 2014). According to the authors, "positive emotional experiences play an important role in academic achievement," but students experience the same type of situations very differently – some react to challenges with a mixture of positive and negative emotion, while others experience only negative emotions (Mega, Ronoconi & De Beni, 2014, p. 121). To understand this discrepancy in emotional reaction to challenges, the authors suggest that cognitive resources, self-regulation, mental strategies and motivation may be mediating processes. They suggest that for motivation to increase performance or achievement, students must believe that intelligence can be

increased, and skills acquired (Mega, Ronoconi & De Beni, 2014, p. 123). In other words, they inherently believe that investing time and effort into a task will yield positive results.

1.2.3 Mathematics motivation

Motivation for studying mathematics is in some ways subject-specific and, according to TIMSS trend data, Norwegian students are consistently less motivated for mathematics than for science study (Kaarstein & Nilsen, 2016, p. 74). Norwegian fourth graders' intrinsic motivation for mathematics decreased between 1995 and 2007, then increasing from 2007 to 2015 (Kaartein, Radisic & Nilsen, 2018, p. 5). At the eighth-grade level, Norwegian students were more motivated than their Swedish peers and less motivated than their Slovenian peers, though students in all three countries reported low levels of motivation in 2008 (Eklöf, Pavesic & Grønmo, 2014). Among younger Norwegian students, it seems that boys are more *individually* interested, while girls invest more *effort* in learning mathematics (Høgheim & Reber, 2019, p. 294). In situational interest, meaning taking an active role in the learning situation, the genders were largely similar (Høgheim & Reber, 2019, p. 293.). Interest and effort may in their own ways relate differently to extrinsic and intrinsic motivation, while situational interest pertains more to school climate and instructional quality.

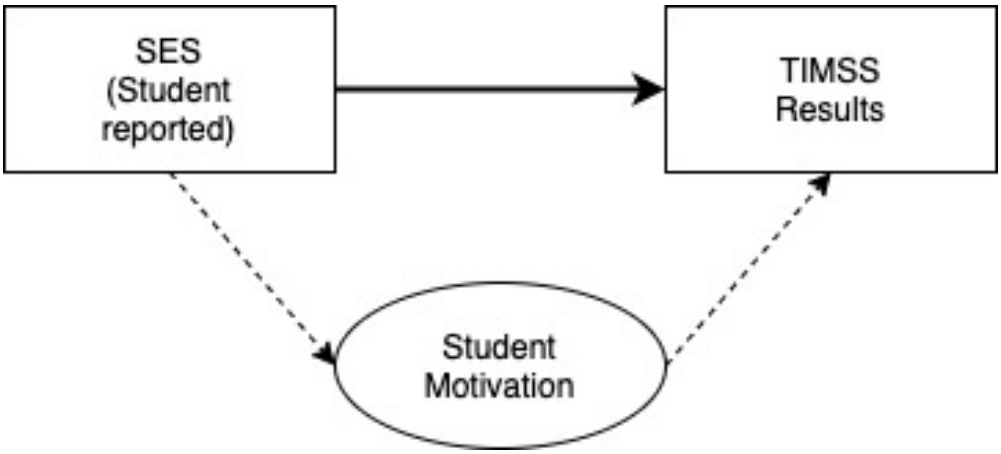
1.3 Present study

The TIMSS 2015 home questionnaire includes eight items for measuring parental attitudes. The attitude items included in TIMSS 2015 were developed based on the 2011 items (Mullis, Martin, Ruddock, O'Sullivan and Preuschoff, 2011, p. 115), which place the importance of parental attitudes on how they in turn influence student attitudes. In analysis of TIMSS 2015 data from South Korea, Turkey and the United States, Geesa, Izci, Song and Chen (2019) found a positive relationship between students' attitudes and science scores. In a meta-analysis of research on parental attitudes and –involvement, Porumbu and Necsoi (2013) found inconsistent results across cultures, but overall confirm an important effect of parental influence on children's academic achievement. This influence is in the meta-analysis defined as a variety of interactions, from parenting styles through parental aspirations and communication to their attitudes. Von Stumm et al (2020, p. 8) also suggest that parent's attitudes could be a potentially important factor mediating the association between SES and school performance.

Our first research question explores whether motivation mediates the relationship between family SES and achievement. The hypothesized relationship is illustrated in figure 1.1.

Figure 1.1

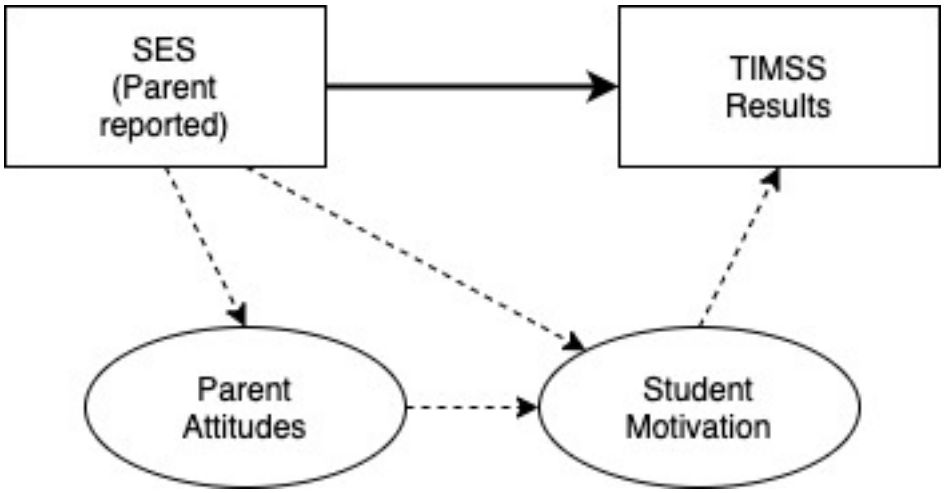
Model of the hypothesized relationship tested in the first research question



Our second research question explores whether parental attitudes *and* motivation mediate the relationship between family SES and achievement. The hypothesized relationship is illustrated in figure 1.2.

Figure 1.2

Model of the hypothesized relationship tested in the second research question



To compare and build upon this previous research, we analyze motivation items in two distinct forms, separating intrinsic and extrinsic motivation. This repurposing of the student context questionnaire items diverges from the TIMSS trend analysis standard of conceptualizing "confidence in" and "liking" of subjects (Martin and Mullis, 2013) and from other research where only confidence and intrinsic motivation has been analyzed at the elementary school level (Kaarstein & Nilsen, 2016; Kaarstein & Nilsen, 2018, p. 40). Due to constraints in time and length we present within results of analyses on mathematics motivation and -achievement only. In Sirin's meta-analysis, the average effect size was larger in analysis of mathematics (.35) achievement outcomes than in science (.27) or verbal ability (.32) (2005, p. 435). As a control feature, we have therefore performed the same analyses on science items, the results of which are included in appendices. Pertinent differences between the subjects are discussed among other robustness checks.

2 Materials and methods

2.1 The TIMSS 2015 data

In this study, we make use of the 2015 iteration of mathematics and science assessment data published by the TIMSS & PIRLS International Study Center at Boston College. The data was collected in 2015 through the administration of mathematics and science exercises (hereby referred to as achievement items); a context questionnaire for the student (background items); and, for the younger participants, a home background questionnaire (parent responses to socioeconomic and attitude items). The test was administered to students in grade four and eight in 60 countries. In the Norwegian subset, grade five students were tested because many Norwegian students enter grade one at age five and so age-wise these are most comparable students to the typical OECD grade four. The present study includes all Norwegian grade five respondents (n = 4329) who participated in TIMSS 2015. As will be discussed, only about 40% of the parents respond (n varies between 1789 and 1823 in analyzed items), while the student response rate is close to complete. The student sample was drawn from the Norwegian fifth grade student population using a stratified two-stage cluster sampling design (LaRoche, Joncas & Foy, 2016, p. 3-1). The two-stage clustered sampling means schools were first sampled based on municipality characteristics, and from each school, whole classes were sampled. The total sample includes 222 classes across 140 schools. Descriptive statistics of the analyzed variables are presented in table S.1 in the supplementary material.

2.2 Outcome variable: achievement items

The dependent variable in all analyses is an estimated achievement score in mathematics. Frameworks for the TIMSS achievement items are updated for each cycle and administered as a full-scale field test prior to translation (Mullis, Cotter, Fishbein & Centurino, 2016, p. 1-1). The framework is designed to assess students across two dimensions: content and cognitive (Mullis et al, 2016, p. 1-5). Fourth grade (Norwegian fifth grade) content domains were numbers, geometric shapes and measures, and data display in mathematics; in science, the content domains were life-, physical- and earth sciences. Cognitive domains were defined as knowing, applying and reasoning and were assessed in both subjects. 114 representatives from 45 participating countries took part in developing the test items. Science achievement is included here only as robustness checks to examine whether or not associations hold across

subjects and analyses are included in the supplementary materials and model specification in the appendix to this manuscript. When results of main analyses are presented below, including standard errors, it will be as an average over five separate calculations using each of the plausible values, as recommended in what von Davier et al call "PV-R," the PV-right method (2009, p. 23). Further information on the plausible values treatment in the current analyses can be found in the supplementary materials (S.2).

2.3 Independent and mediating variables: background items

Independent and mediating variables in the analyses are all derived from the context questionnaires – reported in turn by students and (some of) their parents. Motivation and number of books at home are reported by students, while a scaled SES resource proxy and parental attitudes to subjects are reported by parents.

2.3.1 Student motivation

Mathematics motivation in TIMSS is measured based on responses to 18 questions in the context questionnaire. Examples range from "I learn interesting things in mathematics" to "Mathematics make me nervous" and are all answered on a four-point likert scale. As of the 2015 cycle, TIMSS include items meant to capture both extrinsic and intrinsic motivation in the fourth-grade questionnaire. In their study of 20 years of TIMSS data on mathematics motivation, Kaarstein, Radisic & Nilsen (2018) account for the concepts the questionnaire meant to measure, aligning with Ryan and Deci's distinction between two types of motivation (2000). Items were chosen for both motivation measurement models dependent on their relative fit to the factor found through modification indices. The science motivation items closely resemble those for mathematics, with 16 questions are posed to students about motivation for science.

2.3.2 Socioeconomic status in student data

In the context questionnaire administered with the achievement items, students are asked to report the number of books in their home. The options are presented together with illustrations of books and bookshelves to visualize how a certain number of books may look

at home. The student response rate on this question is close to complete and the responses approximate a normal distribution across the sample, as shown in table 2.1.

Table 2.1

Student Reported Number of Books in the Home

Variable properties

Responses	Missing	Mean	SD	Median	Min	Max
4230	99	3.07	1.09	3	1	5

Variable distribution

Value	1	2	3	4	5
Label	0-10 books	11-25 books	26-100 books	101-200 books	> 200 books
Frequency	310	925	1626	827	515
Proportion	7.3%	22.5%	38.4%	19.6%	12.2%

The number of books at home is commonly included in a scale of home resources, as it is in the TIMSS parent data, combined with other measures of possessions and often with parental education or occupation (Amato, Booth, McHale and Van Hook, 2015, p. 45). But even as a standalone proxy, the number of books at home has been proven repeatedly to be a stable and consistent measure of "objectified cultural capital" (Sieben & Lechner, 2019). In an analysis of socioeconomic indicators in earlier TIMSS data, Yang found that the number of books at home was highly related to cultural capital across most of the TIMSS sample (2003, p. 35). The number of books has also been related to an investment perspective on parents' socialization of their children into an SES bracket (National Academies of Sciences, Engineering and Medicine, 2019, p. 3-3). In order to retain as much data as possible from the sample, we use this variable alone as an SES proxy in student data analyses, as it is reported by 4230 students as opposed to the 1813 students for whom a home resources scale is compiled.

2.3.3 Home Resources for Learning Scale

In the analyses of parent data, a combination of student and parent data are used to define the SES background variable in the structural models. These are comprised in the item response theory-based scale called "home resources for learning," which includes number of books in

the home, number of children's books in the home, highest level of education of either parent, number of home study supports and the highest level of occupation of either parent (Martin, Mullis, Hooper, Yin, Foy & Palazzo, 2016, exhibit 4.1; Hooper, Mullis & Martin, 2016, p. 67). The scale proved to be a significant predictor in all participating countries in 2011 and has since been retained in subsequent TIMSS cycles (Mullis & Martin, 2013, p. 8). It is particularly the combining measure of parental occupational status and education level that makes the home resources for learning scale an interesting proxy for SES.

2.3.4 Parent's attitude to subjects

Parent's attitude to subject is measured based on eight statements in the home questionnaire which parents are asked to rate on a four-point likert scale of agreement. The eight statements cover a combination of science and mathematics, so in our analyses attitude items are combined to capture the parent's attitude to these subjects combined. Examples of statements are: "Most occupations need skills in math, science and technology," "Learning science is for everyone," and "Mathematics is applicable to real life." One out of the eight items was excluded during the confirmatory factor analysis of the attitude measurement model; the statement "science and technology can help solve the world's problems."

2.3.5 Non-response and missing values

The home questionnaire is severely compromised by the amount of non-response. As we do not know the characteristics of those parents who do not respond, we cannot infer the reasons for not responding. One context item is comparable between students and their parents, asking respondents to report the number of books at home. Compared to table 2.1 above, describing the distribution of the student sample across the number of books at home variable, table 2.2 shows a severely skewed response from the parents when asked the same question.

Table 2.2

Parent reported number of books in the home

Variable properties

Responses	Missing	Mean	SD	Median	Min	Max
1819	2510	3.87	1.15	4	1	5

Variable distribution

Value	1	2	3	4	5
Label	0-10 books	11-25 books	26-100 books	101-200 books	> 200 books
Frequency	76	154	456	426	707
Proportion	4.2%	8.5%	25.1%	23.4%	38.9%

The distribution of responses shows that the parents who do fill out the home questionnaire (or at least the question about number of books at home) has a right-skewed distribution on this item compared to their children. Out of the 4329 students, the 1819 whose parents answered this question are not random; the parents who respond are those who report a relatively larger volume of books at home. The 2510 students whose parents did not respond are therefore missing not at random (Kline, 2016, p. 84). This is integral to the understanding and interpretation of other missing information on the parental level, knowing that our parent sample is skewed toward the higher end of the SES spectrum.

2.3.6 Control variables

We include two control variables in the structural models to account for possible effects not included in our research questions. One is gender, which we coded to a binary 0-1. The second covariate controlled is age, to account for whether students were born early or late in the year. The students' ages range from 10 years and 62 days to 12 years and 29 days. We centered the age variable on 0, so younger students receive negative values and older students receive positive values relative to their distance from the mean.

2.4 Statistical analyses

All analysis in this paper was conducted in RStudio version 1.2.5033 (“Orange Blossom”, 2019-12-03) with R version 3.6.2 (“Dark and Stormy Night”, 2019-12-12), on macOS Catalina 10.15.1 (R Studio Inc, 2019; The R Foundation for Statistical Computing, 2019). All models were estimated using maximum-likelihood estimation in the R package lavaan version 0-65, written for latent variable analysis (Rosseel, 2012; 2019). The total number of items analyzed are I = 32 with 5 being outcome items (plausible values), 2 socioeconomic items (one of which is a TIMSS-constructed scale) and 25 plausible mediator items.

2.4.1 Estimating direct and indirect effects

Direct and indirect effects were estimated in lavaan by fitting a path analysis model within the regressions. After specifying the measurement model, the path analysis SEM was fitted as:

*Dependent variable regressed on c*independent variable;*
*Mediating variable regressed on a*independent variable;*
*Dependent variable regressed on b*mediating variable.*

Regression coefficients remain the same as the original SEM model and the lavaan fit standardized output will give estimates based on the following formulas:

Direct effects: c
*Indirect effects: ab = a*b*
*Total effects: c+(a*b)*

2.4.2 Model fit indices

In addition to the model test statistic (chi-square with degrees of freedom and p-value), I use three fit measures to evaluate the models; Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR). According to Hu and Bentler (1999), a CFI value above .95 and a RMSEA value below .06 is sufficient to consider the model well fitted. The “combination rule,” also attributed to Hu and Bentler, states an acceptable fit to have a CFI value equal to or above .95 and an SRMR value equal to or below .08 (Kline, 2016, p. 277; Hu & Bentler, 1999). Some of the confirmatory

factor analysis models, used to evaluate the measurement of latent variables, have CFI and SRMR values indicating good or acceptable fit but RMSEA values that indicate poor fit or have non-significant RMSEA estimation. This could be caused by the low number of degrees of freedom in these measurement models as they are comprised of relatively few variables. Kline (2016, p. 276) explains the penalty that RMSEA imposes on models with few variables. Therefore, even when the RMSEA value casts doubt on the CFA models, if they are otherwise of seemingly good fit they are still used in structural model as long as the latter also proves to be of acceptable fit.

2.4.3 Standard error estimation

We estimate the standard errors in all models by the bootstrap method with 1000 iterations. As a robustness check, we also ran the models with robust standard errors clustered at the school level, to check for any major discrepancies within or between groups. Clustered standard errors led to a slight decrease in t-value for most standardized estimates but always remained within the confidence interval of estimates with bootstrapped standard errors. Due to minimal difference we do not report the clustered standard errors.

3 Results

3.1 Measurement models for motivation and attitudes

As a first stage, we fitted confirmatory factor analysis models for our latent variables subsequently to be included as independent variables in the structural models. For extrinsic and intrinsic motivation, we fitted two separate one-factor models. The factor loadings for each is presented in table 3.2. The CFA model for extrinsic motivation fitted the data very well (χ^2 [2]= 20***, CFI = .995, SRMR = .01, RMSEA 90% CI = [.03 - .07]). The model measuring intrinsic motivation fit almost as well (χ^2 [14]= 249***, CFI = .99, SRMR = .02, RMSEA 90% CI = [.06 - .07]).

Table 3.1

Confirmatory Factor Analysis of Motivation Measurement Models

Observed variable	Factor loading	SE
Extrinsic motivation		
I usually do well in mathematics	.79 ***	.01
I learn things quickly in mathematics	.72 ***	.01
I am just not good at mathematics	.61 ***	.01
My teacher says I am good at mathematics	.50 ***	.01
Intrinsic motivation		
I enjoy learning mathematics	.86 ***	.01
Mathematics is boring	.78 ***	.01
I learn interesting things in mathematics	.70 ***	.01
I like mathematics	.92 ***	.003
I like to solve math problems	.84 ***	.01
I look forward to mathematics lessons	.85 ***	.01
Math is my favorite subject	.84 ***	.01

Standardized estimates. All items measured on a four-point likert scale.

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

A two-factor model combining both motivation constructs also fit the data well (χ^2 = 407*** (DF = 43), CFI = .99, SRMR = .02, RMSEA 90% CI = [.04 - .05]). Factor loadings were very similar to the separate models and no major cross-loadings were identified when inspecting modification indices. The correlation between the motivation factors in the two-factor CFA model was .67*** (.02).

Next, using parent data, we fitted a latent construct for attitudes at home, based on seven out of eight items from the home background questionnaire. One factor loading out of the eight original items had an unacceptably high cross loading against several other indicators and was therefore excluded. This was item 16B in the home questionnaire, "Science and technology can help solve the worlds' problems." The item had especially pronounced link with item 16C, "Science explain how things in the world work." The remaining modification indices indicated that keeping item 16C and excluding item 16B would be most beneficial to model fit. The CFA factor loadings are presented in table 3.3. The model fit the data well (χ^2 = 121*** (DF = 14), CFI = .96, SRMR = .03, RMSEA 90% CI = [.06 - .08]).

Table 3.2

Confirmatory Factor Analysis of Parents Attitude to Subjects

Observed variable	Factor loading	SE
Most occupations need skills in math, science or technology	.60 ***	.02
Science explains how things in the world work	.58 ***	.02
My child needs mathematics to get ahead in the world	.70 ***	.02
Learning science is for everyone	.60 ***	.02
Technology makes life easier	.58 ***	.02
Mathematics is applicable to real life	.61 ***	.02
Engineering is necessary to design things that are safe and useful	.58 ***	.02

Standardized estimates. All items measured on a four-point likert scale.

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

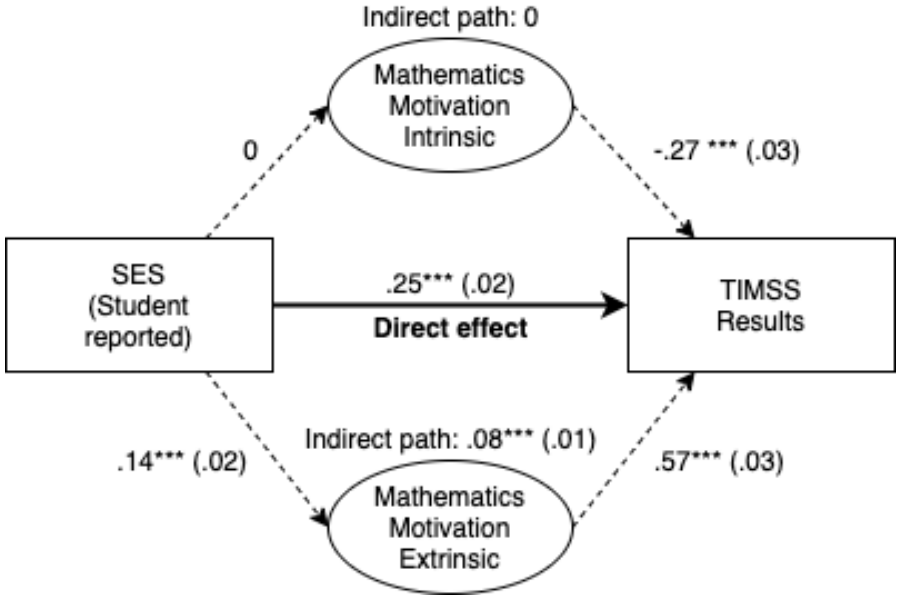
3.2 Structural models in student data

For analysis of associations between SES, motivation and achievement in student data (n = 4329), we fitted the above specified factors in a structural equation model (SEM) with a socioeconomic status (SES) indicator and an outcome variable. In the SEM we regressed intrinsic motivation and extrinsic motivation (separately) on the SES proxy and regressed the achievement score on both forms of motivation as well as SES to capture both indirect and direct effects (figure 3.2). Fit indices for the first combined model indicate good fit (χ^2 = 622*** (DF = 79), CFI = .98, SRMR = .02, RMSEA 90% CI = [.04 – .05]).The direct effect, meaning the effects of SES on achievement not explained by motivation pathways, was .25*** (.02), visualized in figure 3.1. The total effect, adding up the direct effect and the indirect effects estimated through motivation mediators, was .33*** (.02).

Our first research question was whether student motivation mediates the association between SES and achievement and if so, to what extent. The hypothesis associated with this research question is that the relationship between SES and achievement is partially but significantly explained by motivation. The hypothesis holds in the case of extrinsic motivation, but not in the case of intrinsic motivation. The path from SES, through extrinsic motivation, to achievement, was estimated to .08*** (.01). No such significant path was found from SES through intrinsic motivation to achievement.

Figure 3.1

Path Analysis Structural Equation Model with Two Motivation Constructs Using Student Data



Note. Total effect of SES on results including all mediating paths: .33*** (.02). Residual correlation between extrinsic and intrinsic motivation was .68*** (.02). Standard errors are estimated with 1000 bootstrap iterations. Controlled for age and gender.

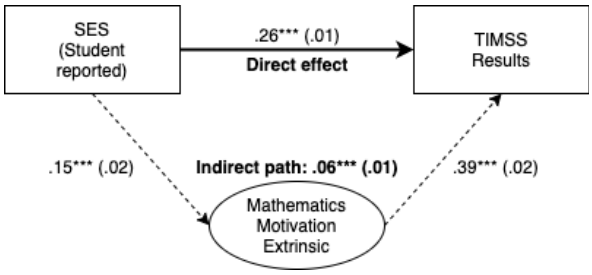
*p < .05 ** p < .01 *** p < .001

Figure 3.1 displays a significant negative effect of intrinsic motivation on mathematics results, and an artificially strong positive effect of extrinsic motivation on the same results. The suppressor effect in the model including two measures of motivation brings to light ways in which intrinsic and extrinsic motivation are related, but not equal. While the two motivation factors often appear together – meaning students who are intrinsically motivated are often also extrinsically motivated – the constructs have very different properties (Watson, Clark, Chmielewski & Kotov, 2013). When intrinsic motivation appears associated with results in our analyses, they are simultaneously correlated with extrinsic motivation. Excluding shared variance in a combined model removes this correlation and creates the artificial appearance that intrinsic motivation is negatively correlated with results, but this only appears because the model excludes the shared variance with extrinsic motivation, properties of intrinsic construct that on their own are very much associated with results. To

alleviate the way the two factors influence each other in the combined model, we fitted separate SEMs for each motivation factor. (figures 3.2a and 3.2b).

Figure 3.2a

Path Analysis of Student Data with an Extrinsic Motivation Factor

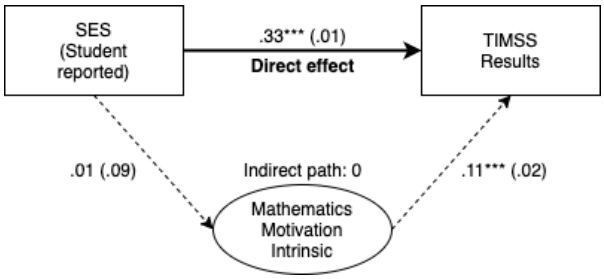


Note. Total association between SES and results, all direct and indirect paths included from figure 3.3a: .32*** (.02). Controlled for age and gender.

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

Figure 3.2b

Path Analysis of Student Data with an Intrinsics Motivation Factor



Note. Total association between SES and results, all direct and indirect paths included from figure 3.3b: .33*** (.02). Controlled for age and gender.

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

Accounting only for extrinsic forms of motivation, model fit indices indicate a stable, well-fitted model (χ^2 = 151*** (DF = 16) CFI = .97, SRMR = .03, RMSEA 90% CI = [.04 - .05]). The regressions are estimated while controlling for gender and age with 1000 bootstrap iterations. The same model accounting only for intrinsic forms of motivation factor also fit the data well (χ^2 = 386*** (DF = 40), CFI = .99, SRMR = .02, RMSEA 90% CI = [.04 - .05]), but revealed zero explanatory power through intrinsic motivation. Total effects of SES on mathematics achievement remain stable across the combined and restricted models. Many of the regression estimates in the restricted model are thus similar to what they were in the full model but the exclusion of intrinsic motivation lowers the relative association between extrinsic motivation and the mathematics score and eases the interpretation of extrinsic motivation effects.

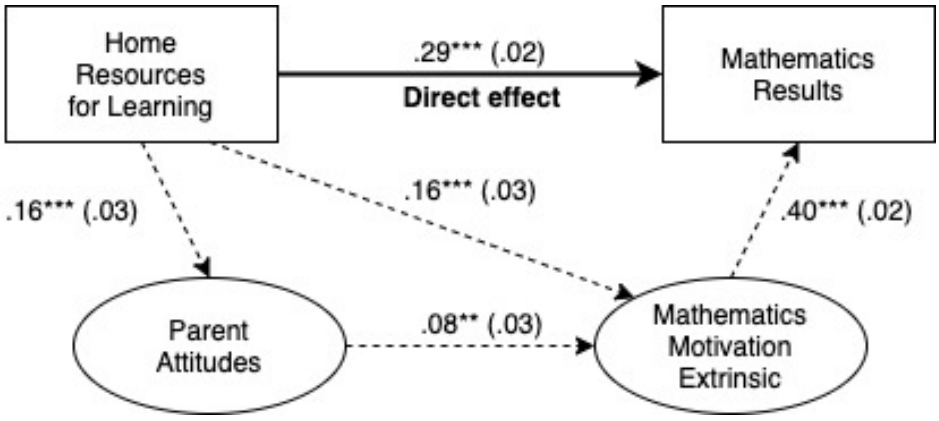
3.3 Structural models including parent data

For evaluating the second research question - how parental attitudes mediate the relationship between SES, motivation and achievement - we included the available parent data (n = 1819). While a model that included both motivation factors was available and fit the data well (χ^2 = 585*** (DF = 199), CFI = .97, SRMR = .03, RMSEA 90% CI = [.03 - .04]), including the intrinsic motivation factor does not lend any further explanatory power to how either SES or parental attitudes are associated with achievement. We already showed this in the student-data models above and the same holds in the data combining parent- and student data. Therefore, we will here present results using only one motivation factor (extrinsic).

The SEM presented in figure 3.3 includes two latent variables: extrinsic motivation, specified as in the former model; and an added factor for parental attitudes with seven indicators. We regressed extrinsic motivation on both attitude and the SES proxy, and regressed attitude on SES. We regressed the achievement score on SES and extrinsic motivation. The model fit the data well (χ^2 = 279*** (DF = 84), CFI = .96, SRMR = .03, RMSEA 90% CI = [.03 - 04]).

Figure 3.3

Path Analysis of Structural Equation Model with Parent- and Student Data, Including One Motivation Factor (Extrinsic) and Parental Attitudes



Note. Total effect of SES on results including all mediating paths: .36 *** (.02). Effect through attitude-motivation path: .005* (.002). Effect through only motivation: .06*** (.01). Controlled for age and gender.

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

Associations are similar to those found in the student-only data. The associations between the SES indicator and achievement is somewhat stronger but both estimates are within the confidence intervals of the other. The association between extrinsic motivation and achievement remains the same. The correlation coefficient between parent-reported SES, measured on a scale of home resources for learning, and extrinsic motivation is estimated to .16*** (.03) [.12 - .22], for all practical purposes the same association found in student-only data (.15*** (.02) [.11 - .18).

3.3.1 Direct and indirect effects including parent attitudes and parent reported SES

Since intrinsic motivation is not associated with SES at a statistically significant level, the direct and indirect effects reported here are calculated using only extrinsic motivation as a mediator. This has a bearing on conclusion drawn from these results, knowing that it is only specific aspects of motivation (herein extrinsic) that are found to mediate SES effects on achievement. The main benefit of excluding the intrinsic motivation variables is to avoid suppressor effects and to achieve a more precise estimate of the remaining, significant, effects.

The total effect of SES on mathematics achievement remains significant and substantial, with a total effect coefficient of .36*** (.02). Most of the total effect comes from the direct effect of SES on achievement, which is .31*** (.02) A miniscule but significant (at $p<.05$) indirect effect (.005* (.002)) is found in the path via attitudes and extrinsic motivation. Circumventing parental attitude, the effect of a path from home resources through extrinsic motivation to outcomes is .06*** (.01).

4 Discussion

4.1 Core findings

We found that SES was associated with test results in both child and parent data, with standardized total effect coefficients of .33 and .36 respectively. In both cases, a small portion of total SES effects (17-19%) was mediated through extrinsic motivation. Our estimates of total effect of SES on achievement mirror Turmo's findings using PISA results and scientific literacy where effect sizes for "home educational resources" and books in the home were similarly predictive (Turmo, 2004, p. 295). Nilsen and Bergem, using the same data as us, found a very strong association between SES indicators and mathematics results in the fifth grade (Nilsen & Bergem, 2016, p. 163). The difference in power between their results and ours may be attributed to the indicators chosen for SES measurement, where Nilsen and Bergem use four indicators rather than the single variable we use in student data or the TIMSS home resources scale we use in parent data. It is worth noting that their four SES indicators included parent education, collected from parents, and therefore resemble most closely our parent data which includes only 1819 cases out of the total n=4329 sample.

4.1.1 Student data: does motivation mediate SES effects?

Our first research question had us examining whether motivation accounted for any of the relationship between SES and mathematics achievement. The answer is yes, in the case of extrinsic motivation. In the models specified with student data and extrinsic motivation, we found that motivation mediated 19% of the total SES effects on achievement. In the model that combined both types of motivation (well fitted but rejected because of the suppressor effect of including intrinsic motivation), extrinsic motivation mediated 24% of the total SES effects. As both estimates are subject to measurement and estimation error, an exact quantification of the mediation effect is ill advised but an approximate estimate around the 20% mark is suggested by our data. In other words, student data alone indicate that extrinsic motivation explains some of the SES effect on achievement, though much remains to be explained.

4.1.2 Lack of evidence for intrinsic motivation

The latent measurement model for intrinsic motivation proved to fit the data well in confirmatory factor analysis. However, in structural models, intrinsic motivation had very low or insignificant associations with both outcome and independent variables. We interpret this to mean that the inclusion of intrinsic motivation lends no explanatory power on how SES and/or attitudes are associated with achievement. Intrinsic motivation was highly correlated with extrinsic motivation (.70 *** (.02)), but when checked for cross-loadings in two-factor models did not measure the same underlying construct. Where Kaarstein and Nilsen find a .15*** correlation between intrinsic motivation and achievement, our analyses established a .11*** correlation, though none of this was related to SES (Kaarstein & Nilsen, 2016, 73). We interpret this to mean that while intrinsic motivation is somewhat important for mathematics achievement, family SES is not instrumental in boosting intrinsic motivation. One explanation for this may be the expectancy-value model, where Eccles and Wigfield propose that the social world precedes individual cognitive processes and motivational beliefs, and that the social world primarily transmits ideas of acknowledgement, praise and reward, so that whatever motivation might be spurred by socioeconomic conditions is closely tied with an expected social value and not the intrinsic value of the activity.

4.1.3 Student and parent data: do attitudes mediate SES effects?

The present study found no evidence that parental attitudes mediate a meaningful portion of the SES correlations with their children's motivation for mathematics, neither extrinsic nor intrinsic. One model showed a correlation between parental attitudes and the children's motivation, however the portion of this that was directed from the SES factor was very small (.005*) and of less reliable significance. This amounts to about 1% of total SES effects on achievement. There is, however, a significant correlation between SES and parental attitude (.16***) – and between SES and extrinsic motivation (also .16***) - but the important (nil) finding is that the parental attitude does *not* meaningfully explain the association between SES and motivation. The aspects of parental attitude that are correlated with SES background are largely different from those aspects that are correlated with the children's extrinsic motivation. While the concepts are connected, we have not found a continual path through attitudes and motivation that explains how SES effects work.

4.2 Study limitations

Quantifying socioeconomic status and -resources is the main challenge for the analyses we have performed. While it would have been beneficial to compare the effects of different indicators, such as income and education in the home versus our most used indicator, books in the home, this is often not feasible in large scale international assessments like TIMSS. Even when collecting data from parents we lose a great deal of other information as it requires us to drop those cases where parents did not respond. Using books at home, as reported by the students, is a flawed and pragmatic approach. By checking both levels of analyses (student- and parent collected data) with both home resources scale and the "books" indicator, we found that the results were largely the same. Still, a more fine-grained or multi-faceted SES measurement could have lent the study more nuance in relation to SES differences.

4.3 Implications for future research

As the 2019 cycle of TIMSS is analyzed and published in 2020, a new set of data will be available to replicate the analyses we have performed. Going forward, the evidence encourage a conceptual divide between intrinsic and extrinsic motivation, and attention to the difference in effect size between the two. The TIMSS data may be of continued use for researchers interested in examining to what extent and in what ways extrinsic motivation mediates the relationship between SES background and achievement. As we found no substantial effects of parental attitudes, it is still unsure whether it is the measurement of attitudes that eludes their effects; yet unspecified paths that divert the effects; or if parental attitudes really have no implication for children's achievement. In our analyses of the TIMSS attitude items we have not found substantive answers to these questions. In all, the present study confirms and supports the long-standing knowledge among education researchers that SES background is substantially related to school achievement. The present study has identified one path through which the effects of SES background is mediated, though much of the total effect remains to be explained. Our analyses also confirmed that dividing motivation into two conceptually distinct forms was meaningful insofar as extrinsic motivation did act as a mediator while intrinsic motivation did not.

Disclosure statement

No potential conflict of interest.

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Supplementary material

S.1 Descriptive statistics of included variables

Table S.1
Descriptive Statistics of Included Variables (N = 4329)

Variable	% Missing	M (%)	SD	Min	Max
Outcomes					
Mean Plausible Value Mathematics	0	550.4	66.1	287.6	763
PV1	0	550.3	69.1	288.2	782.0
PV2	0	551.0	69.7	259.3	815.6
PV3	0	550.8	70.2	244.1	788.8
PV4	0	550.5	69.8	252.3	780.4
PV5	0	549.4	70.8	279.6	788.7
Predictors					
Books at home, student report[a]	2.3	3.1	1.1	1	5
Books at home, parent report[a]	58	3.8	1.2	1	5
Home Resources Scale	58	11.6	1.5	3.9	15.04
Mediator: latent extrinsic motivation for mathematics					
1: I usually do well in mathematics	1.2	3.5	.83	1	4
2: I learn quickly in mathematics	1.9	3.2	.83	1	4
3: I am just not good in math[b]	3.2	3.3	.91	1	4
4: My teacher says I am good at math	2.4	3.4	.73	1	4
Mediator: latent intrinsic motivation for mathematics					
1: I enjoy learning mathematics	1.4	3.4	.79	1	4
2: Mathematics is boring[b]	4.2	3.1	1.0	1	4
3: I learn interesting things in math	2.2	3.4	.79	1	4
4: I like mathematics	3.1	3.3	.92	1	4
5: I like solving math problems	1.9	3.2	.89	1	4
6: I look forward to math lessons	2.2	2.9	.96	1	4
7: Math is my favorite subject	1.7	2.9	1.1	1	4
Mediator: Latent Parental Attitude Indicators					

Table S.1
Descriptive Statistics of Included Variables (N = 4329)

Variable	% Missing	M (%)	SD	Min	Max
1: Most occupations need skills in math, science and technology	58	3.7	.52	1	4
2: Science explains how things work in the world	58	3.7	.51	1	4
3: My child needs math to get ahead in the world	58	3.6	.57	1	4
4: Learning science is for everyone	58	3.7	.57	1	4
5: Technology makes life easier	58	3.6	.56	1	4
6: Math is applicable to real life	58	3.9	.35	1	4
7: Engineering is necessary to design things that are safe and useful	58	3.8	.50	1	4
Covariates					
Girls	0	(49.5)			
Age[c]	0	10.7	.29	10.17	12.08

[a]Number of books at home: 1: 0–10 books; 2: 11–25 books; 3: 26–100 books; 4: 101–200 books; 5: More than 200
[b]Reversed
[c]Centered on 0 in analyses; here as reported in years

S.2 Plausible values treatment

The TIMSS test battery includes a set of questions so large that a single student cannot be expected to answer them all. Therefore, the distribution of proficiency in TIMSS is measured using a matrix-sampling design (Martin, Mullis and Hooper, 2016, p. 12.4). Each student answers relatively few questions, but on a wide range of content. The questions answered are then used to infer the proficiency level across the test content. However, this inference "is achieved with a substantial amount of measurement error» (von Davier, Gonzales and Mislevy, 2009, p. 11).). The estimated characteristics of the student through contextual information allows the generation of multiple imputed scores based on students who are similar (Martin, Mullis and Hooper, 2016, p. 12.4). As each student was administered only a limited number of test questions, the score on the questions administered are used to extrapolate an estimate of means and variations within skillsets. This estimate is presented in

the form of five plausible values (PVs) and so each individual in the dataset are registered with five alternative achievement scores. Neither of these five scores represent a minute account of that individual's abilities but do relate meaningfully to means and variations in ability in the sample. In all cases, the confidence intervals for the estimates from each PV overlap. Results of control analyses of science items, also appended, are estimated using the PV-wrong method, meaning with an average of five PV scores. We therefore caution against using the structural model results of science items as exact estimates and remind the reader that these were only performed to check for (in)consistencies across subjects.

S.3 Robustness checks

S.3.1 Cross-subject robustness of effects

The general pattern when replicating the models with science achievement data is that extrinsic motivation has a lower correlation with achievement in science than it does with mathematics. The direct effects of SES variables on the science achievement score also seem to be stronger, although it is possible to interpret this difference between the subjects as motivation mediating the same SES effect in math but not in science. The low and in several cases insignificant correlations between SES and intrinsic motivation are stable across subjects. These results are illustrated in figures A.1 through A.4 in appendix 3.

S.3.2 Robustness checks for student data models

One robustness check we performed for the SES proxy of number of books at home was to substitute student reported number of books with the parent reported number. This could be a particularly interesting check as the number reported is skewed among the parents. Differences are present, though not drastic, and are visualized in figure A.5 in appendix 4. Using parent reported number of books as an SES proxy in a full model with both types of motivation lowers the estimated direct path between SES and mathematics score by .05, but both estimates are within the confidence interval of the other. Knowing the skew of the parent reported data, the possible though not proven discrepancy could point to differential effects across the SES distribution and future study of SES and motivation may investigate whether intrinsic motivation is more strongly correlated with SES among a subset of the population on the higher end of the SES distribution.

S.3.3 Robustness checks for student- and parent data

In a mirrored version of the robustness check for student data, we substituted the home resources for learning proxy in parent data models with student reported number of books at home to see if this substantially changed the associations found. Results are illustrated in appendix 5. All but one estimates remained relatively stable, regression coefficients and covariates changing with a maximum of .02 and well within the confidence interval of the original model estimates. The only exception was the direct path from SES proxy to mathematics achievement, which was .26*** (.02) modelled with student data and .30*** (.02) when modelled with parent data. Confidence intervals set to 90% overlap but the check supports the suggestion that SES and result correlations may be unevenly distributed among different levels of SES.

Appendices

Appendix 1: Descriptive statistics of variables in analysis of science items

Table A.1

Descriptive Statistics of Variables in Science Analysis (N = 4329)

Variable	% Missing	M (%)	SD	Min	Max
Outcomes					
Mean Plausible Value Science	0	538.4	57.6	279.8	747.9
Plausible Value 1 Science	0	539.6	61.2	298.0	800.74
Plausibel Value 2 Science	0	537.8	61.5	310.12	752.5
Plausible Value 3 Science	0	538.7	63.1	272.4	745.5
Plausible Value 4 Science	0	537	62.3	205.8	766.8
Plausible Value 5 Science	0	539.2	62.7	245.9	729.9
Predictors					
Books at home, student report[a]	2.3	3.1	1.1	1	5
Home Resources Scale	58	11.6	1.5	3.9	15.04
Mediator: latent extrinsic motivation for science					
1: I usually do well in science	1.8	3.4	.77	1	4
2: I learn quickly in science	2.5	3.3	7.7	1	4
3: I am just not good in science[b]	2.9	3.4	.84	1	4
4: My teacher says I am good at science	2.4	3.4	.81	1	4

Mediator: latent intrinsic motivation for science					
1: I enjoy learning science	1.4	3.4	.78	1	4
2: Science is boring[b]	3.4	3.3	.90	1	4
3: I like science	2.5	3.4	.82	1	4
4: I like to do science experiments	1.9	3.8	.56	1	4
5: I look forward to learning science	5.1	3.2	.90	1	4
6: Science is my favorite subject	5.0	3.0	1.0	1	4
Mediator: Latent Parental Attitude Indicators					
1: Most occupations need skills in math, science and technology	58	3.7	.52	1	4
2: Science explains how things work in the world	58	3.7	.51	1	4
3: My child needs math to get ahead in the world	58	3.6	.57	1	4
4: Learning science is for everyone	58	3.7	.57	1	4
5: Technology makes life easier	58	3.6	.56	1	4
6: Math is applicable to real life	58	3.9	.35	1	4
7: Engineering is necessary to design things that are safe and useful	58	3.8	.50	1	4
Covariates					
Girls	0	(49.5)			
Age[c]	0	10.7	.29	10.17	12.07

[a]Number of books at home: 1: 0–10 books; 2: 11–25 books; 3: 26–100 books; 4: 101–200 books; 5: More than 200

[b]Reversed

[c]Centered on 0 in analyses; here as reported

Appendix 2: Measurement models for science motivation

Table A.2

Confirmatory Factor Analysis of Motivation Measurement Models

Observed variable	Factor loading	SE
Extrinsic motivation		
I usually do well in science	.75 ***	.01
I learn things quickly in science	.76 ***	.01
I am just not good at science[a]	.53 ***	.01
My teacher says I am good at science	.54 ***	.01
Intrinsic motivation		
I enjoy learning science	.87 ***	.01
Science is boring[a]	.73 ***	.01
I like science	.92 ***	.01
I like to do science experiments	.40 ***	.01
I look forward to learning science	.89 ***	.01
Science is my favorite subject	.81 ***	.01

Note. Standardized estimates. All items measured on a four-point likert scale. Extrinsic motivation model fit Chisq 61.5 (2), RMSEA [.07-.11] CFI .98, SRMR .02. Intrinsic motivation model fit: Chisq 36 (9), RMSEA [.02 - .04], CFI .99, SRMR .01.

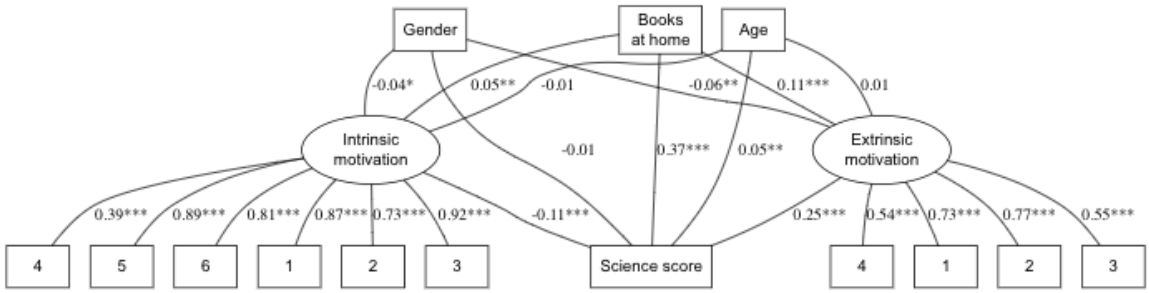
[a]Reversed

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

Appendix 3: Results of structural models in science

Figure A.1

Path Analysis Structural Equation Model with Two Motivation Factors Using Student Data and Science Achievement- and Motivation Items

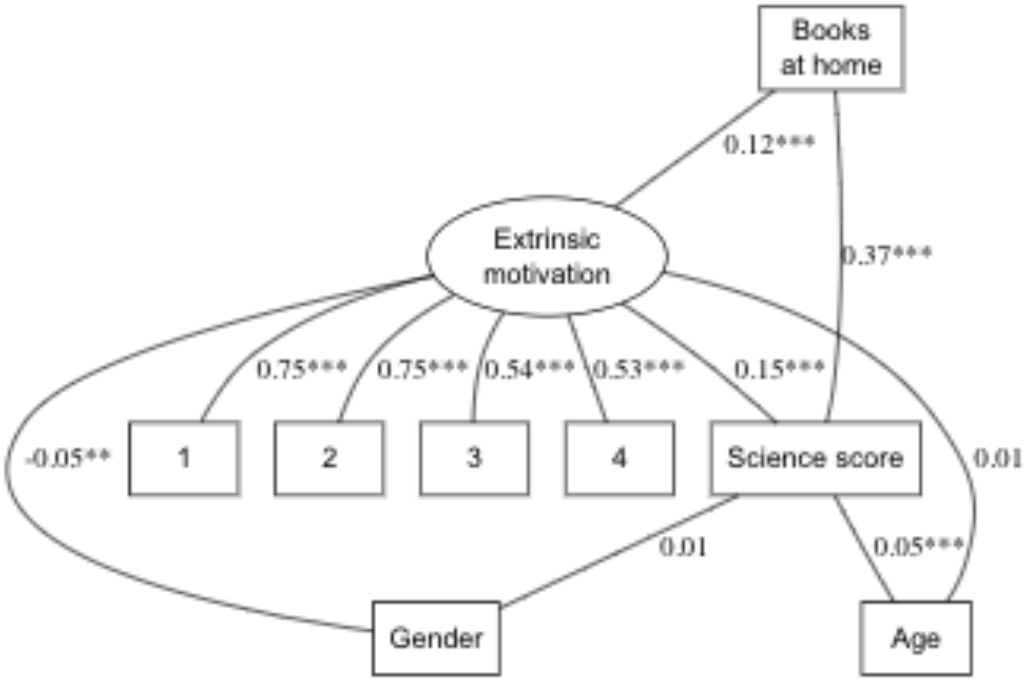


Note. Total effect of SES on results including all mediating paths: .38*** (.01). Effect of SES mediated through extrinsic motivation path: .03*** (.01). Effect of SES mediated through intrinsic motivation path: -.01* (.00). Residual correlation between extrinsic and intrinsic motivation: .74*** (.01). Controlled for age and gender. Model fit: Chisq 617.7 (66), RMSEA [.05 - .05], CFI .97, SRMR .03

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

Figure A.2

Path Analysis Structural Equation Model with Extrinsic Motivation Factor Using Student Data and Science Achievement- and Motivation Items

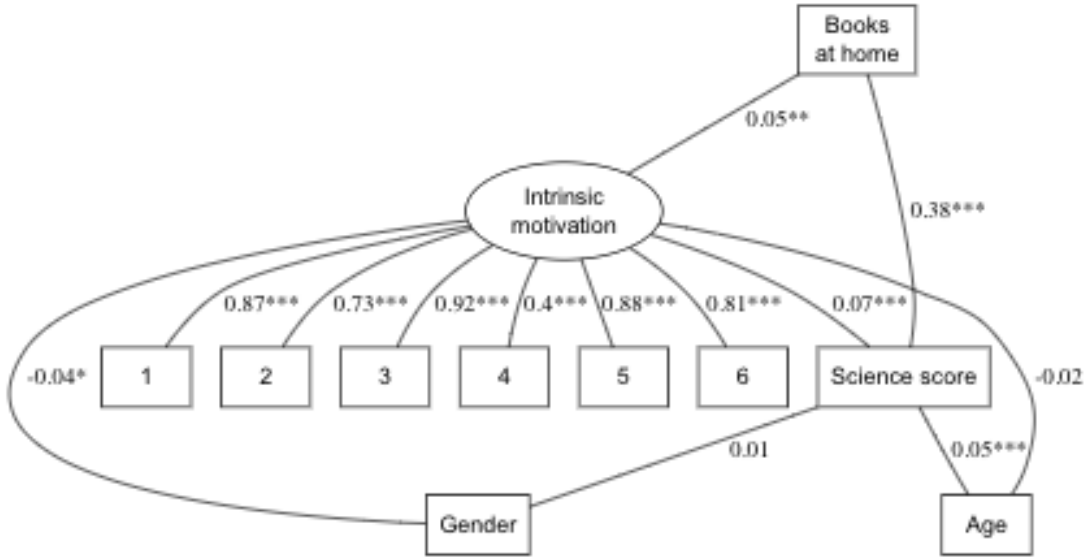


Note. Total effect of SES on results including all mediating paths: .39*** (.01). Effect of SES mediated through extrinsic motivation path: .02*** (.00). Controlled for age and gender. Model fit: Chisq 294.4 (16), RMSEA [.06 - .07], CFI .94, SRMR .04

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

Figure A.3

Path Analysis Structural Equation Model with Intrinsic Motivation Factor Using Student Data and Science Achievement- and Motivation Items

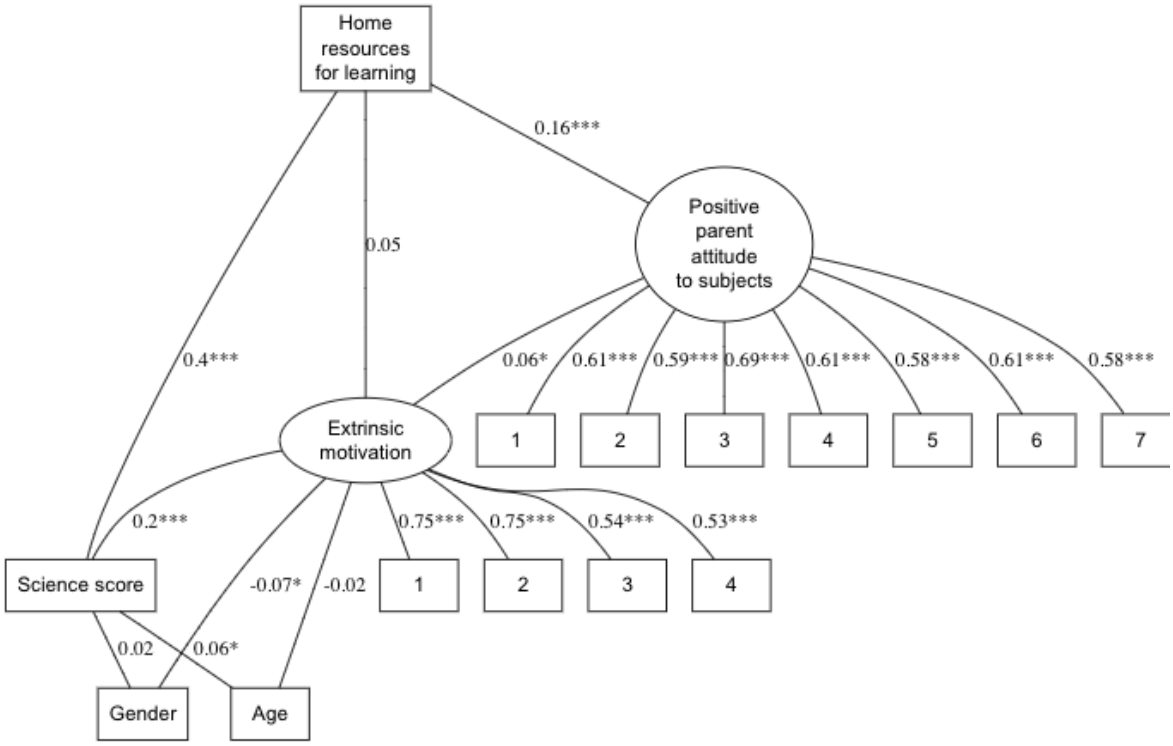


Note. Total effect of SES on results including all mediating paths: .38*** (.01). Effect of SES mediated through intrinsic motivation path: .004* (.001). Controlled for age and gender. Model fit: Chisq 249.9 (31), RMSEA [.04 - .05], CFI .99, SRMR .03

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

Figure A.4

Path Analysis of SEM with Parent- and Student Data, Including One Motivation Factor (Extrinsic) and Parental Attitudes, Science Assessment



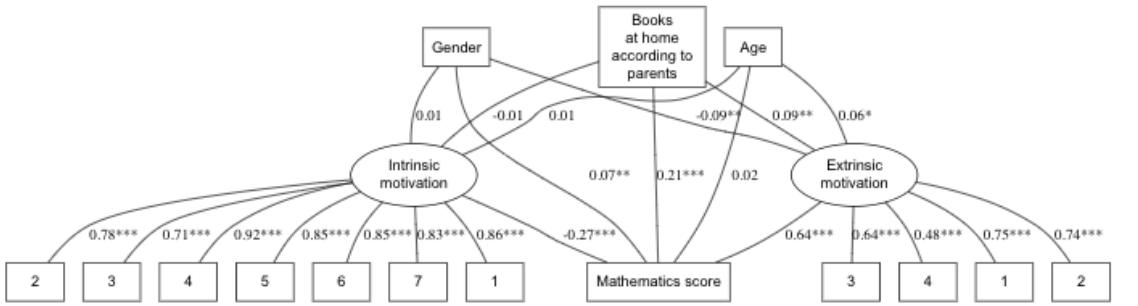
Note. Total effect of SES on results including all mediating paths: .41 *** (.02). Effect through attitude-motivation path: .002 (.001). Effect through only motivation: .009 (.006). Neither path was statistically significant. Controlled for age and gender. Model fit: Chisq 325.4 (84), RMSEA [.04 - .05], CFI .95, SRMR .03

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

Appendix 4: Robustness check for student data model

Figure A.5

Path Analysis Structural Equation Model with Two Motivation Factors Using Student Data and Mathematics Achievement- and Motivation Items, where the SES Variable is Substituted with Parent Reported Number of Books at Home



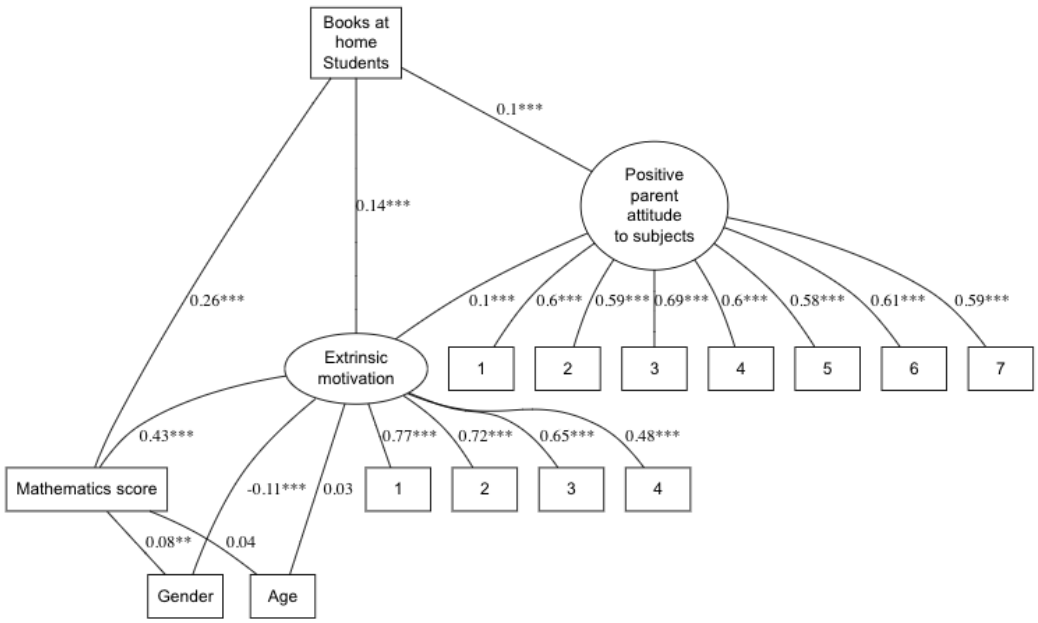
Note. Total effect of SES on results including all mediating paths: .27*** (.02). Effect of SES mediated through extrinsic motivation path: .06** (.02). Effect of SES mediated through intrinsic motivation path: .002 (.007). Residual correlation between extrinsic and intrinsic motivation: .68*** (.02). Controlled for age and gender. Model fit: Chisq 308.2 (79), RMSEA [.04 - .05], CFI .98, SRMR .02

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

Appendix 5: Robustness check for two-level data models

Figure A.6

Path Analysis of SEM with Parent- and Student Data, Including One Motivation Factor (Extrinsic) and a Parental Attitude Factor, where the SES Variable Home Resources Scale is Substituted with Student Reported Number of Books at Home



Note. Total effect of SES on results including all mediating paths: .33 *** (.02). Effect through attitude-motivation path: .005* (.002). Effect through only motivation: .06*** (.01). Controlled for age and gender. Model fit: Chisq 268.62 (84), RMSEA [.03 - .04], CFI .96, SRMR .03

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

Tables in main text

Table 2.1

Student Reported Number of Books in the Home

Variable properties

Responses	Missing	Mean	SD	Median	Min	Max
4230	99	3.07	1.09	3	1	5

Variable distribution

Value	1	2	3	4	5
Label	0-10 books	11-25 books	26-100 books	101-200 books	> 200 books
Frequency	310	925	1626	827	515
Proportion	7.3%	22.5%	38.4%	19.6%	12.2%

Table 2.2

Parent reported number of books in the home

Variable properties

Responses	Missing	Mean	SD	Median	Min	Max
1819	2510	3.87	1.15	4	1	5

Variable distribution

Value	1	2	3	4	5
Label	0-10 books	11-25 books	26-100 books	101-200 books	> 200 books
Frequency	76	154	456	426	707
Proportion	4.2%	8.5%	25.1%	23.4%	38.9%

Table 3.1

Confirmatory Factor Analysis of Motivation Measurement Models

Observed variable	Factor loading	SE
Extrinsic motivation		
I usually do well in mathematics	.79 ***	.01
I learn things quickly in mathematics	.72 ***	.01
I am just not good at mathematics	.61 ***	.01
My teacher says I am good at mathematics	.50 ***	.01
Intrinsic motivation		
I enjoy learning mathematics	.86 ***	.01
Mathematics is boring	.78 ***	.01
I learn interesting things in mathematics	.70 ***	.01
I like mathematics	.92 ***	.003
I like to solve math problems	.84 ***	.01
I look forward to mathematics lessons	.85 ***	.01
Math is my favorite subject	.84 ***	.01

Standardized estimates. All items measured on a four-point likert scale.

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

Table 3.2

Confirmatory Factor Analysis of Parents Attitude to Subjects

Observed variable	Factor loading	SE
Most occupations need skills in math, science or technology	.60 ***	.02
Science explains how things in the world work	.58 ***	.02
My child needs mathematics to get ahead in the world	.70 ***	.02
Learning science is for everyone	.60 ***	.02
Technology makes life easier	.58 ***	.02
Mathematics is applicable to real life	.61 ***	.02
Engineering is necessary to design things that are safe and useful	.58 ***	.02

Standardized estimates. All items measured on a four-point likert scale.

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

List of figures

Figure 1.1

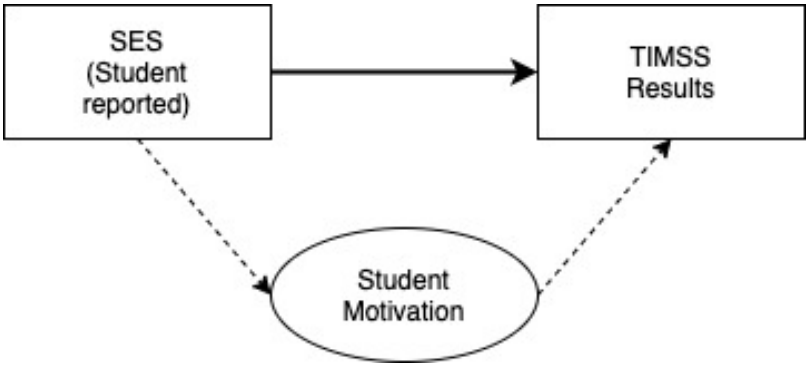


Figure 1.2

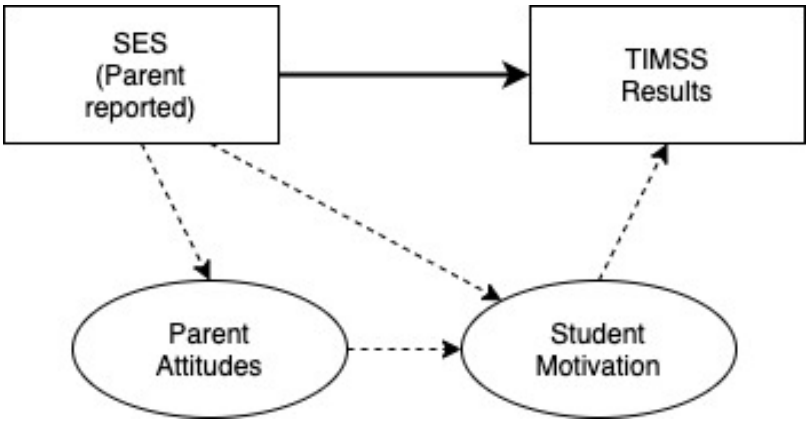


Figure 3.1

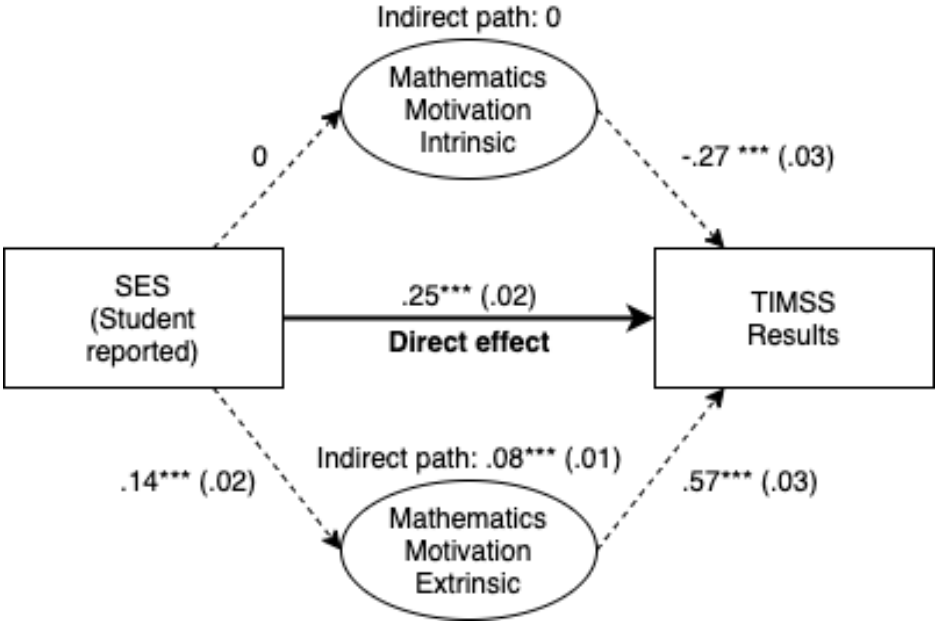


Figure 3.2a

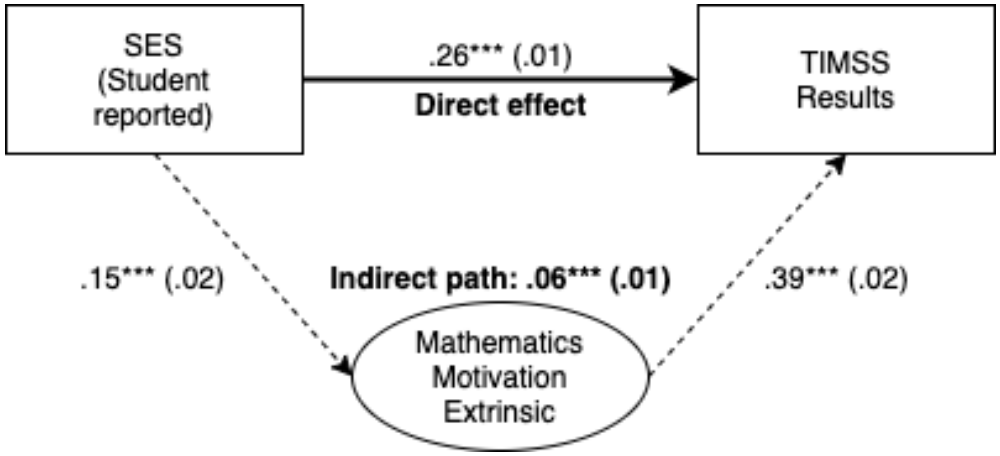


Figure 3.2b

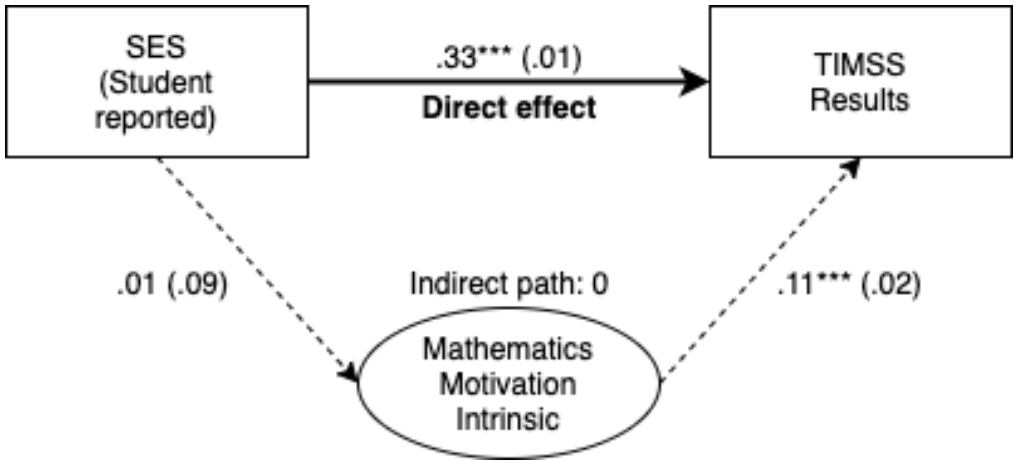


Figure 3.3

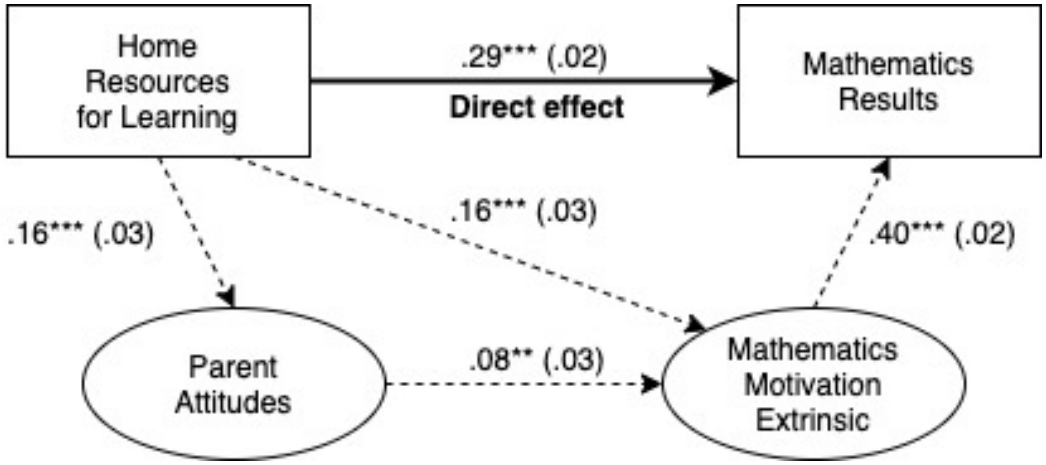


Figure captions

Figure 1.1

Header: *Model of the hypothesized relationship tested in the first research question*

Figure 1.2

Header: *Model of the hypothesized relationship tested in the second research question*

Figure 3.1

Header: *Path Analysis Structural Equation Model with Two Motivation Constructs Using Student Data*

Note: Total effect of SES on results including all mediating paths: .33*** (.02). Residual correlation between extrinsic and intrinsic motivation was .68*** (.02). Standard errors are estimated with 1000 bootstrap iterations. Controlled for age and gender.

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

Figure 3.2a

Header: *Path Analysis of Student Data with an Extrinsic Motivation Factor*

Note: *Note.* Total association between SES and results, all direct and indirect paths included from figure 3.3a: .32*** (.02). Controlled for age and gender.

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

Figure 3.2b

Header: *Path Analysis of Student Data with an Intrinsics Motivation Factor*

Note: *Note.* Total association between SES and results, all direct and indirect paths included from figure 3.3b: .33*** (.02). Controlled for age and gender.

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

Figure 3.3

Header: *Path Analysis of Structural Equation Model with Parent- and Student Data, Including One Motivation Factor (Extrinsic) and Parental Attitudes*

Note: *Note.* Total effect of SES on results including all mediating paths: .36 *** (.02). Effect through attitude-motivation path: .005* (.002). Effect through only motivation: .06*** (.01). Controlled for age and gender.

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